

# Trends in the Surgical Treatment of Articular Cartilage Lesions in the United States: An Analysis of a Large Private-Payer Database Over a Period of 8 Years

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**Purpose:** The purpose of this study was to quantify the current trends in knee cartilage surgical techniques performed in the United States from 2004 through 2011 using a large private-payer database. A secondary objective was to identify salient demographic factors associated with these procedures. **Methods:** We performed a retrospective database review using a large private-payer medical record database within the PearlDiver database. The PearlDiver database is a publicly available, Health Insurance Portability and Accountability Act–compliant national database compiled from a collection of private insurer records. A search was performed for surgical techniques in cartilage palliation (chondroplasty), repair (microfracture/drilling), and restoration (arthroscopic osteochondral autograft, arthroscopic osteochondral allograft, autologous chondrocyte implantation, open osteochondral allograft, and open osteochondral autograft). The incidence, growth, and demographic factors associated with the surgical procedures were assessed. **Results:** From 2004 through 2011, 198,876,000 patients were analyzed. A surgical procedure addressing a cartilage defect was performed in 1,959,007 patients, for a mean annual incidence of 90 surgeries per 10,000 patients. Across all cartilage procedures, there was a 5.0% annual incidence growth (palliative, 3.7%; repair, 0%; and restorative, 3.1%) ( $P = .027$ ). Palliative techniques (chondroplasty) were more common (>2:1 ratio for repair [marrow-stimulation techniques] and 50:1 ratio for restoration [autologous chondrocyte implantation and osteochondral autograft and allograft]). Palliative surgical approaches were the most common technique, regardless of age, sex, or region. **Conclusions:** Articular cartilage surgical procedures in the knee are common in the United States, with an annual incidence growth of 5%. Surgical techniques aimed at palliation are more common than cartilage repair and restoration techniques regardless of age, sex, or region. **Level of Evidence:** Level IV, retrospective database analysis.

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**T**here is a large and growing US patient population with symptomatic focal cartilage lesions in the knee. Numerous surgical procedures have been

developed to address focal cartilage defects, yet controversy remains in distinguishing a superior technique.<sup>1,2</sup> Cartilage treatment strategies can be characterized as palliation (e.g., chondroplasty and debridement), repair (e.g., drilling and microfracture), or restoration (e.g., autologous chondrocyte implantation [ACI], osteochondral autograft, and osteochondral allograft).<sup>3</sup> Cartilage restoration has become a focus of increased interest over the past decade because of its potential to provide pain relief and alter the progression of degenerative disease, with the hope of delaying or obviating the need for joint replacement, which has its own associated limitations including implant-related activity restriction and the likelihood of revision for relatively young patients.<sup>4</sup> However, the national utilization of these procedures is poorly understood.

The purpose of this study was to quantify the number of cartilage palliative, repair, and restoration techniques performed in the United States over the past 8 years

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using a large private-payer database that encompasses nearly 10% of the US population. The secondary objective was to identify salient demographic parameters associated with these procedures. The hypothesis was that surgical procedures for articular cartilage disease of the knee would increase on an annual basis.

## Methods

We performed a retrospective review of a large private-payer medical record database within the PearlDiver database. The PearlDiver database is a publicly available, Health Insurance Portability and Accountability Act–compliant national database compiled from a collection of private insurer records, with UnitedHealth Group representing the largest contributing individual health plan. The database has more than 2 billion individual patient records and contains Current Procedural Terminology (CPT) and *International Classification of Diseases, Ninth Revision* codes related to orthopaedic procedures. From 2004 through 2011, the private-payer database captured from 22.4 million to 26.3 million patients (8.3% to 9.9% of the US population) in each year included in the analysis.

The number of patients having a record of the following CPT codes was recorded: 29877, chondroplasty; 29879, microfracture/drilling; 29866, arthroscopic osteochondral autograft; 29867, arthroscopic osteochondral allograft; 27412, ACI; 27415, open osteochondral allograft; or 27416, open osteochondral autograft. Cartilage surgical procedures were further classified as palliative (29877, chondroplasty), repair (29879, microfracture/drilling), or restorative (29866, arthroscopic osteochondral allograft; 27412, ACI; 27415, open osteochondral allograft; or 27416, open osteochondral autograft). The total number of patients for each CPT code, per year, was identified from the database. The incidence of cartilage procedures was calculated by the number of patients listed with the specific CPT code divided by the total number of patients in the database for each year. CPT codes 29866, 29867, 27412, and 27415 were introduced in 2005, and CPT code 27416 was introduced in 2008. The estimated number of procedures performed in the United States was calculated from the incidence and 2000 and 2010 US census data conversion factor. In addition to CPT and *International Classification of Diseases, Ninth Revision* codes, demographic data such as age, sex, and region were also analyzed. Regions were defined as Midwest, Northeast, South, and West (Table 1).

