Propensity-Matched Patients Undergoing Revision Hip Arthroscopy Older Than the Age of 40 Years Had Greater Risk of Conversion to Total Hip Arthroplasty Compared With Their Primary Counterparts

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Purpose: To report patient-reported outcomes (PROs) and survivorship following revision hip arthroscopy in patients aged ≥40 years and to compare these results with a propensity-matched primary hip arthroscopy control group. **Methods:** Data were prospectively collected and retrospectively reviewed for all patients who underwent revision hip arthroscopy between June 2008 and January 2019. Patients were included if they were ≥40 years of age at the time of surgery and had minimum 2-year follow-up for the modified Harris Hip Score, Nonarthritic Hip Score, Visual Analog Scale for pain, and the Hip Outcome Score-Sports Specific Subscale. Patients who had a previous hip condition, or those who lacked minimum 2-year follow-up, were excluded. The revision group was further analyzed by conducting a 1:1 propensity-matched sub-analysis to a primary hip arthroscopy control group based on age, sex, body mass index, and acetabular labrum articular disruption grade. Statistical significance was set at $P < .05$. **Results:** Eighty-nine hips (92.7% follow-up) were included, with 66.3% being females. The mean age, body mass index, and follow-up time were 49.4 ± 8.0 years, 26.6 ± 4.1, and 62.7 ± 38.5 months, respectively. Significant improvement in all PROs ($P < .001$) was reported, and 71.8%, 58 74.4%, and 65.2% achieved the minimal clinically important difference for the modified Harris Hip Score, Nonarthritic Hip Score, and Hip Outcome Score-Sports Specific Subscale, respectively. Eighty-seven revision hips were successfully propensity-matched to 87 primary hips. Both groups reported similar improvement for all PROs, but the relative risk of conversion to total hip arthroplasty was 2.63 times greater (95% confidence interval 1.20-5.79) for the revision group. **Conclusions:** Patients aged ≥40 years who underwent revision hip arthroscopy reported significant improvement in all PROs at a mean follow-up of 62.7 months with favorable rates of achieving the minimal clinically important difference. When compared to the propensity-matched control group, both achieved similar rates of improvement, but the revision group was 2.63 times more likely to convert to total hip arthroplasty. **Level of Evidence:** III. case-control study.

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The increase in the number of primary hip arthroscopies has led to an increase in the number of revision hip arthroscopies performed.[1] There is an inherent complexity with revision hip arthroscopy cases that may require advanced arthroscopic hip labral restoration techniques including labral reconstruction and sometimes salvage procedures for bone over-resection.[2,3] Significant improvement in patient-reported outcome (PROs) scores have been reported in this setting; nevertheless, revision results are inferior, with a greater rate of conversion to total hip arthroplasty (THA) when compared with the primary context.[4]

Older age has been associated with failure following primary hip arthroscopy for the treatment of femoroacetabular impingement syndrome.[5,6] Patients aged ≥50 years with a hip joint space narrowing ≤2 mm is an accurate predictor for THA conversion at mean 3-year follow-up.[7] The literature has established there is a greater rate of conversion to THA in patients aged ≥40 years than patients <40 years old.[8] This rate increases with each decade of life as the THA conversion rate was 18.1%, 23.1%, and 25.2% in patients older than 40, 50, and 60 years old, respectively, at short-term follow-up.[8] Outcomes and the conversion to THA after revision hip arthroscopy in patients aged ≥40 years have become a major concern. The current data on this situation are scarce, without clear and objective answers to this conundrum.[9]

The purposes of the present study were to report PROs and survivorship following revision hip arthroscopy in patients aged ≥40 years and to compare these results with a propensity-matched primary hip arthroscopy control group. It was hypothesized that (1) patients aged 40 years or older would report significant improvement for all the PROs collected, (2) when compared with the propensity-matched primary control group, inferior improvement and lower achievement rate for the minimal clinically important difference (MCID) and the patient acceptable symptomatic state (PASS) would be reported for the revision study group, and (3) the rate of conversion to THA would be greater for the revision propensity-matched study group.

Methods

Patient Selection

This study was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki. This study was carried out in accordance with relevant regulations of the U.S. Health Insurance Portability and Accountability Act. Details that might disclose the identity of the subjects under study have been omitted. This study was approved by our institutional review board (ID: 5276).

