Original Article

Arthroscopic Procedures Are Performed in 5% of Patients With Knee Osteoarthritis 1 Year Preceding Total Knee Arthroplasty and Are Associated With Increased Stiffness and Increased Costs

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Purpose: To describe the different types of arthroscopic procedures that patients undergo in the year prior to total knee arthroplasty (TKA), reveal the cost associated with these procedures, and understand the relationship between preoperative arthroscopy and clinical outcomes after TKA. **Methods:** An observational cohort study was conducted using the IBM Watson Health MarketScan databases. Patients with knee osteoarthritis who underwent unilateral isolated primary TKA between January 1, 2018, and September 30, 2019, were included. Knee arthroscopic procedures performed in the 1-year period before a primary TKA was identified. The primary outcomes of interest were cost of these procedures and the risk of 90-day postoperative complications. **Results:** In total, 2,904 patients, representing 5.2% of the analyzed cohort, underwent arthroscopic procedures in the year prior to TKA. The most common procedure and diagnosis were meniscectomy and meniscal tear, respectively, with procedures performed an average of 7.2 ± 3.0 months before TKA. Average per patient costs were $9,716 ± $5,500 in the highest payment quartile vs $1,789 ± 636 in the lowest payment quartile. Patients with a history of arthroscopy were more likely to develop postoperative stiffness ($P = .001$), while no difference was found in the risk of 90-day periprosthetic joint infection (PJI). **Conclusions:** Of the patients, 5.2% underwent knee arthroscopy in the year prior to TKA. While no association was seen with PJI risk, the costs associated with these procedures are high and may increase the overall cost of management of knee osteoarthritis. **Level of Evidence:** Level III, retrospective comparative study.

Knee osteoarthritis (OA) is a painful and debilitating condition that is estimated to affect up to 14 million individuals in the United States.[1] When conservative nonoperative management (e.g., medication, physical therapy, intra-articular injections) does not alleviate symptoms, arthroscopic knee procedures may be performed.[2] However, in most patients with late-stage knee OA, the relief provided by arthroscopic procedures is temporary and only serves to delay undergoing total knee arthroplasty (TKA).[3]

The use of arthroscopic procedures in the overall management of knee OA remains varied. Since the landmark study of Moseley and colleagues in 2002,[4] evidence against the use of arthroscopic procedures such as debridement and lavage has shaped clinical recommendations and national insurance mandates.[5,6] For patients who eventually undergo TKA, previous studies have found that a prior arthroscopic procedure may result in inferior outcomes and higher revision rates.[7-10] In addition, it may lead to higher rates of complications, including periprosthetic joint infections,[11] arthrofibrosis, and venous thromboembolism.[12] However, it should be noted that these studies involve interventions that are more complex than

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The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received August 23, 2022; accepted June 15, 2023.

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2666-061X/22866

https://doi.org/10.1016/j.asmr.2023.100776

simple arthroscopy. In addition, the cost-effectiveness of arthroscopic procedures in treating symptomatic knee OA has also been found to be low when compared to other nonoperative treatments.[13] Despite evidence against its use, the utilization of arthroscopic procedures to treat symptomatic knee OA has not decreased,[14] and this suggests that a gap between published literature and clinical practice exists.[15,16] Furthermore, there remains a paucity of studies describing the utilization of different types of arthroscopic procedures prior to TKA and their associated diagnoses and costs.

As the US health care systems transition to a value-based model, it is important that patients begin to receive care for their symptomatic knee OA that is more cost-effective than current management strategies. Considering the clinical impact and costs associated with these arthroscopic procedures, it is important to examine the utilization of these treatments during the preoperative period. Therefore, the purposes of this study were to describe the different types of arthroscopic procedures that patients undergo in the year prior to TKA, show the cost associated with these procedures, and understand the relationship between preoperative arthroscopy and clinical outcomes after TKA. It is hypothesized that patients undergo a variety of preoperative arthroscopic procedures with substantial cost, and the performance of these procedures before TKA may lead to poorer clinical outcomes.

