Declining trends in arthroscopic meniscus surgery and other arthroscopic knee procedures in Denmark: a nationwide register-based study

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Background and purpose — A doubling of arthroscopic meniscal procedures was observed in Denmark from 2000 to 2011, but arthroscopic meniscal procedures for degenerative meniscal tears are no longer recommended. We performed an updated investigation of Danish meniscal procedure trends in the private and public healthcare sectors in Denmark from 2006 to 2018, including trends for other arthroscopic knee procedures.

Patients and methods — We extracted data on the 5 most commonly registered arthroscopic knee procedures (diagnostic arthroscopy, meniscal surgery, anterior cruciate ligament reconstruction, synovectomy, and cartilage resection) from the Danish National Patient Register from January 1, 2006 to December 31, 2018, linked with the Danish Population Statistic Register, to obtain data on age and sex.

Results — 414,253 arthroscopic knee procedures were registered during 315,290 surgeries on 244,113 individual patients in the study period. For meniscal procedures, the highest incidence was observed in 2010 (319 per 10^5 persons/year, 95% CI 314–323) and the lowest in 2018 (173 per 10^5 persons/year, CI 169–176), corresponding to relative decrease of 46% from 2010 to 2018. Remaining arthroscopic procedures also showed declining trends, with lowest incidence for all procedures in 2018.

Interpretation — A large decrease in the incidence for arthroscopic meniscal procedures was observed from 2010 to 2018, possibly in response to mounting evidence of limited benefit of this procedure for degenerative knee disease. All other investigated arthroscopic knee procedures also declined in the same period.

Arthroscopic procedures to treat different knee conditions are the most common types of orthopedic procedures (1). A doubling of arthroscopic meniscal procedures was observed in Denmark in the period from 2000 to 2011, with the largest increase observed in middle-aged and older patients (i.e., aged 35 years or older) (2). During the same period, mounting evidence from several randomized trials, synthesized in systematic reviews and meta-analyses, reported no added benefit of arthroscopic meniscal procedures over placebo or exercise therapy for degenerative meniscal tears (2–4). These results eventually led to clinical guidelines either advising against knee arthroscopy to treat degenerative meniscal tears (5) or a more restricted selection of patients (6), but it is not well documented as to whether these recommendations have led to a reduction in the number of arthroscopic meniscal procedures performed in Denmark.

In 2010, a landmark study comparing anterior cruciate ligament (ACL) reconstruction with exercise therapy with the option of later surgery for patients with ACL tears found that about half of patients randomized to exercise therapy managed without ACL surgery (7). A recent Dutch study confirmed these results with similar findings (8), but how this has been translated into practice is less well known.

The primary aim of the present study was to investigate whether the number of meniscal procedures performed in Denmark had decreased, using data from 2006 to 2018. We also investigated whether the number of arthroscopic ACL reconstructions in Denmark between 2006 and 2018 had changed following the publication of recent clinical trials and clinical guidelines. To address a potential shift in the coding of procedures we also investigated changes in the incidence of related procedures.
Patients and methods

Study sample

We conducted a nationwide register-based study. The 5 most common arthroscopic knee procedures were identified by initial screening of all arthroscopic codes in the study period (January 1, 2006 to December 31, 2018). The 5 most common registered arthroscopic knee procedures, accounting for 96% of procedures, were: diagnostic arthroscopy, KNGA11 = arthroscopic exploratory examination; arthroscopic meniscal surgery, KNGD0 = arthroscopic meniscectomy; KNGD11 = arthroscopic partial resection of the meniscus; KNGD21 = arthroscopic reinsertion of the meniscus; KNGD91 = other arthroscopic surgery on the meniscus; arthroscopic anterior cruciate ligament (ACL) reconstruction, KNGE45 = arthroscopic reconstruction of the anterior cruciate ligament without foreign material; KNGE55 = arthroscopic reconstruction of the anterior cruciate ligament with foreign material; arthroscopic synovectomy, KNGF01 = arthroscopic total synovectomy; KNGF11 = arthroscopic partial synovectomy; and arthroscopic cartilage resection, KNGF31 = arthroscopic resection of articular cartilage. An arthroscopic procedure was considered the primary surgical procedure if the procedure was coded as the most important surgical procedure. An arthroscopic procedure coded as the secondary procedure or part of surgery without being the primary procedure was considered a secondary surgical procedure. Thus, several procedures could be conducted at the same surgery and the same patient could have several surgeries during the study period. When diagnostic arthroscopy was coded in combination with other arthroscopic knee procedure codes, we did not consider this to be an actual procedure. Thus, diagnostic arthroscopy was included in this study only if it was coded as the only knee procedure on a given surgery date.