Prospectively collected data on all patients who underwent revision hip arthroscopy between June 2008 and January 2019 were retrospectively reviewed. Patients were included if they were at least 40 years of age at the time of surgery and had minimum 2-year follow-up for the modified Harris Hip Score (mHHS), Nonarthritic Hip Score (NAHS),[10] and the Hip Outcome Score-Sports Specific Subscale (HOS-SSS)[11] and Visual Analog Scale for pain (VAS).[12] Postoperative International Hip Outcome Tool-12 (iHOT-12)[13] also was included as preoperative values were not available for all patients. Patients who had a previous hip condition (such as fractures, slipped capital femoral epiphysis, avascular necrosis, or Legg−Calve−Perthes disease), or those who lacked minimum 2-year follow-up, were excluded. The patient selection process is outlined in Figure 1.

Participation in the (American Hip Institute) Hip Preservation Registry

While the contemporary study represents a unique analysis of unpublished data, some subjects have been included in previously published investigations.

Radiographic Evaluation

The anterosuperior pelvic view, the 45° Dunn view,[14] and the false-profile view[15] were used to obtain radiographic measurements. The anterosuperior pelvic view was used to obtain the lateral center-edge angle as described by Wiberg and modified by Ogata et al.,[16] acetabular inclination,[17] and grade of osteoarthritis according to the Tönnis classification system.[18] The alpha angle was measured using the 45° Dunn view[14]; angles exceeding 55° indicated the presence of residual cam-type morphology.[19,20] The anterior center-edge angle was assessed using the false profile view.[17] Labral tears as well as other intra- and extra-articular pathologies were assessed using magnetic resonance arthrography in all patients.

Revision Hip Arthroscopy Indication

Revision arthroscopic surgery was indicated by a board-certified hip orthopaedic surgeon specializing in hip preservation (B.G.D.) for patients whose radiographic imaging, history, and physical examination demonstrated evidence of symptomatic residual femoroacetabular impingement syndrome and labral tears. Before pursuing surgery, patients had to attempt at least 3 months of nonsurgical treatment including physical therapy, nonsteroidal anti-inflammatory medication, intra-articular ultrasound-guided injections, and activity modification. In addition, surgery indication was reserved for patients without evidence of

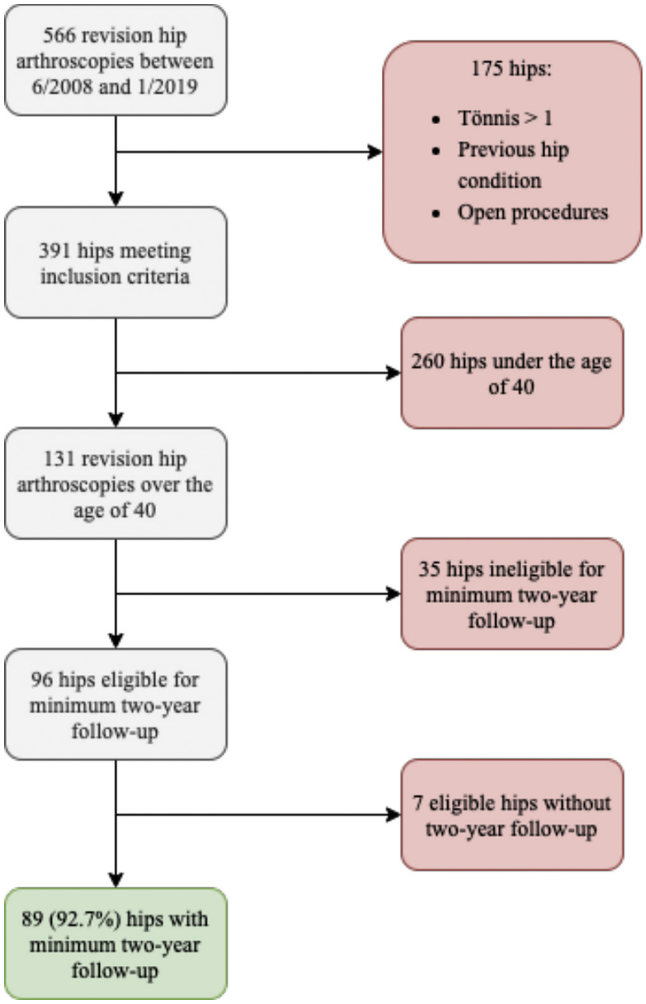

Fig 1. Patient selection flowchart.

advanced osteoarthritis (Tönnis grade >1) on preoperative diagnostic imaging.[21,22]

