Original Article

Incidence of Osteoarthritis Diagnosis Within 5 Years of Surgery Was Greater Following Partial Meniscectomy Than Meniscus Repair and/or Anterior Cruciate Ligament Reconstruction

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Purpose: To compare knee osteoarthritis (OA) incidence within 5 years of surgery between 5 common sports medicine procedures: isolated anterior cruciate ligament (ACL) reconstruction, isolated meniscus repair (MR), isolated arthroscopic partial meniscectomy (APM), ACL reconstruction with MR (ACL + MR), and ACL reconstruction with APM (ACL + APM). **Methods:** The PearlDiver Mariner M157Ortho database was searched. Five cohorts were identified using *Current Procedural Terminology* (*CPT*) codes and included those 16 to 60 years old who underwent isolated ACL reconstruction, isolated MR, ACL + MR, isolated APM, or ACL + APM repair. Groups were matched by age, sex, and presence of diagnosis codes for obesity. The incidence of knee OA diagnosis within 5 years of the index procedure was determined for each group, and odds ratios (ORs) were calculated and compared against isolated ACL reconstruction. **Results:** Each group consisted of 7,672 patients (3,450 females, 4,222 males). A significantly greater proportion of the APM group was diagnosed with knee OA within 5 years of surgery compared to isolated ACL reconstruction (APM = 1,032/7,672 [13.5%] vs ACL = 745/7,672 [9.7%]; $P \leq .001$; OR, 1.45; 95% confidence interval [CI], 1.31-1.60). Similarly, a greater proportion of the MR group was diagnosed with OA compared to isolated ACL reconstruction (MR = 826/7,672 [10.7%]; $P = .030$; OR, 1.12; 95% CI, 1.01-1.25). No differences in OA incidence were noted between the ACL + APM group when compared to isolated ACL reconstruction ($P = .81$). Patients undergoing ACL + MR demonstrated the lowest OA incidence with reduced odds when compared to isolated ACL reconstruction (ACL + MR = 575/7,672 [7.5%]; $P < .001$; OR, 0.75; 95% CI, 0.67-0.84). **Conclusions:** In this analysis using *CPT* codes, APM was associated with the highest knee OA incidence, and ACL + MR was associated with the lowest OA incidence within 5 years of surgery. **Level of Evidence:** Level III, retrospective cohort study.

It is well documented that traumatic knee injuries, including anterior cruciate ligament (ACL) and meniscus injuries, are a substantial risk factor for the development of post-traumatic osteoarthritis (PTOA).[1-4] The pathophysiology of PTOA development and progression is likely multifactorial and may include the effects of mechanical and neuromuscular alterations, a prolonged intra-articular inflammatory response, and concomitant cartilage damage at the time of injury.[3,5] Traumatic knee injuries often occur in young, active patients, and thus, the onset of PTOA is often earlier than idiopathic osteoarthritis (OA).[6] Because PTOA often affects patients earlier in life and can lead to substantial disability, it is important to identify the risk factors for its development.

ACL and meniscus injuries alone or in combination and the surgical techniques employed to treat them may alter the risk of PTOA. Studies have shown that the risk of PTOA development following ACL reconstruction is higher in patients with concomitant meniscus and/or chondral injuries versus ACL injuries alone.[3,7] Furthermore, 1 study examining risk factors of PTOA development following ACL reconstruction found that patients who underwent concomitant meniscal repair

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or partial meniscectomy versus isolated ACL reconstruction had significantly higher grades of radiographic OA at 2 to 3 years following surgery.[6,8] Some recent studies have shown that partial meniscectomy, whether performed at the time of ACL reconstruction or alone, may be a significant risk factor for PTOA development.[9,10] Taken together, these results highlight that combined ACL and meniscal injuries, as well as partial meniscectomy as a treatment for these injuries, may be substantial risk factors for the development of PTOA. However, these risk factors are still not fully understood, and it is unknown whether ACL or meniscus injuries are the more important factor in early PTOA diagnosis. The purpose of this study was to compare knee OA incidence within 5 years of surgery between 5 common sports medicine procedures: isolated ACL reconstruction, isolated meniscus repair (MR), isolated arthroscopic partial meniscectomy (APM), ACL reconstruction with MR (ACL + MR), and ACL reconstruction with APM (ACL + APM). We hypothesized that APM and ACL + APM would have increased OA incidence relative to isolated ACL reconstruction.