We extracted data on age, sex, diagnosis, and procedural sector (public or private) for each contact. The CPR number, a unique personal identifier given to all Danish residents (i.e., at birth or upon immigration), was used to track patients with several arthroscopic surgeries during the study period (defined as surgery on separate dates) and ensure linkage between all Danish health and population registries (9). We excluded patients if we could not retrieve age or sex from the Danish Population Register or if patients had a date of death before surgery date.

Data sources

The Danish National Patient Register (DNPR) contains information on all in- and outpatient contacts with Danish private and public hospital departments (10). The completeness and validity of the clinical data in DNPR vary, but the registration of orthopedic procedure codes is considered to have the highest validity and accuracy of all clinical specialties. The data reported in the DNPR is of 2 types: administrative data including the CPR number, date, and time of activity; and clinical data including diagnosis and surgical procedures (10). The surgical procedures have been coded with high validity according to the Danish version of Nordic Medico-Statistical Committee Classification of Surgical Procedures (11). The Danish Register of Causes of Death and the Danish Population Register from Statistics Denmark contributed information on age, sex, and death (12, 13).

Statistics

We retrieved information on the numbers of registered Danish inhabitants as at January 1 for each year from Statistics Denmark (14). We estimated the mid-year population from numbers at the beginning of each year as the mid-year data was not available (e.g., the mid-year population of 2006 was the average of the population from January 2006 and January 2007). We summarized the total annual number of procedures for each procedure category (diagnostic arthroscopy; arthroscopic meniscal surgery; arthroscopic ACL reconstruction; arthroscopic synovectomy; and arthroscopic cartilage resection) and reported these stratified by sex in the age groups: 0–9 years, 10–19 years, 20–29 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years or older. The yearly incidence of knee procedures per 10^5 inhabitants was calculated with 95% confidence intervals (CI) for each procedure category and in different age groups.

All analyses and graphics were performed using Stata Release 15.2 (StataCorp, College Station, TX, USA) and the R software/environment version 1.4.1106 (R Core Team 2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ethics, funding, data sharing, and potential conflicts of interest

This register-based study was approved by the University of Southern Denmark for the Danish Data Protection Agency (Reference Number: 10.574). According to Danish law, this study was exempt from ethics approval as it pertained only to registry-based data for research purposes (15). The datasets were constructed by and stored at Statistics Denmark according to the Act on Processing of Personal Data (16). This study received no funding. Data sharing is not possible.

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Results

414,253 arthroscopic knee procedures were registered at 315,290 individual surgery dates on 242,113 patients between 2006 and 2018 (Figure 1, see Supplementary data). Most patients had 1 arthroscopic surgery while 55,196 patients had
Table 4. Incidences of procedure categories, number of procedures, mean age at surgery, sex, and sector distribution per year from 2006 to 2018 (primary and secondary procedures combined)

| Procedure                          | Total       | Surgical procedure | Incidence per 10^5 persons/year (95% CI) |
|------------------------------------|-------------|--------------------|------------------------------------------|
| Diagnostic arthroscopy             | 55 (54–58)  |                    | 66 (CI) (155–162)                        |
| Arthroscopic                       |             |                    | (67–72)                                  |
|meniscal surgery                    | 235 (221–249)| 239 (225–243)      | 51,974 (22,855 (44) 29,119 (56)          |
| ACL reconstruction                  | 214 (201–228)| 239 (225–243)      | 35,074 (15,932 (45) 19,142 (44)          |
| synovectomy                        | 159 (145–173)| 160 (157–164)      | 122,145 (68,313 (56) 53,832 (44)         |
| cartilage resection                 | 66 (61–71)  |                    | 214,782 (107,256 (50) 107,526 (48)       |
|ACL (CI)                            |             |                    | (59–63)                                  |
| synovectomy                        | 127 (116–138)| 127 (115–139)      | 53,832 (23,414 (44) 29,418 (45)          |
|cartilage resection                 | 65 (56–74)  |                    | 41,140 (21,410 (100) –                  |
|Procedures, n                       | 29,827      | 31,749             | 414,253 (299,267 114,986)                |

The total number of arthroscopic procedures peaked in 2010 (n = 39,486 procedures) and was the lowest in 2018 (n = 21,469 procedures) (Table 4). Arthroscopic meniscal procedures accounted for 44% of all arthroscopic knee procedures followed by arthroscopic synovectomy, which accounted for 29% of the procedures in the study period. The procedure code KNGD11 (i.e., arthroscopic partial meniscectomy) accounted for 91% of the arthroscopic meniscal procedures (Table 5, see Supplementary data). When the procedure group arthroscopic meniscal procedures (KNGD) was differentiated in procedure code KNGD11 and KNGD21, those aged 35–55 years had the highest incidence with KNGD11 and those younger than 35 had the lowest. However, for KNGD21 the highest incidence was observed for those younger than 35 and the lowest for those older than 55 years (Table 6).