Surgical Technique

All arthroscopic hip surgeries began with the induction of general anesthesia with the patient in the modified supine position on a traction table with a well-padded perineal post.[23] A minimum of 3 portals were created including an anterolateral, modified mid-anterior portal, and distal anterolateral accessory.[24,25] An additional posterolateral portal was created when required.[26] The hip joint was accessed in an inside-out fashion from the central compartment.[24]

A diagnostic arthroscopy was performed after gaining access to the central compartment. The type and degree of labral tearing was defined using the Seldes classification system[27] and the location of the tear was described using the clockface method.[28] Acetabular cartilage damage at the chondrolabral junction was classified using the acetabular labrum articular disruption (ALAD) grading system while all other cartilage damage on the acetabulum or femoral head was graded

Table 1. Patient Demographic Data of the Revision Cohort

Demographics	
Hips included in study	
Left	39 (43.8%)
Right	50 (56.2%)
Sex	
Female	59 (66.3%)
Male	30 (33.7%)
Age at surgery, y, mean, SD [95% CI]	49.4 ± 8.0 [48.8-50.0]
Body mass index, mean, SD [95% CI]	26.6 ± 4.1 [26.3-26.9]
Follow-up time, mo, mean, SD [95% CI]	62.7 ± 38.5 [60.0-65.5]

CI, confidence interval; SD, standard deviation.

using the Outerbridge classification.[29] The type and degree of tearing of the ligamentum teres was described according to the system described by Villar.[30]

Residual femoroacetabular impingement morphology was addressed under fluoroscopic guidance. When indicated, acetabuloplasty was performed using a motorized burr to correct acetabular overcoverage or pincer morphology.[31] Similarly, femoroplasty was performed to correct cam-type morphology by achieving an alpha angle less than 55° while maintaining the spherical contour of the head—neck junction.[20,32] When possible, labral repair was performed. However, selective labral debridement was performed in the presence of a stable tear with the goal of preserving as much tissue as possible. When the labrum was deemed irreparable, labral reconstruction was performed using autograft or allograft.[33,34] Additionally, if a patient was found to have a full-thickness cartilage defect, the area was first debrided to achieve stable borders before undertaking microfracture.[35]

Postoperative Rehabilitation Protocol

Postoperative rehabilitation varied slightly according to intraoperative procedures. However, all patients were required to use an X-Act ROM brace (DJO Global, Vista, CA) while limiting flat-foot weight-bearing to 20 pounds and use crutches for 2 to 6 weeks. In cases of microfracture or labral reconstruction, a longer duration was prescribed. Physical therapy began day 1 postoperatively, regardless of intraoperative procedures.

PRO Scores

The present study reports on the following PROs: mHHS, NAHS, and HOS-SSS. Pain was assessed using the VAS ranging from 0 to 10, where 0 was no pain and 10 was the worst pain imaginable.[36] All PROs and VAS were recorded preoperatively and postoperatively at 3 months, 1 year, and annually thereafter. These scores were collected via encrypted email, clinic visit, or telephone interviews. Postoperative questionnaires also included iHOT-12.[13] Patients included in this study had minimum 2-year follow-up; however, the scores from

Table 2. Radiologic Findings Data of the Revision Cohort

Radiographic Findings	
Tönnis grade, n (%)	
0	69 (77.5%)
1	20 (22.5%)
LCEA, °	29.8 ± 6.0 [29.4, 30.3]
Acetabular inclination, °	5.0 ± 3.9 [4.7, 5.3]
ACEA, °	29.9 ± 7.1 [29.4, 30.4]
Alpha angle, °	52.1 ± 11.7 [51.3, 53.0]

NOTE. Values presented as mean ± standard deviation [95% confidence interval] unless otherwise noted.
ACEA, anterior center-edge angle; LCEA, lateral center-edge angle.

their most recent follow-up time point were reported. Postoperative patient satisfaction also was included and was rated on a scale of 0 to 10, with 0 being completely dissatisfied and 10 being completely satisfied. Throughout the follow-up period, any complications, revision procedures, or conversion to THA were reported and recorded. The MCID was calculated for the mHHS, NAHS, and HOS-SSS using the method described and validated by Norman et al.[37] The PASS values were used using previously established values for the mHHS (≥74),[38] NAHS (≥85.6),[39] and HOS-SSS (≥75).[38]

Statistical Analysis

To ensure that adequate power was achieved, an a priori power analysis was performed. Under the assumption that a mean difference of 10 points in mHHS was statistically significant, this analysis indicated that the study required at least 36 patients in each group to achieve 80% power. Propensity-score matching was performed using R (Version 3.4.0; R Foundation for Statistical Computing, Vienna, Austria) to decrease the influence of potentially confounding variables and therefore, further increase the study's external validity.