Methods

Data Source

An observational cohort study was conducted using the IBM Watson Health MarketScan Commercial Claims and Encounters and MarketScan Medicare Supplemental and Coordination of Benefits databases (IBM Corporation). The data set allows tracking of patients across different providers and hospitals. The Commercial Claims and Encounters database comprises medical and drug data from employers and health plans for over 203 million individuals annually, encompassing employees, their spouses, and dependents who are covered by employer-sponsored private health insurance in the United States.[17] The Medicare Supplemental and Coordination of Benefits database consists of the Medicare-covered portion of payment (represented as Coordination of Benefits Amount or COB), the employer-paid portion, and out-of-pocket patient expenses.[17]

Inclusion and Exclusion Criteria

The study population included patients with knee OA who underwent unilateral isolated primary TKA between January 1, 2018, and September 30, 2019. *Current Procedural Terminology* (*CPT*) and *International Classification of Diseases, 10th Revision* (*ICD-10*) codes were used to identify procedures and diagnoses respectively. TKA was identified using *CPT* code 27447, and knee OA was defined by *ICD-10* codes M17.10 to 12. Patients who required arthroscopic procedures for septic arthritis or had switched insurance providers in the 1-year period prior to TKA were excluded from the study. Septic arthritis and arthroscopic procedures were defined by associated *ICD-10* codes (Supplemental Table 1) and *CPT* codes (Supplemental Table 2).

Primary Independent Variable

We subsequently identified the primary independent variable as any event of arthroscopic procedures in the 1-year period before a primary TKA. Patients who underwent TKA but did not have an arthroscopic procedure in the year prior to surgery served as a control group.

Primary and Secondary Outcomes

The primary outcome measure was the cost of arthroscopic procedures in the 1-year period prior to TKA. The total cost of care was based on the grossed covered payment (PAY) in the database, which includes deductibles, coinsurance, and net insurance payments. All dollar values were inflation-adjusted to July 1, 2020, dollars.[18] The secondary outcomes were the risk of common complications, including knee periprosthetic joint infection (PJI), stiffness, and deep vein thrombosis within 90 days of discharge from primary TKA between patients with and without arthroscopic procedures. Complications were defined by *ICD-10* codes (knee periprosthetic joint infection: T84.53 and T84.54; stiffness: M25.66 and M24.66; deep vein thrombosis: I82.4).

Covariates and Statistical Analysis

Descriptive analyses were performed to compare the aggregate costs of all arthroscopic procedures that took place up to 1 year before primary TKA, among patients who had pre-TKA arthroscopic procedures. Patients were divided into quartiles based on total payments. Differences between categorical exposure and continuous outcome measures were compared using 2-tailed *t* tests and 1-way analysis of variance. Bonferroni-corrected post hoc tests were performed accordingly.

Multivariate logistic regression was performed to compare the risk of 90-day knee PJI, arthrofibrosis, and deep vein thrombosis between patients with and without prior arthroscopic procedures, adjusting for patient age, sex, hospital type, region, and comorbidities. Comorbidities included hypertension, type 2 diabetes, chronic kidney disease, chronic obstructive respiratory disease, cardiovascular disease, and obesity. All statistical analyses were performed using STATA (Version 17.0; StataCorp), and a *P* value of less than .05

Table 1. Characteristics of Patients With and Without Arthroscopic Surgery 1 Year Before TKA

Characteristic	History of Arthroscopic Surgery 1 Year Before TKA		
	No	Yes	*P* Value
N	52,527 (94.8)	2,904 (5.2)	—
Age, y	60.4 ± 8.3	56.9 ± 7.5	<.001
Sex			
Female	30,886 (58.8)	1138 (39.2)	.034
Male	21,641 (41.2)	1766 (60.8)	
Region			
Northeast	8,299 (15.8)	333 (11.5)	<.001
Midwest	15,548 (29.6)	840 (29.0)	
South	21,851 (41.6)	1352 (46.6)	
West	6,829 (13.0)	376 (13.0)	
Comorbidities			
Hypertension	33,407 (63.6)	1775 (61.1)	.007
Type 2 diabetes	11,293 (21.5)	527 (18.1)	<.001
COPD	1,943 (3.7)	112 (3.9)	.632
Chronic kidney disease	2,416 (4.6)	103 (3.5)	.006
Cardiovascular disease	5,462 (10.4)	272 (9.4)	.081
Obesity	16,966 (32.3)	1023 (35.2)	.001

NOTE. Values are presented as number (%) or mean ± SD.
COPD, chronic obstructive pulmonary disease; TKA, total knee arthroplasty.

was considered statistically significant. The project was approved by the New England Baptist Hospital Institutional Review Board (1796186).

