A commentary by Caitlin C. Chambers, MD, is linked to the online version of this article.

Two-Year Outcomes of Primary Arthroscopic Surgery in Patients with Femoroacetabular Impingement

A Comparative Study of Labral Repair and Labral Reconstruction

Grant J. Dornan, MS, Joseph J. Ruzbarsky, MD, Spencer M. Comfort, MD, Justin J. Ernat, MD, Maitland D. Martin, AT, MSc, Karen K. Briggs, MPH, and Marc J. Philippon, MD

Investigation performed at the Steadman Philippon Research Institute, Vail, Colorado

Background: Labral repair has become the preferred method for the arthroscopic treatment of acetabular labral tears that are associated with femoroacetabular impingement (FAI) resulting in pain and dysfunction. Labral reconstruction is performed mainly in revision hip arthroscopy but can be utilized in the primary setting for absent or calcified labra. The purpose of this study was to compare the minimum 2-year patient-reported outcomes (PROs) and risk of revision or conversion to arthroplasty between primary labral reconstruction and primary labral repair.

Methods: Patients with FAI who underwent primary hip arthroscopy with labral repair or reconstruction performed by the senior author between 2006 and 2018 were identified from a prospectively enrolled patient outcome registry. Exclusion criteria included confounding injuries, dysplasia, prior ipsilateral hip surgery, or a joint space of <2 mm. Patients who were 18 to 80 years old were eligible for inclusion. Multiple regression with inverse propensity score weighting was conducted to estimate the average treatment effect in the treated (ATT) for labral reconstruction versus labral repair with respect to postoperative PROs and the likelihood of subsequent surgery (revision hip arthroscopy or conversion to arthroplasty). PRO end points included the Hip Outcome Score Activities of Daily Living subscale (HOS-ADL), modified Harris hip score, Western Ontario and McMaster Universities Osteoarthritis Index total score (WOMAC), 12-Item Short Form Health Survey Physical Component Summary score (SF-12 PCS), and patient satisfaction.

Results: A total of 150 hips undergoing primary labral reconstruction and 998 hips undergoing primary labral repair were included. The median follow-up time was 5.3 years in the reconstruction group and 5.8 years in the repair group. Compared with labral repair, labral reconstruction was associated with a higher risk of conversion to total hip arthroplasty (THA) (20% versus 7%; adjusted odds ratio, 3.2; 95% confidence interval [CI], 1.2 to 8.8; p = 0.024). Inverse propensity score-weighted multiple regression estimated a significant negative effect of labral reconstruction, relative to labral repair, on the postoperative values for the HOS-ADL (ATT, −3.3; 95% CI, −5.8 to −0.7; p = 0.012) and WOMAC (ATT, 2.6; 95% CI, 0.1 to 5.2; p = 0.044).

Conclusions: Compared with primary labral reconstruction, primary labral repair resulted in better postoperative HOS-ADL and WOMAC values and decreased conversion to THA. These findings were demonstrated in both the unadjusted group comparisons and multivariable modeling. These data support the use of labral repair in the primary setting of labral tears and the reservation of labral reconstruction for more advanced labral pathology or for revision cases.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Femoroacetabular impingement (FAI) and the resulting labral pathology are a common source of hip pain and dysfunction[1-5]. Hip arthroscopy, with correction of the osseous conflict and the addressing of concomitant intra-articular pathology, has become the mainstay of treatment for patients in whom conservative treatment has failed. Refixation of the labrum

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to bone with use of suture anchors (labral repair) has demonstrated long-term improvement in patient-reported outcome (PRO) measures and high survivorship free of additional procedures or conversion to arthroplasty[5-7].

Labral reconstruction was introduced as a means to restore the hip fluid seal in the rare instances of a calcified labrum or in the revision setting where the absence of the labrum can disrupt its gasket-like function about the hip[8]. In recent years, labral reconstruction has been applied in primary hip arthroscopy in instances in which there is inadequate natural labral tissue bulk[9,10]. This procedure involves the debridement of nonfunctional or degenerative labral tissue, with substitution of other autograft or allograft tissue in its place. Some researchers have hypothesized that the torn labral tissue is pathologic or a "pain-generating tissue" and should be removed[9,11]. Some short-term outcomes at select centers have been published that appear to show improved PROs and good survivorship[9,10,12]. Other studies have shown rates of failure requiring conversion to arthroplasty of up to 13%[13]. These results indicate that more long-term evidence should be collected before this approach is considered the standard of care.

In primary hip arthroscopy, there is a paucity of evidence directly comparing primary labral repair to reconstruction in the setting of FAI. The purpose of this study was to compare, at a minimum of 2 years of follow-up, the PROs and survivorship after primary labral repair versus segmental labral reconstruction performed by a single surgeon. We hypothesized that labral repair would be associated with superior PROs, a lower conversion rate to arthroplasty, and a lower arthroscopic reoperation rate.