All other statistical analyses were performed using Microsoft Excel (Microsoft Corp., Redmond, WA) and the Real Statistics Add-in. When we examined continuous data, normality was assessed using the Shapiro—Wilk test and variance was compared using the F-test. Additionally, the mean and standard deviation were reported for all continuous data. Comparisons between pre- and postoperative PROs were made using a 2-tailed paired *t* test. Independent cohorts were compared using a student's *t* test or its nonparametric equivalent, the Mann—Whitney *U* test. Further, the Welch test was employed in cases of nonparametric data with unequal variances. Categorical data were analyzed using a χ^2 or Fisher exact test. Statistical significance was set at $P < .05$.

Propensity-Score Matching Process for the Subanalysis

Using a nearest-neighbor (Euclidean distance) match algorithm, patients were propensity-matched on the logit of the propensity score. The study group patients (revisions) were propensity-matched 1:1 to control group patients (primaries) using greedy matching without replacement with a caliper of 0.3; hence, once a study patient had been propensity-matched to a control patient, they were no longer available to be propensity-matched to additional control patients. This method has been established as the ideal method for estimating differences between groups in the litera-

Table 3. Intraoperative Findings Data of the Revision Cohort

Intraoperative Findings	
Seldes	
0	18 (20.2%)
1	10 (11.2%)
2	38 (42.7%)
1 and 2	23 (25.9%)
ALAD	
0	21 (23.6%)
1	26 (29.2%)
2	21 (23.6%)
3	16 (18.0%)
4	5 (5.6%)
Outerbridge (acetabulum)	
0	21 (23.6%)
1	26 (29.2%)
2	21 (23.6%)
3	10 (11.2%)
4	11 (12.4%)
Outerbridge (femoral head)	
0	67 (75.3%)
1	0 (0.0%)
2	10 (11.2%)
3	8 (9.0%)
4	4 (4.5%)
LT villar	
0	46 (51.7%)
1	9 (10.1%)
2	19 (21.3%)
3	15 (16.9%)

NOTE. Values presented as n (%).
ALAD, acetabular labral articular disruption; LT, ligamentum teres.

Table 4. Surgical Procedures Data of the Revision Cohort

Surgical Procedures	
Labral treatment	
None	16 (18.0%)
Debridement	45 (50.6%)
Repair	18 (20.2%)
Reconstruction	10 (11.2%)
Capsular Treatment	
Interportal capsulotomy without repair	67 (75.3%)
Repair	22 (24.7%)
Femoroplasty	51 (57.3%)
Acetabuloplasty	36 (40.4%)
Acetabular microfracture	7 (7.9%)
Femoral head microfracture	2 (2.2%)
LT debridement	26 (29.2%)

NOTE. Values presented as n (%).
LT, ligamentum teres.

Table 5. Patient-Reported Outcomes Data of the Revision Cohort

Patient-Reported Outcomes	
mHHS	
Preoperative	51.7 ± 14.3 [50.7-52.7]
Latest	74.0 ± 19.7 [72.6-75.4]
Pre- to postoperative *P* value	< .001
Improvement	21.6 ± 20.4 [20.1-23.0]
HOS-SSS	
Preoperative	29.2 ± 22.4 [27.6-30.8]
Latest	55.8 ± 29.0 [53.7-57.9]
Pre- to postoperative *P* value	<.001
Improvement	24.6 ± 31.2 [22.4-26.8]
VAS	
Preoperative	6.4 ± 1.9 [6.3-6.6]
Latest	3.3 ± 2.5 [3.1-3.5]
Pre- to postoperative *P* value	<.001
Improvement	−3.0 ± 2.6 [−3.2 to −2.8]
NAHS	
Preoperative	50.5 ± 16.6 [49.3-51.7]
Latest	73.7 ± 17.9 [72.4-75.0]
Pre- to postoperative *P* value	<.001
Improvement	22.3 ± 20.8 [20.8-23.8]
iHOT-12	59.2 ± 26.9 [57.3-61.2]
Satisfaction	7.4 ± 2.7 [7.2-7.6]

NOTE. Values presented as mean ± standard deviation (SD) [95% confidence interval] unless otherwise noted.