Methods

The PearlDiver Mariner M157Ortho database, which contains insurance claims information on more than 157 million orthopaedic patients, was used in this retrospective cohort study. *Current Procedural Terminology* (*CPT*) codes were used to identify 5 patient cohorts: those with an isolated ACL reconstruction (*CPT* 29888), isolated MR (*CPT* 29882), ACL + MR (*CPT* 29888 and 29882), isolated APM (*CPT* 29880), or ACL + APM (*CPT* 29888 and 29880). Patients were excluded if they were outside of the ages of 16 to 60 years, underwent multiligament knee reconstruction, had a concomitant articular cartilage procedure, or had an OA diagnosis prior to their index procedure. All patients were required to have insurance coverage for a minimum of 6 months prior to and 5 years after the index procedure. Subsequent diagnosis of knee OA at any point within 5 years of the index surgical procedure was assessed. Patients with surgery dates between January 1, 2010, and October 31, 2016, were included.

Primary Outcome

The following codes were used to identify knee OA diagnosis: ICD-9-D-715.16 (osteoarthritis localized primary involving lower leg), ICD-9-D-715.26 (osteoarthritis localized secondary involving lower leg), ICD-9-D-715.36 (osteoarthritis localized, not specified whether primary or secondary involving lower leg), ICD-9-D-715.96 (osteoarthritis unspecified whether generalized or localized involving lower leg), and ICD-10-D-M17.

Statistical Analyses

Groups were matched by patient age, sex, and the presence of diagnosis codes for obesity (ICD-9 278.0 [obesity], ICD-10 E66.0 [obesity due to excess calories]). OA incidence for each surgical cohort was determined and odds ratios (ORs) were calculated in comparison to isolated ACL reconstruction. Kaplan-Meier survivorship curves were created to assess subsequent OA diagnosis in each patient cohort.

Results

Each of the 5 cohorts consisted of 7,672 patients (3,450 females and 4,222 males). These cohorts were matched by patient age, sex, and presence of diagnosis *CPT* codes for obesity and morbid obesity (Table 1). A significantly greater proportion of the APM group was diagnosed with knee OA within 5 years of surgery when compared to isolated ACL reconstruction (APM = 1,032/7,672 [13.5%] vs ACL = 745/7,672 [9.7%]; $P \leq .001$; OR, 1.45; 95% confidence interval [CI], 1.31-1.60). Similarly, a greater proportion of the MR group was diagnosed with OA when compared to isolated ACL reconstruction (MR = 826/7,672 [10.7%] vs ACL = 745/7,672 [9.7%]; $P = .030$; OR, 1.12; 95% CI, 1.01-1.25). No differences in OA incidence were noted between the ACL + APM group when compared to isolated ACL reconstruction ($P = .81$). Patients undergoing ACL + MR demonstrated the lowest OA incidence with reduced odds when compared to isolated ACL reconstruction (ACL + MR = 575/7,672 [7.5%]; $P < .001$; OR, 0.75; 95% CI, 0.67-0.84) (Fig 1).

Discussion

The most important finding of this study was that APM was associated with the highest incidence of OA within 5 years of surgery (13.5%). Surprisingly, the lowest OA incidence was observed in patients undergoing ACL reconstruction with concomitant MR (7.5%). These "big data" results confirm previous reports from prospective ACL cohorts and further support efforts to repair the meniscus whenever possible. These results partially support our hypothesis.

In the current study, a significantly greater proportion of patients who underwent APM were diagnosed with OA within 5 years of surgery compared to patients who underwent isolated ACL reconstruction. These results support the findings of previous studies that report the detrimental effects of APM on OA risk.[1-6] A recent review of previous studies demonstrated that patients had better Lysholm scores (OR, 2.20), lower rates of progression to knee OA (22.2% vs 48.3%), and lower odds of reoperation (OR, 0.05) when opting for MR as a treatment for medial meniscus root tears as opposed to APM.[5] Similarly, in patients with lateral meniscus tears, Duethman et al.[11] reported that meniscus repair was associated with decreased arthritis symptoms and

Table 1. Patient Demographics and Osteoarthritis Incidence for the 5 Surgical Cohorts