Materials and Methods

Patient Selection

This study was approved by the local institutional review board (Vail Health Hospital IRB, Protocol #2020-09). The cohort and all patient data were obtained from a prospectively and consecutively enrolled patient outcome registry, and the data were augmented with medical record and/or imaging review when necessary. Patients who were 18 to 80 years old at the time of surgery, were diagnosed with FAI by the senior author, and underwent a procedure for FAI performed by the senior author (M.J.P.) between 2006 and 2018 were eligible for inclusion. Patients who underwent labral reconstruction were identified on the basis of a documented use of a graft implant to address the labral deficiency, as described below in the section on surgical technique. A large pool of patients who underwent labral repair was available to serve as a comparison group, from which 1,000 qualifying cases were selected at random. Apart from the labral treatment approach, identical inclusion and exclusion criteria were applied to each group. Exclusion criteria for both groups included prior ipsilateral hip surgery, an unavailable preoperative radiograph, a lateral center-edge angle of <18°, a baseline minimum joint space of <2 mm, Legg-Calvé-Perthes disease, avascular necrosis, or a traumatic pelvic or femoral fracture.

For all patients, the following PRO measures were prospectively collected preoperatively and at a minimum of 2 years postoperatively: the Hip Outcome Score Activities of Daily Living subscale (HOS-ADL), Hip Outcome Score Sport subscale (HOS-Sport), modified Harris hip score (mHHS), Western Ontario and McMaster Universities Osteoarthritis Index total score (WOMAC), Tegner activity scale, 12-Item Short Form Health Survey Physical Component Summary score (SF-12 PCS), and 12-Item Short Form Health Survey Mental Component Summary score (SF-12 MCS)[14-17]. Additionally, patient demographic characteristics, intraoperative findings, concomitant procedures, and revisions or conversions to total hip arthroplasty (THA) were recorded (Fig. 1).

Clinical Evaluation

Patients were evaluated by the senior author. A comprehensive hip examination, including strength and range of motion in all planes, was performed. Specific provocative tests for all patients included FADIR (flexion, adduction, internal rotation) and FABER (flexion, abduction, external rotation) testing, posterior impingement testing, hip dial testing, and Beighton scoring. Radiographic examination included anteroposterior pelvic, false profile, and 45° Dunn view lateral radiographs of the proximal femur. These radiographs were utilized to measure the alpha angle, Tönnis grade, Tönnis angle, lateral center-edge angle, anterior center-edge angle, and Sharp angle, as well as the joint-space width medially, laterally, and centrally. Each patient underwent noncontrast 3-T magnetic resonance imaging (MRI) of the hip. FAI was diagnosed clinically with use of physical examination findings of either a positive FADIR test or a positive FABER test, coupled with radiographic criteria such as an alpha angle of >55°, a lateral center-edge angle of >40°, and/or radiographic signs of acetabular retroversion, including

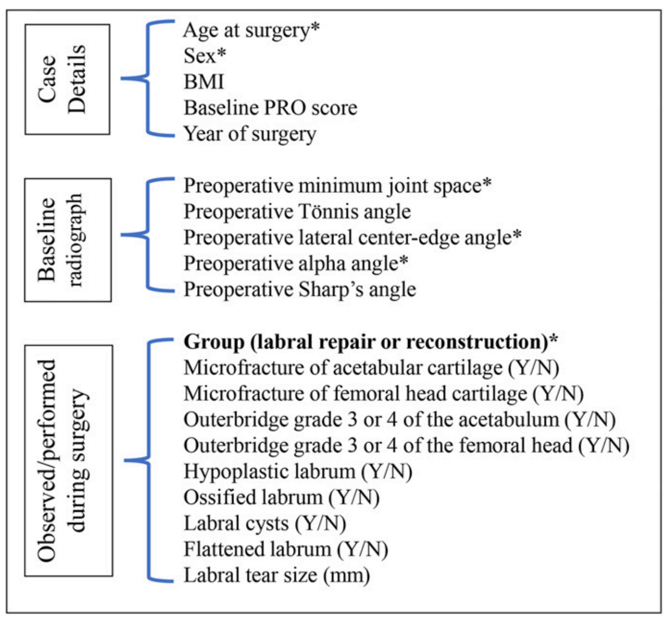

Fig. 1

Independent variables selected a priori for use in the propensity score and outcome models. Asterisks indicate the subset of covariates utilized in models of the risk of subsequent surgery. BMI = body mass index.