HOS-SSS, Hip Outcome Score-Sports Specific Scale; iHOT-12, International Hip Outcome Tool; mHHS, Modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

ture.[4] Propensity-matching was performed on a basis of age at surgery, sex, body mass index, and ALAD.

Results

Patient Demographics and Radiographic Findings

Ninety-six hips satisfied the inclusion criteria for the study, of which 89 (92.7%) had minimum two-year follow-up. Demographic data are outlined in Table 1. The mean age at the time of surgery and body mass index were 49.4 ± 8.0 years and 26.6 ± 4.1, respectively. The mean follow-up time was 62.7 ± 38.5 (24.0-142.5) months. Table 2 describes the radiographic characteristics of the study cohort.

Intraoperative Findings and Procedures

Tables 3 and 4 outline the intraoperative findings and procedures, respectively. The most common type (42.7%) of labral tearing observed in this cohort was Seldes 2. In total, 47.2% of patients were found to have ALAD and acetabular Outerbridge ≥2. Further, 24.7% of patients were found to have some degree of cartilage damage to the femoral head. The group that did not convert to THA had the following ALAD grades (grade 0: 15 hips, grade 1: 21 hips, grade 2: 16 hips, grade 3: 10 hips, grade 4: 3 hips). The group that converted to THA had similar ALAD grades (grade 0: 6 hips, grade 1: 5 hips, grade 2: 5 hips, grade 3: 6 hips, grade 4: 2 hips, $P =$ .653). Labral treatment (repair, selective debridement, or reconstruction) was performed in 82% of patients.

PRO Scores

Patients demonstrated statistically significant improvement in mHHS, HOS-SSS, NAHS, and VAS at a mean follow-up of 62.7 ± 38.5 months. The mean improvement was 21.6 points ($P <$.001) for mHHS, 24.6 ($P <$.001) for HOS-SSS, 22.3 ($P <$.001) for NAHS, and −3.0 ($P <$.001) for VAS. Mean patient satisfaction was 7.4 out of 10. Table 5 depicts preoperative and postoperative PROs.

Fifty-six (71.8%) and 45 (65.2%) met or exceeded the MCID for the mHHS (≥7.1) and HOS-SSS (≥11.2), respectively. Additionally, 75 (96.2%) and 58 (74.4%) met or exceeded the MCID for the VAS (≥0.9) and NAHS (≥8.3), respectively. Forty-three (55.1%) and 22 (31.9%) achieved PASS for the mHHS and HOS-SSS, respectively. In addition, 25 (32.1%) patients achieved PASS for the NAHS.

End Points

Ten (11.2%) hips required re-revision arthroscopy at a mean 42.1 ± 35.0 months. Twenty-four (27.0%) hips underwent conversion to THA at a mean 28.7 ± 29.3 months.

Table 6. Demographic Data for the Propensity-Matched Groups

Demographics	Study Group	Control Group	*P* Value
Hips included in study			.646
Left	39 (44.8%)	36 (41.4%)	
Right	48 (55.2%)	51 (58.6%)	
Sex			.872
Female	58 (66.7%)	59 (67.8%)	
Male	29 (33.3%)	28 (32.2%)	
Age at surgery, y, mean ± SD [CI]	49.5 ± 8.0 [47.8-51.2]	50.3 ± 7.0 [48.8-51.8]	.221
Body mass index, mean ± SD [CI]	26.6 ± 4.1 [25.7-27.5]	26.4 ± 5.1 [25.3-27.5]	.810
Follow-up time, mo, mean ± SD [CI]	63.5 ± 38.6 [55.4-71.6]	66.1 ± 36.8 [58.4-73.8]	.627

NOTE. Values presented as mean ± standard deviation [95% CI] unless otherwise noted.

CI, confidence interval; SD, standard deviation.

Table 7. Radiologic Findings for the Propensity-Matched Groups

Radiological Findings	Study Group	Control Group	*P* Value
Tönnis grade			.853
0	68 (78.2%)	69 (79.3%)	
1	19 (21.8%)	18 (20.7%)	
LCEA, °	30.0 ± 6.0 [28.7-31.3]	31.2 ± 6.5 [29.8-32.6]	.221
Acetabular inclination, °	4.9 ± 4.0 [4.1-5.7]	5.4 ± 5.3 [4.3-6.5]	.548
ACEA, °	29.9 ± 7.2 [28.4-31.4]	31.0 ± 8.2 [29.3-32.7]	0.446
Alpha angle, °	52.1 ± 11.7 [49.6-54.6]	60.3 ± 10.7 [58.0-62.5]	**<.001**

NOTE. Values in bold indicate statistical significance ($P < .05$). Values presented as mean ± standard deviation [95% confidence interval] unless otherwise noted.