Kolmogorov-Smirnov testing showed a Gaussian distribution of the data. Linear regression was performed to determine the significance of annual change for each procedure. Statistical analysis was performed with SPSS software, version 20 (IBM, Armonk, NY). An  $\alpha$  value of .05 was set as significant.

**Table 1.** States Included Within Each Defined Region

| Region    | States Included  |
|-----------|--|
| Midwest   | IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI                         |
| Northeast | CT, MA, ME, NH, NJ, NY, PA, RI, VT                                     |
| South     | AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, PR, SC, TN, TX, VA, WV |
| West      | AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY                     |

## Results

We analyzed 198,876,000 patients' charts. There were 1,959,007 patients (0.99%) who underwent a surgical procedure addressing a cartilage defect in the knee. The mean annual incidence was 90 surgeries per 10,000 patients. The total number of patients analyzed in the database, by year, is listed in Table 2. There was no significant change in the number of patients in the database over the study timeframe ( $P = .140$ ). The estimated number of procedures performed annually, based on 2000 and 2010 US census data, is listed in Table 2. Across all cartilage procedures, there was an annual incidence growth of 5% ( $P = .027$ ).

The incidence and estimated number of procedures performed on an annual basis are listed in Table 3. Cartilage palliative procedures were performed more often than repair or restoration procedures (2:1 ratio for repair and 50:1 ratio for restoration). Restorative procedures showed a 3.1% annual incidence growth over the study period. The palliative procedure incidence grew by 3.7% during the study period. The repair procedure incidence remained stagnant (0%) during the study period (Fig 1).

A description of the studied demographic trends with cartilage surgeries is listed in Tables 4, 5, and 6. The palliative surgical approach is a more commonly used technique than chondral repair or restoration, regardless of age, sex, or region. Palliative procedures are performed at a 2:1 greater ratio for patients aged younger than 40 years, increasing to 3.2:1 for those aged 60 to 69 years. The incidences of restorative procedures were equally distributed across ages 15 to

**Table 2.** Number of Patients Undergoing Cartilage Surgical Procedures by Year in US Private Insurance Database (Medicare Not Included) Represented in PearlDiver Database

| Year  | No. of Procedures | No. of Patients in Database | Incidence (per 10,000 Patients) | US Estimates |
|-------|-------------------|-----------------------------|---------------------------------|--------------|
| 2004  | 13,589            | 21,411,000                  | 63                              | 165,828      |
| 2005  | 20,651            | 24,590,000                  | 84                              | 234,446      |
| 2006  | 23,685            | 25,700,000                  | 92                              | 246,394      |
| 2007  | 23,641            | 25,525,000                  | 92                              | 252,178      |
| 2008  | 24,074            | 26,345,000                  | 91                              | 251,328      |
| 2009  | 22,821            | 24,625,000                  | 92                              | 256,636      |
| 2010  | 25,855            | 24,810,000                  | 104                             | 291,305      |
| 2011  | 23,977            | 25,870,000                  | 93                              | 260,892      |
| Total | 179,292           | 198,876,000                 | 90                              | 1,959,007    |

**Table 3.** Annual Breakdown of Patients Undergoing Specified Cartilage Procedures Based on CPT Code

| CPT Code | Procedure                     | 2004    | 2005    | 2006    | 2007    | 2008    | 2009    | 2010    | 2011    |
|----------|-------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| 29877    | Chondroplasty*                | 122,368 | 180,601 | 190,647 | 192,406 | 192,185 | 196,367 | 220,785 | 197,351 |
| 29879    | Microfracture/drilling†       | 66,244  | 72,887  | 74,433  | 79,629  | 75,436  | 76,777  | 84,780  | 78,456  |
| 29866§   | Arthroscopic autograft‡       | —       | 1,181   | 1,376   | 1,137   | 1,074   | 999     | 1,155   | 1,044   |
| 29867§   | Arthroscopic allograft‡       | —       | 930     | 1,202   | 971     | 832     | 719     | 631     | 662     |
| 27412§   | ACI‡                          | —       | 885     | 630     | 742     | 728     | 767     | 1,446   | 1,343   |
| 27415§   | Open osteochondral allograft‡ | —       | 660     | 808     | 848     | 663     | 863     | 1,351   | 1,619   |
| 27416    | Open osteochondral autograft‡ | —       | —       | —       | —       | 496     | 509     | 653     | 798     |

\*Palliative procedure.