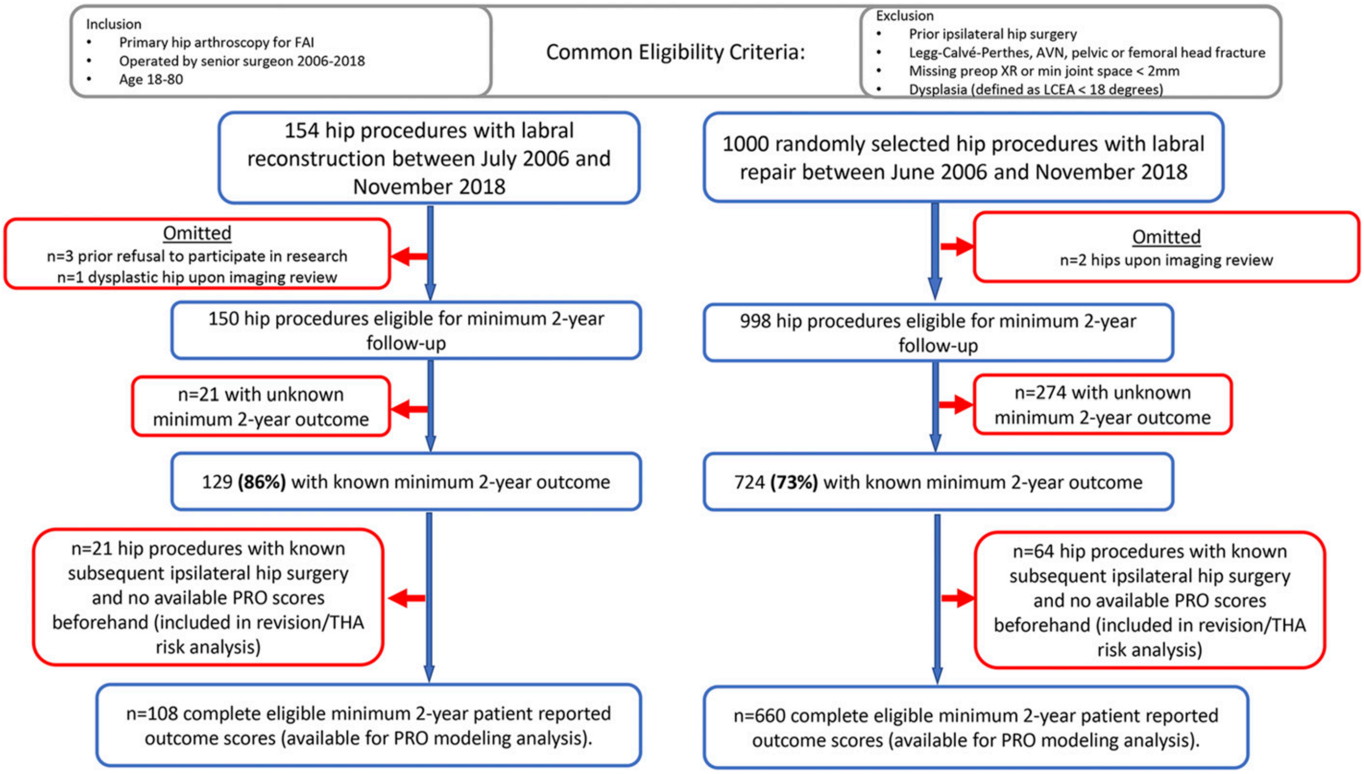

Fig. 2
Flowchart of the study cohort. AVN = avascular necrosis, preop XR = preoperative x-ray (radiograph), min = minimum, LCEA = lateral center-edge angle.

the presence of a crossover sign, an ischial spine sign, or a posterior wall sign.

Surgical Techniques and Postoperative Rehabilitation

The techniques for hip arthroscopy with labral repair or labral reconstruction have previously been reported by the senior surgeon (M.J.P.)[18-23]. The decision to proceed with labral reconstruction was made intraoperatively for cases in which the remaining tissue was inadequate for repair. A detailed description of the surgical techniques and rehabilitation protocol is included in the Appendix.

Statistical Analysis

To address the primary aim of this study, we utilized 2 strategies for the between-group comparisons of PROs and the risk of subsequent surgery (revision hip arthroscopy or conversion to arthroplasty): a robust multivariable modeling approach (the primary analysis) and a crude (secondary, unadjusted) analysis. For the unadjusted analysis, the Mann-Whitney U test was utilized for continuous end points and either the Pearson chi-square test or the Fisher exact test was utilized for binary or categorical end points.

Our selection of the statistical approach was motivated by the understanding that, although the labral quality of a given patient may predispose a surgeon to choose one technique over the other, there exists a gray area in which surgeons may disagree. Moreover, the use of a historical cohort of patients whose labral treatment approach was not determined through randomization may give rise to systematic biases in the repair and reconstruction groups that could confound the comparison of outcomes. Thus, a 3-step modeling process, including multiple imputation of missing data, propensity score modeling, and multiple linear (or logistic) regression modeling with inverse propensity score weighting, was employed to estimate the average treatment effect in the treated (ATT)[24-28]. The ATT may be interpreted as the average effect of the decision to pursue labral reconstruction over labral repair on the postoperative PRO score or risk of subsequent surgery in the group that underwent labral reconstruction. We reported the results of the propensity score analysis according to guidelines modified from the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement[25].

A list of independent covariates that were selected a priori for use in the propensity score and outcome models is presented in Figure 1. A detailed description of the patterns of missing data and the multiple imputation methods that were utilized is included in the Appendix.