Results

A total of 55,431 patients who underwent TKA for knee OA were identified for inclusion (Table 1). Of these, 2,904 (5.2%) underwent arthroscopic procedures in the year prior to primary TKA. The mean ± standard deviation age of the cohort was 57.3 ± 7.5 years and had a majority of female patients (1,766 females, 60.8%). The most common arthroscopic procedure patients underwent was meniscectomy while the meniscal repair was least performed (Fig 1). The average interval between arthroscopic knee procedures to the primary TKA was 7.2 ± 3.0 months. The most common diagnosis of patients undergoing arthroscopic surgery was a tear of the meniscus followed by derangement of the meniscus (Fig 2). Figure 3 shows the percentage of patients who underwent arthroscopic procedures over the number of months preceding TKA.

The average total cost of arthroscopic procedures per patient was $4,808 ± $4,091, for a total of approximately $14 million in this national sample. There was a wide range of distribution in total costs, with $9,716 ± $5,500 in the highest payment quartile (Q4) vs $1,789 ± $636 in the lowest payment quartile (Q1) (Table 2). Costs of arthroscopic procedures were similar between female ($4,752) and male ($4,897) patients. The highest per-patient costs were found in patients from the Northeast while patients from the South had the lowest costs ($6,504 ± $7,056 vs $4,431 ± $3,457, $P < .01$) (Fig 4). Almost all arthroscopic procedures (99.3%) were performed in an outpatient setting. Costs were higher in a hospital outpatient department ($4,151 ± $3,516) compared to an ambulatory surgery center ($5,242 ± $4,369; $P = .02$).

On adjusted analysis, patients with a history of knee arthroscopic procedures were more likely to develop complications, specifically stiffness, within 90 days of TKA (Tables 3 and 4).

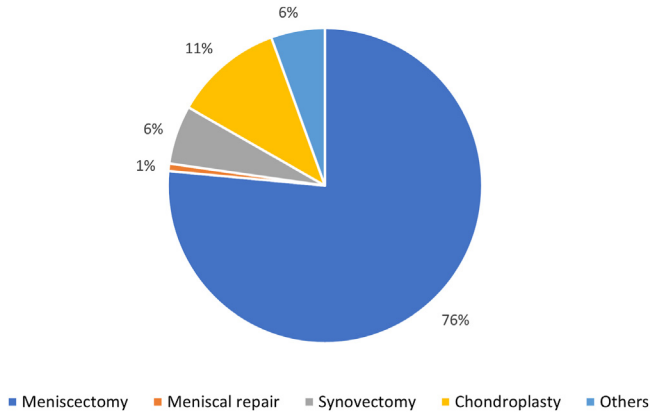

Fig. 1. Types of knee arthroscopic procedures in the year prior to total knee arthroplasty.

Discussion

This study demonstrates that arthroscopy continues to be a frequent treatment for knee OA in the acute period prior to primary TKA and is associated with substantial costs and postoperative complications such as stiffness following surgery. The percentage of patients who underwent arthroscopic procedures in our study (5.2%) is slightly higher than the number (4.7%) reported in a similar study in an earlier time period (2006 to 2017).[10]

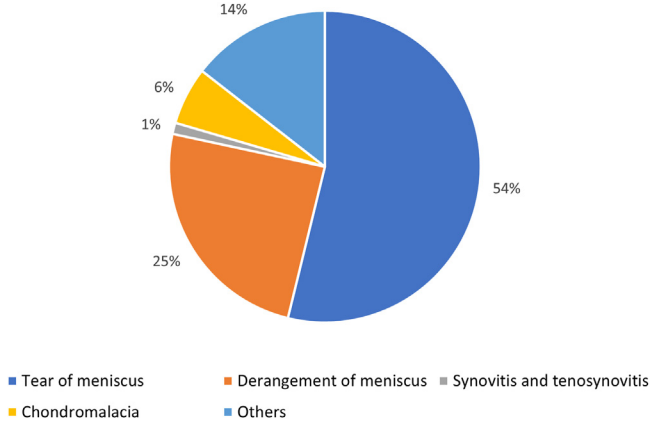

Fig. 2. Primary diagnosis for knee arthroscopic procedures in the year prior to total knee arthroplasty.