Arthroscopic meniscal procedures were typically coded in combination with a diagnosis of “unspecific knee problems” (58%) or “traumatic meniscus tear” (27%). Arthroscopic ACL reconstructions were mostly coded with the diagnoses “lesion/rupture of cruciate ligament” (62%) followed by “unspecific knee problems” (28%) (Table 7, see Supplementary data).

Arthroscopic knee procedures were more often registered for males than females across all procedure categories except for diagnostic arthroscopic procedures. For all procedures except ACL reconstruction, most procedures were registered on patients in their 40s, whereas ACL reconstruction was most often registered for patients in their 20s (Figure 2). The same distribution was present when procedures registered as secondary surgical procedures were removed (Figure 3, see Supplementary data). Patients aged 35–55 years accounted for 47% of the total number of arthroscopic procedures in the years 2006–2018, whereas patients younger than 35 years

Table 2. Primary and secondary procedures in the period 2006–2018 in Denmark. Values are count (%)

| Procedure                        | Total 2006 | Total 2007 | Total 2008 | Total 2009 | Total 2010 | Total 2011 | Total 2012 | Total 2013 | Total 2014 | Total 2015 | Total 2016 | Total 2017 | Total 2018 |
|----------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Diagnoses                        |            |            |            |            |            |            |            |            |            |            |            |            |            |
| Diagnostic arthroscopy           |            |            |            |            |            |            |            |            |            |            |            |            |            |
| Arthroscopic                     |            |            |            |            |            |            |            |            |            |            |            |            |            |
| meniscal surgery                 | 184,782    | 151,614    | 31,168     | 31,168     | 31,168     | 31,168     | 31,168     | 31,168     | 31,168     | 31,168     | 31,168     | 31,168     | 31,168     |
| ACL reconstruction               | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     | 35,942     |
| synovectomy                      | 124,145    | 68,313     | 53,832     | 53,832     | 53,832     | 53,832     | 53,832     | 53,832     | 53,832     | 53,832     | 53,832     | 53,832     | 53,832     |
| cartilage resection              | 51,974     | 22,855     | 29,119     | 29,119     | 29,119     | 29,119     | 29,119     | 29,119     | 29,119     | 29,119     | 29,119     | 29,119     | 29,119     |
| Total                            | 414,253    | 299,267    | 114,986    | 114,986    | 114,986    | 114,986    | 114,986    | 114,986    | 114,986    | 114,986    | 114,986    | 114,986    | 114,986    |

*Diagnostic procedures were included only if they were the only procedure registered on a separate surgery date.*
Table 6. Incidences of the arthroscopic meniscal procedures (KNGD11: arthroscopic partial resection of the meniscus and KNGD21: arthroscopic reinsertion of the meniscus) and mean age at surgery per year from 2006 through 2018 (primary and secondary procedures combined)