Logistic regression was utilized to build the propensity score models via the WeightIt package[29]. Propensity scores were estimated separately within each imputation set, and each unique propensity score set was utilized in the outcome model pertaining to that imputation set before averaging the model results[30]. To encourage

TABLE I Comparison of Baseline Covariates Between the Groups*

Characteristic	Labral Reconstruction (N = 129)	Labral Repair (N = 724)	P Value†
Year of surgery	2011 [2006, 2018]	2011 [2006, 2018]	0.424
Age at surgery *(yr)*	39 [18, 71]; 38 ± 12	36 [18, 68]; 37 ± 12	0.163
Sex			<0.001
Female	42 (33%)	361 (50%)	
Male	87 (67%)	363 (50%)	
BMI‡ *(kg/m²)*	24.1 [17.7, 33.9]; 24.7 ± 3.6	23.1 [15.0, 37.6]; 23.4 ± 3.1	0.005
Minimum joint space *(mm)*	3.00 [2.00, 5.20]; 3.09 ± 0.68	3.30 [2.00, 5.90]; 3.32 ± 0.70	<0.001
LCEA§ *(deg)*	32 [18, 58]; 33 ± 9	33 [18, 54]; 33 ± 7	0.994
Tönnis angle# *(deg)*	5.5 [−3.0, 43.0]; 7.3 ± 6.6	5.7 [−11.8, 96.9]; 7.0 ± 8.0	0.517
Alpha angle** *(deg)*	73 [39, 101]; 71 ± 12	70 [38, 100]; 71 ± 12	0.266
Sharp angle†† *(deg)*	38.0 [30.0, 51.0]; 38.1 ± 4.0	39.0 [13.0, 94.0]; 38.9 ± 5.0	0.044
Microfracture, femoral head	7 (5.4%)	25 (3.5%)	0.310
Microfracture, acetabulum	29 (22%)	73 (10%)	<0.001
OB grade 3 or 4, acetabulum	61 (47%)	221 (31%)	<0.001
OB grade 3 or 4, femur	64 (50%)	205 (28%)	<0.001
Hypoplastic labrum	47 (36%)	97 (13%)	<0.001
Ossified labrum	44 (34%)	4 (0.6%)	<0.001
Labral cysts	3 (2.3%)	15 (2.1%)	0.745
Labral flattening	13 (10%)	54 (7.5%)	0.308
Labral tear size‡‡ *(mm)*	40 [6, 80]; 42 ± 17	30 [0, 70]; 32 ± 12	<0.001
SF-12 PCS§§	44 [22, 62]; 43 ± 10	42 [18, 61]; 42 ± 9	0.346
SF-12 MCS##	56 [29, 66]; 54 ± 8	56 [18, 69]; 53 ± 9	0.460
WOMAC total***	25 [1, 79]; 28 ± 17	25 [0, 74]; 27 ± 16	0.781
mHHS†††	67 [28, 100]; 65 ± 16	63 [22, 100]; 63 ± 15	0.211
HOS-ADL‡‡‡	71 [17, 98]; 70 ± 16	73 [21, 100]; 70 ± 17	0.860
HOS-Sport§§§	47 [0, 100]; 51 ± 26	47 [0, 100]; 48 ± 24	0.343

*BMI = body mass index, LCEA = lateral center-edge angle, OB = Outerbridge. Values are given either as the median, with the range in brackets, and the mean ± standard deviation, or as the number of hips, with the percentage in parentheses. Only hips with a known minimum 2-year end point are included. †Comparisons were performed with use of the Mann-Whitney U test, Pearson chi-square test, or Fisher exact test. ‡BMI was missing for 45 hips in the reconstruction group and for 296 in the repair group. §LCEA was missing for 2 hips in the reconstruction group and for 5 in the repair group. #Tönnis angle was missing for 4 hips in the reconstruction group and for 34 in the repair group. **Alpha angle was missing for 12 hips in the reconstruction group and for 75 in the repair group. ††Sharp angle was missing for 3 hips in the reconstruction group and for 43 in the repair group. ‡‡Labral tear size was missing for 35 hips in the reconstruction group and for 48 in the repair group. §§Baseline SF-12 PCS score was missing for 29 hips in the reconstruction group and for 186 in the repair group. ##Baseline SF-12 MCS score was missing for 29 hips in the reconstruction group and for 186 in the repair group. ***Baseline WOMAC total score was missing for 35 hips in the reconstruction group and for 214 in the repair group. †††Baseline mHHS was missing for 17 hips in the reconstruction group and for 93 in the repair group. ‡‡‡Baseline HOS-ADL was missing for 17 hips in the reconstruction group and for 93 in the repair group. §§§Baseline HOS-Sport was missing for 19 hips in the reconstruction group and for 99 in the repair group.

model stability, extreme low or high weights were trimmed to the 1st or 99th percentile value, respectively. A figure showing the baseline covariate balance after weighting is included in the Appendix.

Weighted multiple linear regression was utilized to model postoperative PRO scores among hips that did not undergo subsequent surgery. The labral treatment group estimate (reconstruction versus repair) was interpreted as the ATT of selecting labral reconstruction instead of labral repair. Secondarily, the effect estimates of other baseline covariates were interpreted for their independent relationship to postoperative outcomes. Weighted multiple logistic regression was utilized to model binary end points (THA conversion and revision arthroscopy) with a reduced set of 6 covariates (labral treatment group, age, sex, minimum joint space, alpha angle, and lateral center-edge angle), following the rule of thumb that 1 covariate should be allowed for every 10 positive binary end-point cases. The multiple R^2 value is reported for each linear regression model in order to describe its predictive power. Significance was set at $p < 0.05$. A sensitivity analysis was