†Repair procedure.

‡Restorative procedures.

§CPT code available in 2005.

||CPT code available in 2008.

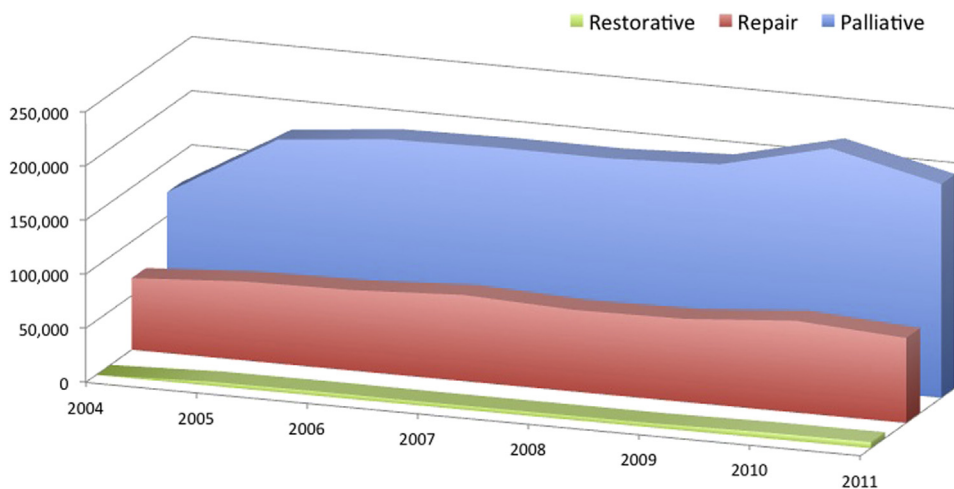
39 years but showed a dramatic decline in patients aged 50 years or older and were extremely rare at age 60 years or older. Whereas microfracture procedure incidences were highest for those aged 40 years or older, they remained elevated until the age of 60 years. There were no differences among surgical techniques among regions. Men and women were equally likely to undergo both cartilage palliative and repair techniques, whereas men were 45% more likely to undergo restorative procedures.

## Discussion

The purpose of this study was to quantify the number of articular cartilage surgical techniques performed in the knee in the United States over the past 8 years using a large private-payer database. The study's key finding is that a large number of patients are undergoing arthroscopic cartilage surgery of the knee each year in the United States and the number of cartilage surgical techniques per year is significantly increasing, at an annual incidence increase of 5%. A mean incidence of 90 surgeries per 10,000 patients ranks cartilage procedures as 1 of the most common arthroscopic knee surgeries (ranging from 197 per 10,000 patients for

meniscectomy to 47 per 10,000 patients for anterior cruciate ligament procedures).<sup>5</sup> However, patients are 2 to 3 times more likely to undergo palliative treatment, irrespective of age, sex, or region; marrow-stimulation techniques are the second most common approach because this trend continued to grow over the study period.

An important finding is the trend in cartilage restoration techniques. Though comprising a smaller number of procedures, cartilage restorative techniques are taking on a greater role in the treatment armamentarium for symptomatic focal chondral defects. Over the study period, there was decreased utilization of arthroscopic autograft and allograft transplantation approaches and increased growth in these transplantation procedures through an open technique, whereas ACI grew at a rate similar to the overall growth. The greater utilization of these procedures may be influenced by advances in technology and instrumentation, allowing for easier implantation of these types of grafts. Furthermore, surgeon comfort level with performing these procedures is likely to increase as these procedures become more frequent. It is important to note that both direct costs (devices, operative time) and indirect costs



**Fig 1.** Total numbers of estimated cartilage palliative, repair, and restoration procedures performed annually in United States from 2004 through 2011.

