Knee arthroscopy to address meniscus tears is among the most common orthopedic procedures performed, and technical advances in the treatment of meniscus tears have affected the treatment options available to orthopedic surgeons. The purpose of this study was to perform a large cross-sectional analysis of orthopedic patients to investigate trends in arthroscopic meniscectomy and meniscus repair in the United States. Patients who underwent arthroscopic meniscectomy (Current Procedural Terminology codes 29881 and 29880) and arthroscopic meniscus repair (Current Procedural Terminology codes 29882 and 29883) were identified using the PearlDiver Patient Record Database, which is a national database of insurance records. The authors identified 187,607 arthroscopic medial or lateral meniscectomies and repairs performed between 2004 and 2009. Ninety-six percent of patients underwent meniscectomy and 4% underwent repair. No change occurred in the incidence of medial or lateral meniscectomy. The incidence of medial meniscus repair decreased from 5.3 cases per 10,000 patients in 2004 to 3.8 in 2009 (P<.001), although no significant change occurred in the incidence of lateral meniscus repair. Medial meniscectomy was most commonly performed in patients aged 50 to 59 years, whereas lateral meniscectomy demonstrated a bimodal age distribution. Conversely, meniscus repairs were most frequently performed in patients aged 10 to 19 years. Sex differences were more pronounced with meniscus repair (63% male vs 37% female) compared with meniscectomy (53% male vs 47% female). A high frequency of meniscus debridement can be expected in arthroscopic knee surgery. Despite advances in meniscus repair techniques and devices, no increase occurred in the performance of meniscus repair compared with meniscectomy.

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Knee arthroscopy to treat meniscal injury is the most commonly performed orthopedic surgery in the United States. Although the meniscus was originally thought to be a vestigial tissue without functional consequence, biomechanical and clinical research has demonstrated the importance of the meniscus in maintaining knee stability, facilitating joint lubrication, and decreasing the load transmitted to the tibial and femoral articular cartilage. Total meniscectomy results in increased contact stresses on the articular cartilage and hastens the development of osteoarthritis. Orthopedic surgeons attempt to preserve the meniscus when addressing tears via partial meniscectomy or meniscal repair.

The outcomes of partial meniscectomy have been well documented in the orthopedic literature. Good or excellent results have been reported after partial meniscectomy in 88% of patients at 15-year follow-up. In a systematic review, Salata et al. reported that total meniscectomy, degenerative meniscal tears, lateral meniscectomy, presence of chondral damage, and genetic predisposition to osteoarthritis were predictors of poor clinical outcome. Demographic variables, such as patient sex and age, have not consistently predicted outcomes after partial meniscectomy.

Meniscal repair is preferred to partial meniscectomy in patients with meniscal tears amenable to repair. Open repair, arthroscopic outside-in, arthroscopic inside-out, and all-inside techniques have been used for meniscal repair. Inside-out repair with vertical mattress sutures is considered the gold standard technique. However, technical advances in the treatment of meniscal tears have improved the surgical options for orthopedic surgeons, with all-inside meniscal repair systems gaining popularity secondary to decreased surgical time and decreased risk to structures surrounding the knee.

Although an abundance of literature has reported on the outcomes of meniscectomy and meniscus repair and more than 600,000 knee arthroscopies are performed annually in the United States, few epidemiologic data exist on the surgical treatment of meniscus tears. The purpose of this study was to investigate the current trends in arthroscopic meniscectomy and meniscal repair over a 6-year period across age groups, sex, and regions in the United States and to test the hypothesis that meniscal repair is increasing in frequency.

### Materials and Methods

A search of the PearlDiver Patient Records Database (PearlDiver, Inc, Fort Wayne, Indiana) was performed to identify patients who underwent arthroscopic meniscectomy and meniscus repair. The PearlDiver Patient Records Database is a national database of insurance billing records that can be used to search for patients who have had at least 1 orthopedic International Classification of Diseases, Ninth Revision (ICD-9) code or Current Procedural Terminology (CPT) code. The database is formed through record collections across all age groups from multiple private payer insurance agencies, the largest contribution of which is from UnitedHealth Group, Inc (Minnetonka, Minnesota). The database contains over 216 million patient records from approximately 11 million patients between the years 2004 and 2009. Further characterization of the database population through direct contact with PearlDiver, Inc, is listed in Tables 1 through 4, including stratification by year, age, sex, and region. No patient-identifying information was available in the database; thus, a determination of nonhuman research was obtained from the authors’ institutional review board.

### Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>No. (%) of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>1,561,066 (14)</td>
</tr>
<tr>
<td>2005</td>
<td>1,787,491 (16)</td>
</tr>
<tr>
<td>2006</td>
<td>1,914,721 (17)</td>
</tr>
<tr>
<td>2007</td>
<td>1,958,644 (18)</td>
</tr>
<tr>
<td>2008</td>
<td>2,003,157 (18)</td>
</tr>
<tr>
<td>2009</td>
<td>1,927,960 (17)</td>
</tr>
<tr>
<td>Total</td>
<td>11,153,039 (100)</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Age, y</th>
<th>No. (%) of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>577,849 (5)</td>
</tr>
<tr>
<td>10-19</td>
<td>1,173,090 (11)</td>
</tr>
<tr>
<td>20-29</td>
<td>1,062,649 (10)</td>
</tr>
<tr>
<td>30-39</td>
<td>1,146,114 (10)</td>
</tr>
<tr>
<td>40-49</td>
<td>1,853,870 (17)</td>
</tr>
<tr>
<td>50-59</td>
<td>1,216,410 (11)</td>
</tr>
<tr>
<td>&lt;70</td>
<td>1,062,649 (10)</td>
</tr>
<tr>
<td>Total</td>
<td>11,153,039 (100)</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Sex</th>
<th>No. (%) of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>6,022,641 (54)</td>
</tr>
<tr>
<td>Male</td>
<td>5,130,398 (46)</td>
</tr>
<tr>
<td>Total</td>
<td>11,153,039 (100)</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Region</th>
<th>No. (%) of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>5,068,085 (45)</td>
</tr>
<tr>
<td>Midwest</td>
<td>2,758,924 (25)</td>
</tr>
<tr>
<td>West</td>
<td>1,853,870 (17)</td>
</tr>
<tr>
<td>Northeast</td>
<td>1,472,160 (13)</td>
</tr>
<tr>
<td>Total</td>
<td>11,153,039 (100)</td>
</tr>
</tbody>
</table>
The database was searched to query all individuals who underwent arthroscopic medial or lateral meniscectomy or repair between 2004 and 2009. The CPT codes 29881 (arthroscopic meniscectomy medial OR lateral), 29880 (arthroscopic meniscectomy medial AND lateral), 29882 (meniscus repair medial OR lateral), and 29883 (meniscus repair medial OR lateral) were used to search the database. Current Procedural Terminology codes 29881 and 29882 were cross-referenced with ICD-9 Revision codes 836.0 (medial meniscus) and 836.1 (lateral meniscus) to determine the side of repair. Patients were stratified by year of surgery (2004 to 2009), age, sex, and region of the United States (ie, South, Northeast, West, or Midwest).

The incidence of meniscectomy or meniscus repair was defined as the number of cases per 10,000 patients in the database with an orthopedic ICD-9 or CPT code. The incidence was normalized to account for differences in the number of patients in the database during a given year or within each age group, region, or sex (Tables 1-4). The Cochran-Armitage trend test was used when evaluating temporal trends, and chi-square analysis was used to test differences between age, sex, and region. Significance was set for all analyses to a \(P\) value less than .05.

**RESULTS**

Between 2004 and 2009, the authors identified 187,607 arthroscopic medial or lateral meniscectomies and medial or lateral repairs. Ninety-six percent of patients underwent meniscectomy and 4% underwent meniscus repair.

**Meniscectomy**

Of all meniscectomies identified, 78% were performed in the medial compartment and 22% were performed in the lateral compartment. Between 2004 and 2009, the incidence of medial meniscectomy did not significantly change. Although 20,276 medial meniscectomies were performed in 2004 and 24,039 were performed in 2009, the incidence was 130 per 10,000 patients in 2004 and 125 per 10,000 patients in 2009 (\(P=.08\)) (Figure 1). Medial meniscectomy was most commonly performed in patients aged 50 to 59 years, with an incidence of 216 cases per 10,000 patients (\(P<.0001\)) (Figure 2A).

No significant change occurred in the incidence of lateral meniscectomy from 2004 (37 per 10,000 patients) to 2009 (36 per 10,000 patients) (\(P=.36\)) (Figure 1) despite a small increase in number from 2004 (\(n=5371\)) to 2009 (\(n=6961\)). A bi-modal age distribution was observed with regard to lateral meniscectomy. The greatest number (10,628) of procedures was observed in patients aged 50 to 59 years. However, when normalized to the num-
The number of patients in each age group, lateral meniscectomy was most commonly performed in the 10- to 19-year-old (46 per 10,000 patients) and 20- to 29-year-old (41 per 10,000) age groups, followed by the 50- to 59-year-old age group (39 per 10,000) (P < .0001) (Figure 2B).

An additional 47,136 patients underwent simultaneous medial and lateral meniscectomy. A statistically significant increase in simultaneous medial and lateral meniscectomies (P < .0001) occurred from 2004 (5960 cases) to 2009 (8662 cases) (incidences of 38 and 45 per 10,000 patients, respectively) (Figure 1). The 60- to 69-year-old age group demonstrated the highest incidence of simultaneous medial and lateral meniscectomies when compared with all other age groups (P < .0001) (Figure 2C).