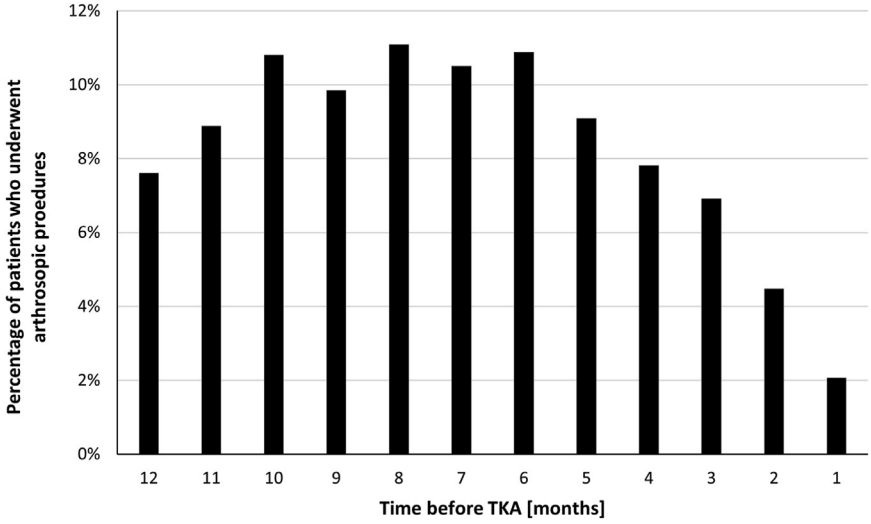

Fig. 3. Breakdown of percentage of patients who underwent arthroscopic procedures over proximity to total knee arthroplasty.

This suggests that the utilization of knee arthroscopic surgery in the 12-month period prior to TKA has not decreased despite evidence against its use in the overall management of knee OA.[4,19-21]

Compared to the estimated lifetime medical costs of knee OA care of $16,000 per patient,[22] the costs associated with arthroscopic procedures found in this study are substantial. For patients in this study, the short duration between knee arthroscopy and TKA may suggest that arthroscopy prior to TKA does not represent value-based health care (VBHC). Although our study did not show this, other studies have identified increased rates of revision and rerevision following surgery,[10,23] further reducing VBHC. Meniscectomy and chondroplasty, the 2 most common arthroscopic procedures found in this study, were previously found to be associated with post-TKA all-cause revision rates of 2.5% and 4.1%, respectively.[10] With growing evidence of poorer prognosis for patients with late-stage knee OA after arthroscopic surgery, it is important to carefully consider the decision to perform knee arthroscopy in these patients.

While arthroscopic procedures may provide temporary symptomatic relief, this symptomatic relief is short-lived and does not persist beyond a year. Several studies have found the temporary relief from knee arthroscopy to be similar to many nonoperative treatments.[20,24] With the results of the landmark studies from the early 2000s,[4,21] followed by the Centers for Medicare & Medicaid Services noncoverage determinations in 2004,[5] certain arthroscopic procedures such as debridement and lavage have seen a decrease in

Table 2. Patients Who Received Arthroscopic Procedures Prior to TKA, by Quartiles of Total Costs of Care

Characteristic	First Quartile	Second Quartile	Third Quartile	Fourth Quartile
Number of patients	726	726	726	726
Mean payment per patient, $	1,789 ± 636	3,187 ± 299	4,543 ± 579	9,716 ± 5,500
Age, y	58.5 ± 8.3	57.6 ± 7.5	56.2 ± 6.3	57.0 ± 7.4
Sex, %				
Female	60.7	61.0	61.4	60.1
Male	39.3	39.0	38.6	39.9
Region, %				
Northeast	9.7	7.4	11.9	16.8
Midwest	23.2	32.6	28.8	30.9
South	54.8	48.8	43.2	39.7
West	12.3	11.2	16.1	12.7
Hospital type, %				
Inpatient	0.8	0.7	0.6	0.6
ASC	47.6	44.8	32.2	24.6
HOPD	51.5	54.5	67.3	74.9
Total payment within quartile, $	1,299,114	2,313,652	3,298,374	7,053,694
Duration between arthroscopy and TKA, mo	7.1 ± 3.0	7.2 ± 3.0	7.2 ± 3.0	7.3 ± 3.0

ASC, ambulatory surgery center; HOPD, hospital outpatient department; TKA, total knee arthroplasty.