Cohort	N	Age, Mean ± SD, y	Female Sex, n (%)	Obese, n (%)	OA Incidence, n (%)	*P* Value*
ACL	7,672	28.5 ± 11.3	3,450 (45.0)	1,725 (22.5)	745 (9.7)	—
APM	7,672	28.6 ± 11.4	3,450 (45.0)	1,725 (22.5)	1,032 (13.5)	<.001
MR	7,672	28.5 ± 11.3	3,450 (45.0)	1,725 (22.5)	826 (10.7)	.030
ACL + APM	7,672	28.5 ± 11.3	3,450 (45.0)	1,725 (22.5)	736 (9.6)	.810
ACL + MR	7,672	28.5 ± 11.3	3,450 (45.0)	1,725 (22.5)	575 (7.5)	<.001

ACL, anterior cruciate ligament; APM, arthroscopic partial meniscectomy; MR, meniscus repair; OA, osteoarthritis.
**P* values represent the comparison in OA incidence between the isolated ACL group and the other groups.

greater improvement in International Knee Documentation Committee scores when compared to meniscectomy.

It has also been shown that patients with specific characteristics may be exposed to higher risk of knee OA following APM. Lamplot et al.[10] found that females were more likely than males to have clinical OA within 6 years following APM (73% vs 21%, $P = .009$). The presence of a horizontal tear in a discoid lateral meniscus injury has also been reported to be one of the strongest predictors of knee OA within 5 years following APM.[12] The decision to undergo APM should be made with careful consideration of these and other associated risk factors when patients discuss treatment options with their physician. Arthroscopy as treatment for meniscal tears has also been shown to increase the likelihood for total knee arthroplasty in the future and should therefore be yet another factor to be considered by the patient.[13]

An interesting finding from our study showed only 7.5% of patients undergoing ACL + MR were diagnosed with OA, which was significantly lower than the OA incidence of the matched group of patients who underwent isolated ACL reconstruction. This is a notable finding and one that should be explored more in the future. There has been some level of analysis and review of the positive outcomes of ACL + MR,[14-16] but follow-up time was not extensive and long-term findings are unclear. One review by Petersen et al.[17] examining case series with follow-up of more than 7 years found that MR combined with ACL reconstruction resulted in lower rerupture rates and contributed to positive effects on the results of ACL reconstruction. The review also noted lower rates of OA in these patients, which supports our findings.

Some studies have demonstrated findings that differ from those in this study. In particular, 1 meta-analysis[18] and another systematic review[14] reported a higher incidence of OA after ACL reconstruction with APM when compared to isolated ACL reconstruction. This stands in opposition to our findings, which showed ACL reconstruction + APM incidence (9.6%) to be similar to the OA incidence after isolated ACL reconstruction (9.7%, $P = .81$). First, the clinical studies included in the meta-analysis and systematic review have the advantage of combining both clinical and radiographic data when determining the incidence of OA. However, the current study has neither clinical nor radiographic data but instead was limited to only diagnosis codes. These methodological differences may contribute to the differences between studies. Second, while the current results did not identify a difference in OA incidence

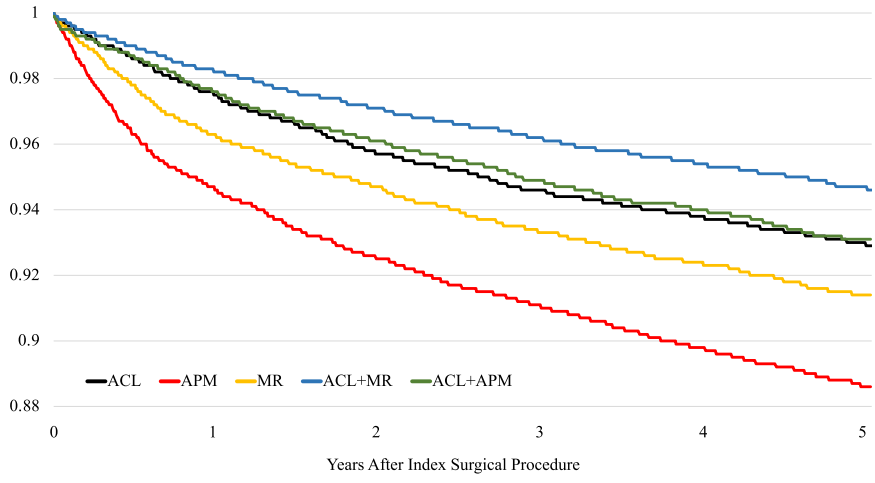

Fig 1. Kaplan-Meier survivorship curves showing the progression to subsequent osteoarthritis diagnosis after anterior cruciate ligament (ACL), arthroscopic partial meniscectomy (APM), meniscus repair (MR), ACL + MR, or ACL + APM.

between ACL and ACL + APM groups, the results do not suggest that ACL + APM is somehow protective against OA compared to ACL alone.