Meniscus Repair

Of the 7006 single-sided meniscus repairs performed, 4708 (67%) were medial and 2298 (33%) were lateral. The incidence of medial meniscus repair decreased significantly from 2004 through 2009 (P < .0001). A total of 829 (incidence of 5.3 per 10,000 patients) medial repairs were performed in 2004 compared with 732 (incidence of 3.8 per 10,000) patients in 2009 (Figure 3). Medial meniscus repairs were most commonly performed in patients aged 10 to 19 years (P < .0001) (Figure 4A). The incidence of lateral meniscus repair did not significantly change from 2004 through 2009 (P = .4), with 376 repairs performed in 2004 and 402 performed in 2009. Lateral repairs were also most commonly performed in patients aged 10 to 19 years (P < .0001) (Figure 4B).

A total of 496 combined medial and lateral meniscal repairs were performed. The number of simultaneous medial and lateral meniscus repairs decreased significantly from 2004 through 2009 (P < .0001), with 125 cases in 2004 to 70 cases in 2009 (Figure 3). The 50- to 59-year-old age group demonstrated the highest incidence of medial and lateral meniscal repairs (0.7 per 10,000 patients) between 2004 and 2009 (Figure 4C).

Sex

Males accounted for the greatest proportion of medial, lateral, and simultaneous meniscectomies and medial, lateral, and combined meniscal repairs (P < .001). Of all meniscectomies, 53% were performed in males and 47% in females. Of the meniscus repairs, 63% were performed in males and 37% in females. The greatest sex differences were observed in
patients undergoing medial or lateral meniscus repair (Figure 5).

Region

No significant differences existed across regions with regard to partial meniscectomy and meniscal repair. For example, 62,919 (44%) medial meniscectomies were identified in the South between 2004 and 2009, whereas 17,383 (12%) cases were in the Northeast, 22,615 (16%) were in the West, and 38,015 (26%) were in the Midwest. This regional distribution of cases corresponded with a similar distribution of patients in the database because the South had a patient population of 5.1 million (45%), the Northeast 1.5 million (13%), the West 1.9 million (17%), and the Midwest 2.8 million (25%) (Table 4). A similar pattern existed for lateral meniscectomy, combined meniscectomy, medial and lateral repair, and combined repair.

Discussion

Arthroscopic knee surgery is commonly performed across all regions of the United States. The purpose of this study was to report the current trends in meniscectomy and meniscus repair and to evaluate demographics, including age, sex, and region of patients undergoing these procedures. This study demonstrates that meniscectomy is more commonly performed than meniscus repair and that no recent increase has occurred in the incidence of meniscus repair.

The incidence of medial meniscectomy and lateral meniscectomy in this database did not change with time. The greatest number of patients undergoing medial meniscectomy were in the 50- to 59-year-old age group, in which patients are more likely to have degenerative tears not amenable to repair. Similarly, the greatest incidence of simultaneous medial and lateral meniscectomies occurred in the 60- to 69-year-old age group. Lateral meniscectomy was also often performed in the middle-aged population, demonstrating a second peak in procedures after those performed in the second and third decades of life.

An aging but active population has been presenting with knee pathology and symptoms not fully accounted for by degenerative joint disease. Although arthroscopic surgery to address osteoarthritis of the knee is not indicated, several studies have demonstrated the benefits of partial meniscectomy in middle-aged populations.21-24 Boe and Henning21 reported the results of partial meniscectomy in a series of 30 patients older than 50 years. Medial meniscal tears accounted for 80% of the tears, and degenerative and flap tears represented the most common types of tears. Lysholm scores were improved 2 years postoperatively, although patients with articular cartilage degeneration at the time of arthroscopy improved less compared with their counterparts with preserved cartilage. Similarly, Bonomo et al22 reported that patients with coexisting articular cartilage lesions fared worse after partial meniscectomy. The current results indicate that a significant demand remains for arthroscopic partial meniscectomy in the middle-aged population and that the incidence of meniscectomy remained relatively constant between 2004 and 2009.

Of the 187,607 cases of arthroscopic medial or lateral meniscectomy and medial or lateral repair, meniscal repairs accounted for 4% of the operations and occurred most frequently in younger patients. Moreover, a decrease in the rate of medial meniscus repair was observed despite the recent increase in medical devices facilitating all-inside meniscal repairs. Several studies have reported the efficacy and long-term survival of arthroscopic meniscal repairs.25-28 When comparing meniscal repair strategies, outcomes appear equivalent. In their systematic review of isolated inside-out compared with all-inside meniscal repair, Grant et al29 reported similar clinical failure rates, Lysholm scores, and Tegner activity scores. More nerve symptoms were associated with the inside-out repair, whereas implant-related complications were more common with the all-inside technique.