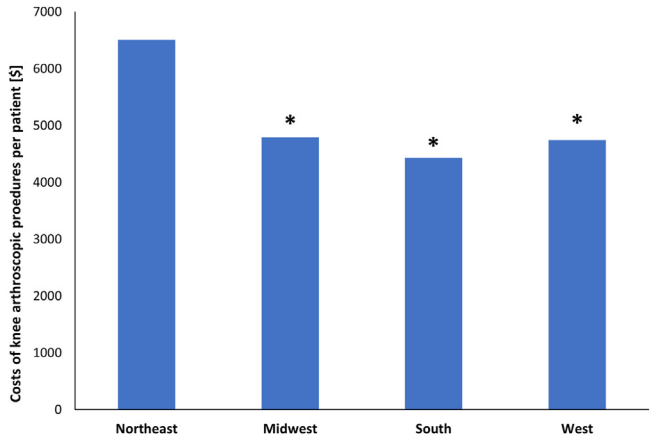

Fig. 4. The average cost of arthroscopic procedures across regions. *Significantly different from Northeast.

utilization.[14,25] However, these decreases have been offset by a corresponding increase in rates of other arthroscopic procedures.[25] Therefore, it is unclear if an actual translation of knowledge into clinical practice has taken place or if surgeons are using different codes, such as those for meniscectomy,[19] to treat the same pathology in the arthritic knee.

Prior studies have attempted to characterize the relationship between the timing of knee arthroscopy and post-TKA outcomes. These studies have found that knee arthroscopy performed in the 6-month period before TKA was found to be associated with worse knee functional outcome scores.[26] In addition to reduced function, Werner and colleagues[27] found that patients who underwent TKA within 6 months after knee arthroscopy were more likely to be diagnosed with postsurgery complications such as infection, stiffness, and venous thromboembolism. In our study, the average interval between knee arthroscopy and TKA procedures was 7 months, and patients had an increased likelihood of developing stiffness when compared to nonarthroscopic patients. A recent study found a time-dependent relationship between the timing of knee arthroscopy and complications following TKA, and it suggested that an interval of at least 9 months needs to be maintained between both surgeries to minimize risks and the need for revision.[10] Although we did not find any increased risk of infection or deep vein thrombosis, patients with a history of arthroscopy were more likely to develop postoperative stiffness. It has been previously reported that the postoperative management costs associated with knee stiffness may be up to 7.5 times that of patients with no knee stiffness.[28] Therefore, the costs to both the individual and health care system are high when the patient develops debilitating complications or experiences poor outcomes that necessitate additional procedures. Therefore, the authors believe that it is important to be conservative when determining the timing of TKA for a patient with a history of knee arthroscopy.

Table 3. Adjusted Likelihood of 90-Day Complication (Infection, Stiffness, and Deep Vein Thrombosis), Adjusted for Patient Comorbidities

	Likelihood of 90-Day Complication	
Characteristic	OR (95% CI)	*P* Value
History of arthroscopic procedure		
No	1 [Reference]	NA
Yes	1.12 (1.02-1.24)	.015
Age		
Below 60 years	1 [Reference]	NA
60 years and above	0.87 (0.83-0.90)	<.001
Sex		
Male	1 [Reference]	NA
Female	0.94 (0.90-0.99)	<.001
Comorbidities (vs absent)		
Hypertension	0.94 (0.89-0.99)	.015
Type 2 diabetes	1.02 (0.97-1.07)	.424
Chronic kidney disease	1.07 (0.98-1.16)	.115
Chronic obstructive pulmonary disease	0.95 (0.86-1.04)	.227
Cardiovascular disease	0.99 (0.93-1.06)	.813
Obesity	1.05 (1.00-1.10)	.030
Region		
Northeast	1 [Reference]	NA
Midwest	1.59 (1.48-1.71)	<.001
South	1.64 (1.53-1.76)	<.001
West	1.54 (1.42-1.68)	<.001
Hospital type		
Inpatient	1 [Reference]	NA
HOPD	1.02 (0.98-1.07)	.342
ASC	1.02 (0.93-1.12)	.673

NOTE. Multivariate logistic regression was performed to compare the risk of 90-day complication between patients with and without prior arthroscopic procedures, adjusting for patient age, sex, comorbidities, region, and hospital type. Comorbidities included hypertension, type 2 diabetes, chronic kidney disease, chronic obstructive pulmonary disease, cardiovascular disease, and obesity.

ASC, ambulatory surgery center; CI, confidence interval; HOPD, hospital outpatient department; NA, not applied; OR, odds ratio.

The strength of this study lies in the utilization of a large national database that includes information from different hospitals and providers. The large study sample synthesizes interregional differences in trends and helps to assimilate the results of prior single-institution studies.