**Table 4.** Annual Breakdown of Cartilage Procedures Based on CPT Classification and Age

|          | Chondroplasty | Microfracture | Arthroscopic Autograft | Arthroscopic Allograft | ACI | Open Osteochondral Allograft | Open Osteochondral Autograft | Ratio of Palliative to Repair/Restorative |
|----------|---------------|---------------|------------------------|------------------------|-----|------------------------------|------------------------------|---|
| 15-19 yr | 4,741         | 1,966         | 101                    | 51                     | 69  | 97                           | 46                           | 2.0:1                                     |
| 20-29 yr | 7,946         | 3,387         | 138                    | 98                     | 129 | 142                          | 47                           | 2.0:1                                     |
| 30-39 yr | 18,095        | 7,507         | 185                    | 148                    | 206 | 169                          | 48                           | 2.2:1                                     |
| 40-49 yr | 37,164        | 13,924        | 193                    | 161                    | 153 | 151                          | 49                           | 2.6:1                                     |
| 50-59 yr | 47,363        | 15,142        | 93                     | 79                     | 36  | 46                           | 17                           | 3.1:1                                     |
| 60-69 yr | 16,882        | 5,026         | 18                     | —                      | —   | —                            | —                            | 3.2:1                                     |
| Total    | 132,191       | 46,952        | 728                    | 537                    | 593 | 605                          | 207                          |   |

(rehabilitation, sick leave) associated with cartilage restoration procedures can be significant, especially when compared with less invasive, palliative procedures.

A significant concern raised by our findings is the vast and routine application of chondroplasty, in lieu of other strategies, despite the absence of proven treatment superiority. There is a paucity of current literature advocating for chondroplasty as the preferred treatment for focal cartilage defects. A review of the PubMed database found only 1 recent study showing that chondroplasty with meniscal debridement showed improved outcomes at 4 years.<sup>6</sup> Although there is no clear superior treatment, a palliative approach such as chondroplasty may be considered the easiest and most inexpensive approach with the least morbidity potential. The popularity may highlight the perceived weaknesses with our current surgical approaches to treating symptomatic cartilage defects. An alternative explanation is that the cartilage lesions may have been addressed by chondroplasty as a secondary procedure with the primary procedure treating a torn meniscus or loose body. However, a palliative approach to cartilage lesions may not be the best treatment strategy as we face a large growing burden of progressive arthritis and disability.

Repair techniques for focal defects may be considered an easy alternative to chondroplasty but require a more extensive rehabilitation. A recent systematic review showed that microfracture techniques yield a 22-point overall Knee Injury and Osteoarthritis Outcome Score improvement on average.<sup>7</sup> The results may provide only short-term relief because there is concern about degeneration after 18 to 24 months.<sup>8</sup> There are also emerging techniques to augment repair strategies such as microfracture augmentation (autologous

matrix-induced chondrogenesis),<sup>9</sup> subchondroplasty, and platelet-rich plasma<sup>10</sup>/bone marrow aspirate concentrate augmentation.

The overall literature is currently inconclusive on the optimal treatment strategy for cartilage lesions. However, the recent increased enthusiasm for cartilage restorative procedures within this study period corresponds with recent studies showing their superiority over the current “gold standard” of microfracture in high-quality studies.<sup>11-15</sup> Thus recent literature supports increased use of restorative approaches based on patient-, limb-, knee-, and defect-specific parameters. The findings of this study suggest a need for education and policy to include cartilage repair and restorative techniques in the isolated chondral defect management algorithm.

### Limitations

This study has specific limitations and sources of bias that must be considered. The database did not analyze other important demographic and epidemiologic factors, including height, weight, body mass index, location and size of lesion, activity level, mechanical alignment, meniscus and anterior cruciate ligament status, duration of symptoms, sports status, and concurrent procedures. These factors may ultimately play a role in surgical decision making. In addition, the database did not provide information on the size or grade of the cartilage lesions. This information would be helpful because these details guide surgical decision making as well. This study also incorporated CPT codes that were first introduced in 2005, which may introduce selection bias. Furthermore, as with any retrospective database investigation, the accuracy of coding within the system is critical to the validity of the

**Table 5.** Annual Breakdown of Cartilage Procedures Based on CPT Classification and Region

|           | Chondroplasty | Microfracture | Arthroscopic Autograft | Arthroscopic Allograft | ACI | Open Osteochondral Allograft | Open Osteochondral Autograft | Ratio of Palliative to Repair/Restorative |
|-----------|---------------|---------------|------------------------|------------------------|-----|------------------------------|------------------------------|---|
| Northeast | 13,606        | 4,918         | 93                     | 115                    | 75  | 65                           | 27                           | 3.3:1                                     |
| Midwest   | 33,310        | 9,002         | 165                    | 107                    | 126 | 175                          | 58                           | 3.4:1                                     |
| South     | 63,557        | 25,161        | 358                    | 219                    | 309 | 246                          | 94                           | 2.5:1                                     |
| West      | 22,722        | 8,310         | 129                    | 110                    | 108 | 148                          | 48                           | 2.8:1                                     |