TABLE II Unadjusted Comparison of Minimum 2-Year PRO Scores Between the Groups*

	Labral Reconstruction (N = 108)	Labral Repair (N = 660)	P Value†
Follow-up duration *(yr)*	5.3 [2.1, 14.5]; 6.4 ± 3.4	5.8 [1.8, 16.1]; 6.6 ± 3.5	0.579
SF-12 PCS	54 [22, 62]; 50 ± 9	55 [15, 64]; 51 ± 9	0.150
SF-12 MCS	57 [27, 67]; 53 ± 9	56 [13, 68]; 53 ± 8	0.221
WOMAC	10 [0, 97]; 17 ± 19	6 [0, 80]; 12 ± 15	0.017
mHHS	85 [16, 100]; 80 ± 19	86 [22, 100]; 83 ± 17	0.121
HOS-ADL	90 [17, 100]; 84 ± 19	93 [21, 100]; 88 ± 16	0.028
HOS-Sport	80 [0, 100]; 70 ± 28	86 [0, 100]; 75 ± 27	0.047
Tegner activity scale	6.00 [0.00, 10.00]; 5.32 ± 2.38	5.00 [0.00, 10.00]; 4.83 ± 2.19	0.045
Patient satisfaction	9.00 [1.00, 10.00]; 7.68 ± 2.82	9.00 [1.00, 10.00]; 7.92 ± 2.60	0.608

*Values are given as the median, with the range in brackets, and the mean ± standard deviation. Hips with valid minimum 2-year PRO scores that were obtained prior to a subsequent ipsilateral surgery are included. A total of 21 hips in the reconstruction group and 64 in the repair group are omitted from this table because of the unavailability of eligible PRO scores prior to a known subsequent ipsilateral surgery. †Mann-Whitney U test.

performed to reconstruct the models after imputing the worst possible PRO score (i.e., 0 for the HOS-ADL, mHHS, and SF-12 PCS; 96 for the WOMAC; 1 for patient satisfaction) for hips that underwent subsequent ipsilateral surgery. The R language (version 4.2.1; R Core Team) was utilized for all statistical analyses[31].

Results

Study Cohort

The labral reconstruction group included 150 hips, of which 129 (86%) had available minimum 2-year outcome data (Fig. 2). The labral repair group included 998 hips, of which 724 (73%) had available minimum 2-year outcome data. To assess the possible risk of attrition bias, patients with completed follow-up and those who were lost to follow-up were compared with respect to the baseline covariates (see Appendix Supplementary Table S1). Younger patients and male patients were disproportionately more likely to be lost to follow-up, but there were no other major, clinically relevant differences.

A thorough comparison of the labral reconstruction and labral repair groups with respect to the baseline covariates is included in Table I. Of note, the labral reconstruction group was significantly more male and had lower minimum radiographic joint-space measurements, higher rates of grade-3 or 4 cartilage damage in the femur and acetabulum, larger labral tears, and higher rates of concomitant hypoplasia and ossification ($p < 0.05$ for all; Table I).

TABLE III Unadjusted Comparison of THA Conversion and Subsequent Arthroscopy Rates Between the Groups*

	Labral Reconstruction (N = 129)	Labral Repair (N = 724)	P Value
THA conversion	26 (20%)	51 (7.0%)	<0.001
Subsequent arthroscopy	13 (10%)	45 (6.2%)	0.108

*Values are given as the number of hips, with the percentage in parentheses. The hips of patients who were lost to follow-up are excluded from the denominator.

Comparison of Postoperative Outcomes

The median duration of follow-up was 5.3 years in the labral reconstruction group and 5.8 years in the labral repair group (Table II). The labral reconstruction group demonstrated worse median postoperative scores than the labral repair group for the WOMAC (10 versus 6; $p = 0.017$), HOS-ADL (90 versus 93; $p = 0.028$), and HOS-Sport (80 versus 86; $p = 0.047$). However, the median score for the Tegner activity scale in the labral reconstruction group was significantly higher than that in the labral repair group (6 versus 5; $p = 0.045$). The median patient satisfaction with the surgical outcome was 9 (on a scale of 1 to 10) in both groups. The labral reconstruction group exhibited a significantly higher rate of conversion to THA than the labral repair group (26 [20%] of 129 hips versus 51 [7%] of 724; $p < 0.001$; Table III). The prevalence of subsequent ipsilateral hip arthroscopy was higher among patients who underwent labral reconstruction, but the difference was not significant (13 [10%] of 129 hips versus 45 [6.2%] of 724; $p = 0.108$).

Inverse Propensity-Weighted Regression Modeling of Postoperative Outcomes

Diagnostics for the multiple imputation and propensity score models are included in the Appendix. The results of the inverse propensity score-weighted multiple linear regression models are shown in Table IV. A significant negative ATT was found for the labral reconstruction group with respect to the postoperative HOS-ADL (ATT, −3.3; 95% confidence interval [CI], −5.8 to −0.7; $p = 0.012$) and WOMAC (ATT, 2.6; 95% CI, 0.1 to 5.2; $p = 0.044$). The ATT of labral reconstruction on the mHHS, the SF-12 PCS, and patient satisfaction was not significant, independent of the other covariates.