ACEA, anterior center-edge angle; LCEA, lateral center-edge angle.

Propensity-Matched Subanalysis

Eighty-seven study group hips were successfully propensity-matched to 87 control group hips. Demographic data for the propensity-matched groups is located in Table 6.

The groups were fairly similar upon examination of radiographs; however, the primary control group was found to have a significantly greater alpha angle 60.3 ± 10.7° (compared with 52.1 ± 11.7°, $P < .001$). Radiographic findings are further outlined in Table 7.

The intraoperative findings and procedures differed between the groups. The study and control groups had significantly different labral tears classified using the Seldes system ($P < .001$). The labral treatment differed between the groups with more study patients undergoing selective debridement and more control patients undergoing labral repair ($P < .001$). The study group had a significantly lower rate of capsular repair than the control group (24.1% vs 49.4%, $P = .001$). The study group also underwent significantly lower rates of femoroplasty and acetabuloplasty than the control group (57.5% vs 88.5%, $P < .001$) and (41.4% vs 65.5%, $P = .001$). Data on intraoperative findings and procedures for both groups can be found in Tables 8 and 9, respectively.

Both groups demonstrated statistically significant improvement in mHHS, HOS-SSS, NAHS, and VAS at latest follow-up. The study group demonstrated lower mHHS, NAHS, and VAS preoperatively and lower mHHS, NAHS, VAS, HOS-SSS, and iHOT-12 postoperatively compared to the control group ($P < .05$). Patient satisfaction was greater in the control group (8.2 ± 2.6 vs 7.5 ± 2.5, $P = .017$). However, the improvement (delta value) was similar for all PROs (Table 10). The study group and the control group had comparable rates of achieving MCID for the mHHS (study = 7.1 and control = 6.9) (55 [72.4%] vs 60 [72.3%], $P = .991$), HOS-SSS (study = 11.2 and control = 12.4) (45 [66.2%] vs 47 [71.2%], $P = .530$), VAS (study = 0.9 and control = 1.0) (63 [82.9%] vs 59 [71.1%], $P = .078$), and NAHS (study = 8.3 and control = 8.8) (56 [79.4%] vs 58 [76.9%], $P = .679$). The study group achieved PASS at a lower rate than the control group, (42 [55.3%] vs 59 [71.1%], $P = .038$). The study group also achieved lower rates of PASS for the HOS-SSS (20 [29.4%] vs 38 [57.6%], $P = .001$). PASS rates were lower in the study group for the NAHS (24 [31.6%] vs 49 [59.8%], $P < .001$).

Table 8. Intraoperative Findings for the Propensity-Matched Groups

Intraoperative Findings	Study Group, n (%)	Control Group, n (%)	*P* Value
Seldes			**<.001**
0	18 (20.7%)	2 (2.3%)	
1	10 (11.5%)	21 (24.1%)	
2	37 (42.5%)	28 (32.2%)	
1 and 2	22 (25.3%)	36 (41.4%)	
ALAD			.683
0	21 (24.1%)	20 (23.0%)	
1	25 (28.7%)	26 (29.9%)	
2	21 (24.1%)	26 (29.9%)	
3	15 (17.2%)	8 (9.2%)	
4	5 (5.7%)	7 (8.0%)	
Outerbridge (acetabulum)			.822.
0	21 (24.1%)	20 (23.0%)	
1	25 (28.7%)	26 (29.9%)	
2	21 (24.1%)	26 (29.9%)	
3	9 (10.3%)	8 (9.2%)	
4	11 (12.6%)	7 (8.0%)	
Outerbridge (femoral head)			.875
0	66 (75.9%)	67 (77.0%)	
1	0 (0.0%)	1 (1.1%)	
2	10 (11.5%)	10 (11.5%)	
3	7 (8.0%)	4 (4.6%)	
4	4 (4.6%)	5 (5.7%)	
LT villar			.082
0	44 (50.6%)	33 (37.9%)	
1	9 (10.3%)	4 (4.6%)	
2	19 (21.8%)	25 (28.7%)	
3	15 (17.2%)	25 (28.7%)	

NOTE. Values in bold indicate statistical significance ($P < .05$). Values presented as n (%).

ALAD, acetabular labral articular disruption; LT, ligamentum teres.