A lack of research exists on the current trends in the management of meniscal tears. Hede et al25 initially reported on the epidemiology of meniscal tears in 1215 patients undergoing open knee surgery between 1982 and 1984 in a cohort of patients in Copenhagen. In that series, 79% of meniscal lesions underwent total meniscectomy, 19% underwent partial meniscectomy, and 0.7% underwent repair. With the discovery of the importance of the meniscus in knee function, partial meniscectomies or meniscal repairs have become the standard of care.

A recent analysis of the American Board of Orthopaedic Surgeons database between 2003 and 2007 showed a modest increase in meniscal repairs in association with anterior cruciate ligament (ACL) reconstruction from 13.9% in 2003 to
16.4% in 2007, but the difference was not statistically significant.\textsuperscript{26} Meniscal repair was performed in conjunction with ACL reconstruction 11% to 18% of the time depending on the region and was performed significantly more often by sports medicine fellowship–trained surgeons and in patients younger than 25 years. These findings are surprising in this patient population given the abundance of data suggesting that meniscal repairs have better outcomes when performed in conjunction with ACL reconstructions. The results of the current study, which excluded patients with ACL or posterior cruciate ligament injuries, were similar with regard to trends in repair over time and age of repair.

The reason for the decrease in meniscus repair found in the current study is unclear. Meniscus preservation and the importance of meniscus repair have been emphasized in the orthopedic literature.\textsuperscript{3-4} However, a similarly strong emphasis has been placed on the importance of the location of the tear to determine repairability.\textsuperscript{27,28} Noyes et al\textsuperscript{29} reported good outcomes at long-term follow-up in young patients undergoing meniscus repair for tears extending into the avascular zone; a 21% reoperation rate existed for tibiofemoral symptoms. Nine patients had clefts present on follow-up arthroscopy at the repair location or had areas more than 10 mm long that were not healed on magnetic resonance imaging. Despite improved techniques and all-inside repair options, the repair rate has not increased because surgeons are using relatively strict indications for repairability based on tear morphology and location. In addition, the performance of repair adds time to the procedure, a more extensive rehabilitation, and the potential need for reoperation for partial meniscectomy if failure occurs.

The outcome of meniscal repair vs partial meniscectomy is also important to consider. No overwhelming evidence supports meniscal repair over partial meniscectomy. Paxton et al\textsuperscript{30} reported a systematic literature review to compare the short- and long-term outcomes between partial meniscectomy and meniscal repair in patients with a traumatic meniscal tear. Partial meniscectomy had a lower reoperation rate when compared with isolated meniscal repair. However, in studies with long-term follow-ups, meniscal repair was associated with higher Lysholm scores and less radiologic degeneration than partial meniscectomy. Most studies in the review provided Level IV evidence, making it difficult to draw decisive conclusions.

A higher incidence of meniscectomy and repair was observed in males than females in the current study, which is consistent with prior evaluations of surgical treatment of meniscal tears. In the review by Meredith et al\textsuperscript{31} on outcomes after partial meniscectomy, the percentage of female patients ranged from 11% to 63% in each series, but 2 of 21 studies reviewed had a greater proportion of females than males undergoing partial meniscectomy. Similarly, in a randomized prospective study comparing meniscal repair with bioabsorbable arrows to inside-out suturing, 62% of patients were male.\textsuperscript{32} The sex difference was larger with repair compared with meniscectomy. The reason for this difference is unclear. To the authors’ knowledge, no data suggest that meniscal tears in males are more amenable to repair (ie, more favorable morphology of tear).

This study had several limitations. Although all 4 regions of the United States are represented in the PearlDiver Patient Record Database, this does not necessarily represent the United States population as a whole. Various demographic differences may exist between patients in this insurance database when compared with the country at large. In addition, the data collection period only included 6 years, which limited the authors’ capability to evaluate long-term trends and to obtain information on the natural history of patients undergoing meniscectomy and repair with regard to additional arthroscopies, high tibial osteotomy, or total knee arthroplasty. Error may also be introduced into this study by miscoding of procedures or by confounding diagnoses that were coded along with meniscectomy and meniscal repair. However, patients undergoing ACL and posterior cruciate ligament reconstruction were excluded from the study. Future studies may be performed to determine the difference in trends of meniscectomy and meniscal repair in patients with concomitant ACL and posterior cruciate ligament reconstruction.

**Conclusion**

Arthroscopic meniscectomy remains a common orthopedic procedure and is most commonly performed in patients in the sixth decade of life. Meniscal repair is preferred to meniscectomy in instances in which the tear is repairable. However, analysis of this database does not indicate a trend toward an increase in the rate of meniscal repairs.

**References**

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