TABLE IV Results of Multiple Linear Regression Models for Each of 5 PRO Scales*

	HOS-ADL (R^2 = 0.124)			mHHS (R^2 = 0.080)		
Covariate	Beta	95% CI	P Value	Beta	95% CI	P Value
Group						
Labral repair	—	—		—	—	
Labral reconstruction	−3.3	−5.8, −0.72	0.012	−0.1	−2.9, 2.8	0.965
Baseline HOS-ADL	0.18	0.07, 0.29	0.002			
Baseline mHHS				0.17	0.05, 0.28	0.005
Baseline WOMAC						
Baseline SF-12 PCS						
Baseline SF-12 MCS						
Age at surgery	−0.2	−0.28, −0.05	0.004	−0.1	−0.22, 0.03	0.15
Sex						
Female	—	—		—	—	
Male	1.7	−1.5, 5.0	0.3	1	−2.4, 4.5	0.557
BMI	−0.2	−1.1, 0.64	0.588	−0.1	−1.0, 0.83	0.823
Year of surgery	0.29	−0.19, 0.77	0.233	0.06	−0.46, 0.58	0.81
Preop. minimum joint space	−2.7	−4.6, −0.77	0.006	−2.4	−4.5, −0.31	0.024
Preop. lateral center-edge angle	0.19	−0.01, 0.39	0.057	0.15	−0.06, 0.36	0.158
Preop. Tönnis angle	0.06	−0.12, 0.25	0.506	0.02	−0.18, 0.22	0.852
Preop. alpha angle	−0	−0.15, 0.12	0.812	−0	−0.17, 0.11	0.686
Preop. Sharp angle	−0.5	−0.78, −0.13	0.006	−0.2	−0.50, 0.18	0.356
Microfracture, femoral head	−4.9	−12, 2.1	0.169	−5.4	−13, 2.3	0.168
Microfracture, acetabulum	−2.5	−6.3, 1.4	0.21	0.83	−3.4, 5.1	0.699
Grade 3-4 cartilage lesion, acetabulum	0.87	−2.3, 4.0	0.591	−0.2	−3.6, 3.2	0.898
Grade 3-4 cartilage lesion, femur	−0.5	−3.2, 2.2	0.727	0.78	−2.2, 3.8	0.607
Hypoplastic labrum	0.95	−2.2, 4.1	0.555	−1.7	−5.1, 1.7	0.331
Ossified labrum	3.1	−0.51, 6.8	0.091	−1	−5.0, 3.0	0.624
Labral cysts	0.45	−9.0, 9.9	0.926	−1.7	−12, 8.6	0.744
Labral flattening	5	0.67, 9.3	0.024	7.7	2.9, 13	0.002
Labral tear size	−0.1	−0.28, 0.04	0.134	−0.1	−0.31, 0.04	0.14

*BMI = body mass index. Each final model was combined across the 40 regression models generated from the 40 multiply imputed data sets, according to Rubin's rules. Inverse propensity score weighting was performed to estimate the ATT associated with selecting labral reconstruction.

A better baseline PRO score and a decreased baseline minimum joint space (recall that hips with a joint space of <2 mm were excluded) were each independently associated with better postoperative HOS-ADL, mHHS, WOMAC, and SF-12 PCS values. Increased patient age was independently associated with worse HOS-ADL and WOMAC values. A higher Sharp angle was independently associated with worse postoperative HOS-ADL, WOMAC, and SF-12 PCS values. Microfracture of the femoral head was the only significant independent predictor of diminished patient satisfaction.

The ATT of labral reconstruction on the risk of conversion to THA was significant (odds ratio, 3.19; 95% CI, 1.2 to 8.8; p = 0.024; Table V). Increased patient age, decreased minimum joint space, and decreased lateral center-edge angle

TABLE IV (*continued*)