Limitations

This study is not without limitations. We acknowledge that the study group is heterogenous, and this should be kept in mind when interpreting the results. Another limitation is our reliance on administrative databases for accurate documentation and coding. It is possible that some confounding diagnoses and relevant procedures have been overlooked. However, this has been minimized by using codes that were identified based on a review of existing literature and treatment

Table 4. Likelihood of Developing Infection, Stiffness, or Deep Vein Thrombosis Within 90 Days of Total Knee Arthroplasty for Patients Who Underwent Knee Arthroscopic Procedures 1 Year Prior to Surgery

	Likelihood of Complication			
	Unadjusted		Adjusted	
Characteristic	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Infection	1.10 (0.70-1.73)	.679	1.08 (0.69-1.70)	.739
Stiffness	1.17 (1.07-1.29)	.001	1.12 (1.02-1.23)	.022
Deep vein thrombosis	1.20 (0.91-1.58)	.201	1.24 (0.94-1.64)	.120

CI, confidence interval; OR, odds ratio.

guidelines from governing bodies.[6] In the present study, laterality codes could not be confidently used to attribute all procedures identified to the ipsilateral knee undergoing TKA. However, due to the proximity of the arthroscopic procedure being performed close in time to surgery, it is likely that for most patients, the procedure performed was for the ipsilateral knee. Additionally, due to the nature of the database, measures such as quality of life and patient-reported outcomes following surgery could not be captured. Lastly, although the *ICD-10* code for knee OA does not account for severity, it was likely that most patients were at the latter stages of the disease as they underwent TKA within a year.

Conclusions

In total, 5.2% of patients underwent knee arthroscopy in the year prior to TKA despite literature support and clinical recommendations against its use. While no association was seen with PJI risk, the costs associated with these procedures are high and may increase the overall cost of management of knee OA.

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Appendix

Supplemental Table 1. *IDC-10* Codes of Excluded Diagnoses That May Require Knee Arthroscopic Procedures

Diagnosis		Associated *ICD-10* Codes
Septic arthritis	Staphylococcal arthritis	M00.061, M00.062, M00.069
	Pneumococcal arthritis	M00.161, M00.162, M00.169
	Other streptococcal arthritis	M00.261, M00.262, M00.269
	Arthritis due to other bacteria	M00.861, M00.862, M00.869
	Direct infection of knee in infectious and parasitic diseases classified elsewhere	M01.X61, M01.X62, M01.X69
	Other reactive arthropathies	M02.861, M02.862, M02.869

Supplemental Table 2. *CPT* Codes of Identified Knee Arthroscopic Procedures

29866	Arthroscopy, knee, surgical; osteochondral autograft(s) (e.g., mosaicplasty (includes harvesting of the autograft)
29867	Arthroscopy, knee, surgical; osteochondral allograft (e.g., mosaicplasty)
29868	Arthroscopy, knee, surgical; meniscal transplantation (includes arthrotomy for meniscal insertion), medial or lateral
29870	Arthroscopy, knee, diagnostic, with or without synovial biopsy (separate procedures)
29871	Arthroscopy, knee, surgical; for infection, lavage and drainage
29873	Arthroscopy, knee, surgical; with lateral release
29874	Arthroscopy, knee, surgical; for removal of loose body or foreign body (e.g., osteochondritis dissecans fragmentation, chondral fragmentation)
29875	Arthroscopy, knee, surgical; synovectomy, limited (e.g., plica or shelf resection) (separate procedure)
29876	Arthroscopy, knee, surgical; synovectomy, major, two or more compartments (e.g., medial or lateral)
29877	Arthroscopy, knee, surgical; debridement/shaving of articular cartilage (chondroplasty)
29879	Arthroscopy, knee, surgical; abrasion arthroplasty (includes chondroplasty where necessary) or multiple drilling or microfracture
29880	Arthroscopy, knee, surgical; with meniscectomy (medial AND lateral, including any meniscal shaving)
29881	Arthroscopy, knee, surgical; with meniscectomy (medial OR lateral, including any meniscal shaving)
29882	Arthroscopy, knee, surgical; with meniscus repair (medial OR lateral)
29883	Arthroscopy, knee, surgical; with meniscus repair (medial AND lateral)
29884	Arthroscopy, knee, surgical; with lysis of adhesions, with or without manipulation (separate procedure)
29885	Arthroscopy, knee, surgical; drilling for osteochondritis dissecans with bone grafting, with or without internal fixation (including debridement of base of lesion)
29886	Arthroscopy, knee, surgical; drilling for intact osteochondritis dissecans lesion
29887	Arthroscopy, knee, surgical; drilling for intact osteochondritis dissecans lesion with internal fixation
G0289	Arthroscopy, knee, surgical, for removal of loose body, foreign body, debridement/shaving of articular cartilage (chondroplasty) at the time of other surgical knee arthroscopy in a different compartment of the same knee.