Table 9. Surgical Procedures for the Propensity-Matched Groups

Surgical Procedures	Study Group n (%)	Control Group, n (%)	*P* Value
Labral treatment			**<.001**
None	16 (18.4%)	2 (2,2%)	
Selective debridement	45 (51.7%)	30 (34.5%)	
Repair	18 (20.7%)	51 (58.6%)	
Reconstruction	8 (9.2%)	4 (4.6%)	
Capsular treatment			**.001**
Interportal capsulotomy without repair	66 (75.9%)	44 (50.6%)	
Repair	21 (24.1%)	43 (49.4%)	
Femoroplasty	50 (57.5%)	77 (88.5%)	**<.001**
Acetabuloplasty	36 (41.4%)	57 (65.5%)	**.001**
Acetabular microfracture	7 (8.0%)	6 (6.9%)	.773
Femoral head microfracture	2 (2.3%)	1 (1.1%)	.623
LT debridement	26 (29.9%)	30 (34.5%)	.522

NOTE. Values in bold indicate statistical significance ($P < .05$). Values presented as n (%).
LT, ligamentum teres.

The relative risk of conversion to THA was 2.63 times greater (95% confidence interval 1.20-5.79) for the revision group. Twenty-four (27.6%) hips in the study group and 11 (12.6%) hips in the control group underwent conversion to THA ($P = .013$). The average time for the conversion to THA for the study and control groups was (28.7 ± 29.3 [17.0-40.4] months and 26.4 ± 21.1 [13.9-38.9] months, respectively, $P = .560$). Figure 2 details a survivorship curve for the study and control groups.

Discussion

The main findings of the present investigation were that patients aged 40 years and older who underwent revision hip arthroscopy reported significant PROs improvement and high rate of achievement for the MCID for all PROs at a mean follow-up of 62.7 ± 38.5 months. The percentage of patients that survived was found to be 73%. The secondary subanalysis demonstrated that, although lower postoperative PROs were obtained for the propensity-matched revision study

Table 10. Patient-Reported Outcomes for the Propensity-Matched Groups

Patient-Reported Outcomes	Revision, mean [95% CI]	Control, mean [95% CI]	*P* value
mHHS			
Preoperative	52.2 ± 14.6 [48.9-55.5]	61.9 ± 13.8 [58.9-64.9]	**<.001**
Latest	74.0 ± 19.6 [69.6-78.4]	82.7 ± 18.6 [78.7-86.7]	**.006**
Pre- to postoperative *P* value	**<.001**	**<.001**	
Improvement	21.8 ± 20.5 [17.2-26.4]	20.7 ± 21.0 [16.2-25.2]	.748
HOS-SSS			
Preoperative	29.6 ± 21.9 [24.4-34.8]	37.0 ± 24.7 [31.0-43.0]	.060
Latest	54.4 ± 28.7 [47.6-61.2]	69.6 ± 34.3 [61.3-77.9]	**.002**
Pre- to postoperative *P* value	**<.001**	**<.001**	
Improvement	24.8 ± 31.4 [17.3-32.3]	32.6 ± 35.6 [24.0-41.2]	.180
VAS			
Preoperative	6.3 ± 1.9 [5.9-6.7]	5.0 ± 2.1 [4.6-5.5]	**<.001**
Latest	3.3 ± 2.4 [2.8-3.8]	2.4 ± 2.8 [1.8-3.0]	**.005**
Pre- to postoperative *P* value	**<.001**	**<.001**	
Improvement	−3.0 ± 2.5 [−3.6 to −2.4]	−2.6 ± 3.1 [−3.3 to −1.9]	.327
NAHS			
Preoperative	51.3 ± 16.3 [47.6-55.0]	59.9 ± 17.6 [56.1-63.7]	**.001**
Latest	73.7 ± 17.9 [69.7-77.7]	81.8 ± 18.7 [77.8-85.8]	**.002**
Pre- to postoperative *P* value	**<.001**	**<.001**	
Improvement	22.4 ± 21.1 [17.7-27.1]	21.9 ± 22.5 [17.1-26.7]	.884
iHOT-12	59.4 ± 26.6 [53.3-65.5]	73.7 ± 27.2 [67.7-79.7]	**<.001**
Satisfaction	7.5 ± 2.5 [6.9-8.1]	8.2 ± 2.6 [7.6-8.8]	**.017**

NOTE. Values in bold indicate statistical significance ($P < .05$). Values presented as mean ± standard deviation [95% confidence interval] unless otherwise noted.
HOS-SSS, Hip Outcome Score-Sports Specific Scale; iHOT-12, International Hip Outcome Tool; mHHS, Modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