WOMAC (R^2 = 0.156)			SF-12 PCS (R^2 = 0.105)			Satisfaction (R^2 = 0.093)		
Beta	95% CI	P Value	Beta	95% CI	P Value	Beta	95% CI	P Value
—	—		—	—		—	—	
2.6	0.07, 5.2	0.044	−0.2	−1.7, 1.3	0.827	0.14	−0.31, 0.59	0.545
						−0	−0.06, 0.01	0.206
						0.02	0.00, 0.04	0.105
0.28	0.18, 0.37	<0.001				−0	−0.05, 0.02	0.407
			0.18	0.03, 0.34	0.02	−0	−0.06, 0.05	0.819
						0.03	−0.01, 0.07	0.173
0.16	0.05, 0.28	0.006	−0.1	−0.13, 0.01	0.116	−0	−0.03, 0.02	0.566
—	—		—	—		—	—	
−0.7	−3.9, 2.5	0.668	1.3	−0.52, 3.1	0.161	0.45	−0.09, 1.0	0.102
0.04	−0.85, 0.92	0.934	−0.1	−0.52, 0.34	0.678	0.05	−0.07, 0.17	0.423
0	−0.47, 0.47	>0.999	−0.2	−0.48, 0.07	0.148	0.04	−0.04, 0.13	0.331
2.5	0.47, 4.5	0.016	−1.3	−2.4, −0.22	0.019	−0.2	−0.56, 0.12	0.21
			–				–	
−0.1	−0.28, 0.10	0.345	0.1	−0.18, 0.05	0.293	0.02	0.01, 0.06	0.2
0.05	−0.14, 0.23	0.629	0.05	−0.05, 0.15	0.327	−0	−0.04, 0.03	0.72
0.05	−0.07, 0.18	0.4	−0	−0.08, 0.06	0.738	−0	−0.03, 0.01	0.516
0.45	0.13, 0.77	0.006	−0.3	−0.47, −0.10	0.002	−0	−0.08, 0.03	0.403
7.7	0.79, 15	0.029	−2.4	−6.3, 1.5	0.221	−1.9	−3.1, −0.63	0.003
2.8	−1.1, 6.6	0.163	−1.6	−3.8, 0.55	0.142	−0.1	−0.79, 0.58	0.764
0.09	−3.1, 3.3	0.957	0	−1.8, 1.8	0.996	0.02	−0.56, 0.60	0.947
0.14	−2.5, 2.8	0.92	0.04	−1.6, 1.6	0.962	0.14	−0.36, 0.63	0.584
−0.9	−4.1, 2.4	0.599	0.73	−1.0, 2.5	0.408	−0.3	−0.87, 0.21	0.228
−2.2	−5.8, 1.3	0.22	0.12	−2.0, 2.2	0.907	−0.1	−0.82, 0.53	0.673
0.47	−9.1, 10	0.922	−2.4	−7.7, 2.9	0.38	−0.6	−2.3, 1.1	0.493
−4.4	−8.7, −0.06	0.047	1.1	−1.4, 3.5	0.403	0.22	−0.58, 1.0	0.585
0.1	−0.06, 0.26	0.211	−0.1	−0.13, 0.03	0.214	−0	−0.05, 0.00	0.095

were each independently predictive of a higher risk of THA conversion. Younger patient age was the only significant independent predictor of subsequent ipsilateral arthroscopy.

Discussion

The most important finding of this study is that patients undergoing primary labral repair exhibited better postoperative HOS-ADL and WOMAC values and a lower likelihood of undergoing conversion to THA than those undergoing primary labral reconstruction. This study employed a 3-step modeling strategy to estimate the treatment effect of selecting labral reconstruction over labral repair, while controlling for a collection of key covariates and explicitly accounting for the factors that influenced the senior surgeon's decision of reconstruction versus repair for each patient.

In aggregate, the between-group differences in the postoperative PRO scores were modest in magnitude and did not surpass commonly reported minimal clinically important difference (MCID) values in the literature. An individual-level analysis of attainment rates by group for the MCID and patient

TABLE V Results of Multiple Logistic Regression Models for the Risk of Conversion to THA and the Risk of Subsequent Ipsilateral Hip Arthroscopy*

	THA Conversion			Subsequent Arthroscopy		
Covariate	OR	95% CI	P Value	OR	95% CI	P Value
Group						
Labral repair	—	—		—	—	
Labral reconstruction	3.19	1.17, 8.76	0.024	1.33	0.47, 3.77	0.591
Age at surgery	1.08	1.04, 1.13	<0.001	0.93	0.89, 0.98	0.006
Sex						
Female	—	—		—	—	
Male	0.74	0.27, 2.05	0.567	0.79	0.27, 2.34	0.669
Preop. minimum joint space	0.3	0.13, 0.65	0.003	0.58	0.26, 1.28	0.176
Preop. alpha angle	1	0.96, 1.04	0.898	1	0.96, 1.05	0.907
Preop. lateral center-edge angle	0.9	0.85, 0.96	0.002	0.99	0.93, 1.06	0.798

*Each final model was combined across the 40 regression models generated from the 40 multiply imputed data sets, according to Rubin's rules. Inverse propensity score weighting was performed to estimate the ATT associated with selecting labral reconstruction. OR = odds ratio.

acceptable symptom state (PASS) is included in Appendix Table S2. The Appendix also contains a sensitivity analysis of the regression models, whereby the worst possible postoperative PRO score was imputed for hips that underwent any subsequent ipsilateral surgery (see Appendix Table S3). These sensitivity models simultaneously reflect the lower risk of THA conversion and higher PRO scores in the labral repair group compared with the labral reconstruction group, providing surgeons with further motivation to pursue labral repair whenever possible.

Labral reconstruction has gained in popularity since the initial descriptions of this procedure in the early 2000s. The procedure was developed out of necessity under salvage circumstances for a primary calcified labrum or iatrogenic labral insufficiency, when the only alternative treatment approach was debridement and a functionally labral-deficient state[32]. Since its initial description, primary labral reconstruction has gained traction in some centers as an equivalent to, or even as a superior alternative to, labral preservation procedures such as labral repair[9,10,33,34]. Even after several years during which both procedures have been performed, there is a paucity of clinical evidence to help definitively guide surgeons. A recent systematic review examined all clinical comparative studies comparing both labral repair and labral reconstruction[35]. Ten small studies were included, and no formal meta-analysis was performed. The utilization of primary labral reconstruction when sufficient labral tissue is present, and without clear clinical or preclinical data to support its use, may be harmful given that revision options for a failed reconstruction are limited and that reconstruction involves permanent destruction of the native chondrolabral junction.