Both postoperative biomechanical and biologic differences may be involved with the lower rates of knee OA following combined ACL + MR. Capin et al.[19] demonstrated that patients undergoing ACL + APM showed meaningfully smaller peak knee flexion angle when compared to groups with either no medial meniscus involvement or with medial meniscus repair. Similar results were reported in another study that exhibited clear differences in the gait mechanics and tibiofemoral joint loading patterns of ACL + APM patients when compared to ACL + MR patients.[20] Additionally, the biologic environment for healing may be better for meniscus tears that are repaired in conjunction with ACL reconstruction. Healing rates for meniscus tears repaired concurrently with ACL reconstruction are greater than those repaired in isolation.[21-24] It has been theorized that improved healing may be due to the release of bone marrow elements into the joint space when drilling bone tunnels and/or microfracture of the femoral notch during ACL reconstruction.[25] More intensive long-term studies are highly indicated by these conclusions in order to explore the potential protective effect of combined ACL + MR.

Limitations

This study is not without limitations. Like all insurance claims database studies, the results can be impacted by coding variability. ICD-9 codes do not indicate laterality (right vs left), so we cannot definitively determine if the subsequent OA diagnosis is associated with the operative or contralateral knee but believe in the short time frame of this study that the diagnosis is more likely to be associated with the operative knee. Second, we are limited by only being able to use diagnosis codes to identify the prevalence of OA. Radiographic data are not available, and with countless providers involved with the more than 30,000 patients in this study, there is undoubtedly variability in the clinical criteria used for diagnosing OA between providers.

Our inclusion criteria for surgical cohorts did not differentiate between specific subcategories of surgical procedures or disease types. For example, we did not specify whether patients received a patellar tendon graft versus hamstring graft. Nor did we specify specific classifications of meniscus tears when including patients in cohorts. Patients were grouped based on surgical procedure codes. This is important to note given that different subdifferentiating factors could play an important role in the future development of osteoarthritis, including whether the osteoarthritis was caused by traumatic injury or was degenerative in nature.

It is important to recognize that our study used ICD-9 278.0 (obesity) and ICD-10 E66.0 (obesity due to excess calories) when matching our groups. A potential limitation of this is that each degree of obesity may vary between patients and could affect the risk for osteoarthritis development. Ideally, body mass index (BMI) would have been used for matching purposes, but again, we were limited in this insurance claims database study to only include diagnoses related to obesity and not BMI itself.

Conclusions

In this analysis using *CPT* codes, APM was associated with the highest knee OA incidence, and ACL + MR was associated with the lowest OA incidence within 5 years of surgery.

Disclosure

The authors report the following potential conflicts of interest or sources of funding: D.J. reports board membership with the American Orthopedic Society for Sports Medicine, Journal of Surgical Orthopedic Advances, Orthopedics Today, SLACK Incorporated, Southern Orthopedic Association, and Sports Medicine and Arthroscopy Review and has received research support from DJ Orthopaedics and Smith & Nephew Endoscopy. M.L.I. reports receiving a consulting fee/honorarium or payment for lectures from an UpToDate publication, the James E. Ireland Foundation, and Smith & Nephew speakers bureau. D.L. reports board membership with the American Journal of Sports Medicine and received payment for lectures from Smith & Nephew. A.S. reports board membership with the American Orthopedic Society for Sports Medicine and Arthroscopy Association of North American; is a consultant for Bioventus, Smith & Nephew, and Allosource; has provided expert testimony for Terumo; and has received research support from Flexion Therapeutics and Surgical Care Affiliates. C.J. reports board membership with the Video Journal of Sports Medicine and has received research support from Flexion Therapeutics and Smith & Nephew. All other authors (M.S., B.S., C.C.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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