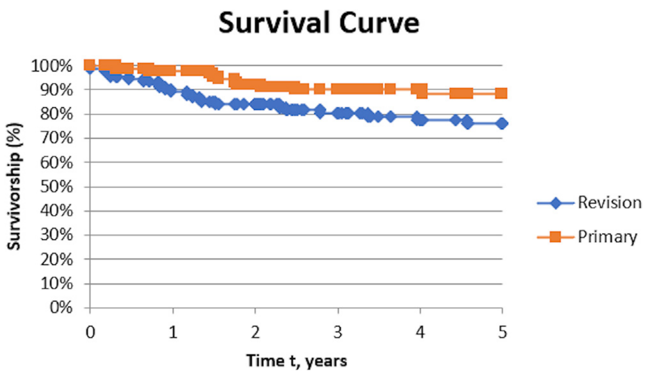

Fig 2. Total hip arthroplasty conversion survivorship curve for revision and control groups.

group; the improvement for each metric was comparable to the primary control group. In addition, the revision group had a 2.63 times greater risk of THA conversion than the primary group.

Older age has previously been reported as a factor that negatively influenced the outcomes after hip arthroscopy.[8] In the primary setting, patients older than 45 years of age performed worse than younger patients.[40] In a retrospective cohort study following 390 patients, 260 younger than 40 years of age were propensity-matched and compared with 130 patients older than 40 years of age, Yacovelli et al.[41] demonstrated a mean improvement and postoperative mHHS score of 11 and 65, respectively, with an overall THA conversion rate of 16% within 2 years of surgery for the late group. Based on these results, these authors recommended avoiding this procedure in this patient population. Martin et al.[42] reported in a randomized controlled trial that patients older than 40 years with limited osteoarthritis, hip arthroscopy with labral repair, and postoperative physical therapy led to better outcomes than physical therapy alone. O'Connor et al.[9] systematically reviewed 4,316 patients (4765 hips) undergoing revision hip arthroscopy, the rates of additional surgery were reported to be between 5% and 14%, the mean rates of conversion to THA and re-revision arthroscopic surgery were 8.3%, and 7.5%, respectively, but as high as 14% for both. The patient mean age for the 15 studies included was 32.23 years. Age may be one of the reasons of why the THA conversion rate was almost the double (27%) in the present study. In terms of PROs improvement, revision hip arthroscopy seems to be a suitable option for patients aged ≥40 years; nevertheless this patient population must be counseled of the greater risk for THA conversion. The data reported in the present study can be used in the clinical practice to provide guidance during the surgical decision-making process.

Noteworthy strengths of the present study have to be acknowledged. This is one of the few studies reporting data on PROs and psychometric tools following revision hip arthroscopy in this specific patient population, using multiple validated functional PROs designed for hip preservation surgery, and the MCID and the PASS, respectively. In addition, the propensity-matched sub-analysis minimizes the effect of confounding variables

Limitations

The present study is not without limitations. It is important to highlight that the reproducibility of the results may be affected, as data were obtained from a single institution and a single hip arthroscopy surgeon.[43] Surgeon expertise, experience, and learning curve play a critical role in the approach for the failed hip arthroscopy, and the decision-making process for treatment in revision hip arthroscopy.[1,4] Using the age of 40 years old as a cut-off was selected by the authors based on prior studies[8,42,44]; notwithstanding, it remains an arbitrary decision. The potential confounding effect of several variables that were not included in the matching process including diagnosis may have influenced the results presented. The retrospective nature of the analysis introduced bias. Additionally, the entire study cohort was unable to be matched. Patients in the revision group that required re-revision arthroscopic surgery or conversion to THA, and patients in the primary group that required secondary surgeries were considered an endpoint; hence, not included within the PROs analysis. A PROs comparison according to sex was not performed. Surgical technique and indications have evolved over time; therefore, patients that may have originally received an interportal capsulotomy with labral debridement may now have a underwent capsular repair with labral repair, reconstruction, or augmentation. As expected, there were significant differences in the intraoperative findings and surgical procedures in the sub-analysis between the study and control group. Lastly, the sample size was modest.

Conclusions

Patients aged ≥40 years who underwent revision hip arthroscopy reported significant improvement in all PROs at a mean follow-up of 62.7 months with favorable rates of achieving the MCID. When compared with the propensity-matched control group, both achieved similar rates of improvement, but the revision group was 2.63 times more likely to convert to THA.

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