Some centers perform primary circumferential labral reconstruction in the majority of cases[9,33]. Study authors from these centers have advocated for this approach on the basis of findings that such reconstruction has a lower reoperation rate than labral repair in isolation. Specifically, a published head-to-head comparison by White et al. demonstrated a failure rate of 0% in the reconstruction group and a failure rate of 31% in the repair group[9]. However, there are critical issues with this often-cited reason for performing primary labral reconstruction. First, a failure rate of 0% is not consistent with the rates of 5% to 10% reported in the majority of the literature on labral reconstruction[13], which align with the findings of the present study. Furthermore, the failure rate reported by White et al. differs even from the previously reported outcomes from that same center, which included a 13% revision rate and a 10% rate of conversion to arthroplasty at the 2-year follow-up[36]. Second, the failure rate of 31% in the labral repair group is also much higher than that reported for primary labral repair in other studies, which found rates of approximately 2% to 5%[9,37]. Advocating for excising the labrum and replacing it with cadaveric tissue is somewhat radical, and the limited published evidence from a small minority of centers should not result in a paradigm shift in clinical practice.

Labral reconstruction remains a useful procedure in the rare circumstances for which it was originally described—namely, in cases of an absent or calcified labrum. Outside of such circumstances, most high-volume hip arthroscopists perform labral reconstruction predominantly in the revision setting[38]. Utilized in this manner, labral reconstruction can be safe, improve PROs, and have good survivorship in the midterm[35,39,40]. However, biomechanical studies have demonstrated that labral reconstruction does not restore the fluid seal as effectively as labral repair and that, at time zero, it has the ability to restore only 66% of the distractive stability of the native joint, a finding that is likely related to the complete elimination of the chondrolabral junction[22,41-43]. Furthermore, as the role of the chondrolabral junction becomes better understood[41,43], techniques such as labral augmentation for deficient labra may offer the best preservation solutions in primary and revision scenarios, with labral reconstruction remaining an option only in salvage cases[44-46].

On the basis of the data of the present study and the current preponderance of evidence in the literature, we propose the following recommendations. Labral repair in the setting of labral tears encountered during primary hip arthroscopy should remain the gold standard. In instances of a deficient labrum in either the primary or revision setting, labral augmentation with autograft or allograft tissue should be preferred as the reconstructive option, as it has the benefit of preserving as much native tissue as possible as well as the chondrolabral junction. Labral reconstruction should be reserved for the rare circumstances in which neither of the above options are feasible as a salvage procedure. Finally, more biomechanical and animal studies demonstrating the definite safety and efficacy of primary labral reconstruction are needed before this procedure is widely applied, especially in adolescent patients.

Limitations

This investigation has several limitations. First and most importantly, the labral treatment was not chosen via random allocation, and the observed degree of labral pathology present in each case influenced the surgeon's decision-making. Despite this, we believe that our carefully considered inclusion criteria and robust 3-step modeling approach provides justification for our strong conclusions regarding the average treatment effect of labral reconstruction relative to labral repair. Second, this cohort of patients was treated by a single surgeon over the course of 13 years, giving rise to some degree of evolution across both the patient population and treatment approach and resulting in heterogeneous follow-up lengths among patients. Third, 5 PRO scores were modeled in parallel to assess multiple dimensions of patient-centered health. A strict Bonferroni correction to control the familywise error rate to 0.05 would require testing at a per-model significance level of 0.01. Model results with a p value between 0.01 and 0.05 should thus be interpreted with caution. Fourth, we found acceptable, but not excellent, distributional overlap in the propensity scores between the groups, which partially limited the covariate balance that was achieved. Lastly, the follow-up rate for the labral repair control group was 72.5%. The Appendix includes an analysis of the resulting risk of bias in which patients with complete outcomes and those who were lost to follow-up were compared with respect to baseline covariates.

Conclusions

Primary labral repair resulted in better postoperative HOS-ADL and WOMAC values and decreased conversion to THA when compared with primary labral reconstruction. These findings were demonstrated in both the unadjusted group comparisons and the multivariable modeling. The data herein support the use of labral repair in the primary setting of labral tears and suggest that labral reconstruction should be reserved for more advanced labral pathology or for revision cases.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/I167). ■

Grant J. Dornan, MS[1]
Joseph J. Ruzbarsky, MD[1,2]
Spencer M. Comfort, MD[3]
Justin J. Ernat, MD[4]
Maitland D. Martin, AT, MSc[5]
Karen K. Briggs, MPH[1]
Marc J. Philippon, MD[1,2]

[1]Steadman Philippon Research Institute, Vail, Colorado

[2]The Steadman Clinic, Vail, Colorado

[3]Department of Orthopedic Surgery, University of Minnesota, Minneapolis, Minnesota

[4]Department of Orthopaedic Surgery, University of Utah, Salt Lake City, Utah

[5]Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Calgary, Alberta, Canada

Email for corresponding author: drphilippon@sprivail.org

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