**Table 6.** Annual Breakdown of Cartilage Procedures Based on CPT Classification and Sex

|        | Chondroplasty | Microfracture | Arthroscopic<br>Autograft | Arthroscopic<br>Allograft | ACI | Open<br>Osteochondral<br>Allograft | Open<br>Osteochondral<br>Autograft | Ratio of Palliative to<br>Repair/Restorative |
|--------|---------------|---------------|---------------------------|---------------------------|-----|------------------------------------|------------------------------------|--|
| Female | 66,571        | 21,989        | 304                       | 207                       | 260 | 260                                | 89                                 | 2.88:1                                       |
| Male   | 66,633        | 25,404        | 441                       | 345                       | 358 | 358                                | 138                                | 2.45:1                                       |

findings. Although the database contains a large number of medical records, it is subject to selection bias and cannot track patients who enter or exit the provider mix available for review in this database.

### Conclusions

Articular cartilage surgical procedures in the knee are common in the United States, with an annual incidence growth of 5%. Surgical techniques aimed at palliation are more common than cartilage repair and restoration techniques regardless of age, sex, or region.

### References

- Vavken P, Samartzis D. Effectiveness of autologous chondrocyte implantation in cartilage repair of the knee: A systematic review of controlled trials. *Osteoarthritis Cartilage* 2010;18:857-863.
- Benthien JP, Schwaninger M, Behrens P. We do not have evidence based methods for the treatment of cartilage defects in the knee. *Knee Surg Sports Traumatol Arthrosc* 2011;19:543-552.
- McNickle AG, Provencher MT, Cole BJ. Overview of existing cartilage repair technology. *Sports Med Arthrosc* 2008;16:196-201.
- Gomoll AH, Filardo G, de Girolamo L, et al. Surgical treatment for early osteoarthritis. Part I: Cartilage repair procedures. *Knee Surg Sports Traumatol Arthrosc* 2012;20:450-466.
- Montgomery SR, Ngo SS, Hobson T, et al. Trends and demographics in hip arthroscopy in the United States. *Arthroscopy* 2013;29:661-665.
- Spahn G, Klinger HM, Muckley T, Hofmann GO. Four-year results from a randomized controlled study of knee chondroplasty with concomitant medial meniscectomy: Mechanical debridement versus radiofrequency chondroplasty. *Arthroscopy* 2010;26:S73-S80.
- Negrin L, Kutscha-Lissberg F, Gartlehner G, Vecsei V. Clinical outcome after microfracture of the knee: A meta-analysis of before/after-data of controlled studies. *Int Orthop* 2012;36:43-50.
- Mithoefer K, McAdams T, Williams RJ, Kreuz PC, Mandelbaum BR. Clinical efficacy of the microfracture technique for articular cartilage repair in the knee: An evidence-based systematic analysis. *Am J Sports Med* 2009;37:2053-2063.
- Gomoll AH. Microfracture and augments. *J Knee Surg* 2012;25:9-15.
- Gobbi A, Karnatzikos G, Mahajan V, Malchira S. Platelet-rich plasma treatment in symptomatic patients with knee osteoarthritis: Preliminary results in a group of active patients. *Sports Health* 2012;4:162-172.
- Gudas R, Gudaite A, Mickevicius T, et al. Comparison of osteochondral autologous transplantation, microfracture, or debridement techniques in articular cartilage lesions associated with anterior cruciate ligament injury: A prospective study with a 3-year follow-up. *Arthroscopy* 2013;29:89-97.
- Krych AJ, Harnly HW, Rodeo SA, Williams RJ III. Activity levels are higher after osteochondral autograft transfer mosaicplasty than after microfracture for articular cartilage defects of the knee: A retrospective comparative study. *J Bone Joint Surg Am* 2012;94:971-978.
- Crawford DC, DeBerardino TM, Williams RJ III. NeoCart, an autologous cartilage tissue implant, compared with microfracture for treatment of distal femoral cartilage lesions: An FDA phase-II prospective, randomized clinical trial after two years. *J Bone Joint Surg Am* 2012;94:979-989.
- Saris DB, Vanlauwe J, Victor J, et al. Treatment of symptomatic cartilage defects of the knee: Characterized chondrocyte implantation results in better clinical outcome at 36 months in a randomized trial compared to microfracture. *Am J Sports Med* 2009;37(suppl 1):10S-19S.
- Basad E, Ishaque B, Bachmann G, Sturz H, Steinmeyer J. Matrix-induced autologous chondrocyte implantation versus microfracture in the treatment of cartilage defects of the knee: A 2-year randomised study. *Knee Surg Sports Traumatol Arthrosc* 2010;18:519-527.