| Procedure                  | 2006       | 2007       | 2008       | 2009       | 2010       | 2011       | 2012       | 2013       | 2014       | 2015       | 2016       | 2017       | 2018       |
|----------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Age, mean (SD)             | KNGD11     | KNGD21     | KNGD11     | KNGD21     | KNGD11     | KNGD21     | KNGD11     | KNGD21     | KNGD11     | KNGD21     | KNGD11     | KNGD21     | KNGD11     |
| <35 years                  | 102 (106)  | 107 (110)  | 126 (129)  | 117 (121)  | 119 (119)  | 111 (112)  | 119 (119)  | 107 (111)  | 116 (116)  | 112 (112)  | 111 (111)  | 109 (109)  | 112 (112)  |
| CI                         | (197–106)  | (101–110)  | (117–126)  | (113–122)  | (113–122)  | (107–116)  | (112–122)  | (107–116)  | (95–103)   | (89–99)    | (96–100)   | (96–100)   | (96–100)   |
| 35–55 years                | 168 (175)  | 230 (236)  | 284 (292)  | 319 (324)  | 301 (302)  | 299 (301)  | 297 (299)  | 304 (305)  | 306 (308)  | 300 (302)  | 290 (293)  | 291 (293)  | 289 (290)  |
| CI                         | (330–348)  | (371–390)  | (379–399)  | (495–517)  | (511–533)  | (495–516)  | (481–502)  | (468–508)  | (370–388)  | (304–329)  | (283–299)  | (283–301)  | (283–301)  |
| >55 years                 | 179 (193)  | 222 (236)  | 275 (292)  | 310 (328)  | 293 (301)  | 291 (308)  | 287 (303)  | 285 (302)  | 286 (302)  | 282 (298)  | 277 (292)  | 276 (290)  | 276 (290)  |
| CI                         | (179–193)  | (211–226)  | (222–236)  | (293–308)  | (291–308)  | (291–308)  | (291–308)  | (291–308)  | (291–308)  | (291–308)  | (291–308)  | (291–308)  | (291–308)  |

Figure 2. Number of primary and secondary procedures stratified by sex in the study period (2006–2018).

Trends in the 5 most common arthroscopic knee procedures

A 45% decrease in the incidence of arthroscopic meniscal procedures was observed from 2010 (319 per 10^5 persons/year, 95% CI 314–323) to 2018 (173 per 10^5 persons/year, CI 169–176) (Table 4). The incidence of meniscal procedures decreased for all age groups. However, the relative decrease was largest for those aged 35–55 years (41%) and over 55 years (59%) from 2010 to 2018, compared with those younger than 35 (33%) (Figure 4 and Table 8, see Supplementary data).

A 39% reduction was observed in the incidence of arthroscopic ACL reconstructions from 2010 (57 per 10^5 persons/year, CI 55–59) to 2018 (35 per 10^5 persons/year, CI 34–37), with most of this reduction observed from 2017 to 2018. Patients aged 35–55 years had the largest relative decrease in incidence (55%) from 2010 to 2018 (Figure 4 and Table 8, see Supplementary data).

The incidence of arthroscopic synovectomy followed the same pattern as meniscal procedures whereas the incidence of arthroscopic cartilage resection increased until 2012 and then decreased until 2018. The incidence of diagnostic arthroscopy...
procedures for degenerative meniscal tear procedures and relatively stable over time. Similar reductions in arthroscopic partial meniscectomy (KNGD11), whereas meniscal repair was not.

The incidence of registered meniscal procedures from 2010 to 2018. Arthroscopic ACL reconstructions were at their highest peak of procedures registered in the private sector in 2008, with the lowest proportion observed in 2008. After the peak of procedures registered in the private sector in 2008, the proportion decreased until 2015. From 2016 to 2018, an increase in the proportion of procedures in the private sector was observed (Table 4 and Figure 6).

**Discussion**

The number and annual incidence of arthroscopic meniscal procedures decreased substantially in the period from 2010 to 2018. Arthroscopic ACL reconstructions were at their highest in 2010 and the number and annual incidence have decreased steadily since. A decrease was also observed across other related procedure categories, and, similar to meniscal procedures, the lowest number of procedures and incidences were observed in 2018 for these procedures.

We previously reported a marked increase in the use of arthroscopic meniscal procedures from 2000 to 2008, especially for middle-aged and older patients, despite mounting evidence in the same time period pointing to limited benefit for this age group (3,4). Since then, further evidence from randomized trials has influenced clinical guidelines in advising against knee arthroscopic surgery to treat degenerative meniscal tears (5) or a more restricted selection of patients (6). In the present study, we observed a marked decrease in the incidence of registered meniscal procedures from 2010 to 2018. This decrease was due to a decrease in arthroscopic partial meniscectomy (KNGD11), whereas meniscal repair was relatively stable over time. Similar reductions in arthroscopic procedures for degenerative meniscal tear procedures and meniscal resections have been observed in other countries. For instance, a general reduction in the incidence of arthroscopic partial meniscectomies has been observed in the UK from 2014 to 2017 (17), and in Norway from 2012 to 2016 (18). In Finland, arthroscopic procedures for degenerative meniscal tears have been reported to decrease from 2007 to 2012 (19).

These comparisons should be made with caution due to variations in healthcare systems, coding practices, procedure codes studied, and years of reporting. Nevertheless, the decrease in meniscal procedures across several countries suggests that research evidence on the treatment of degenerative meniscal tears may have influenced clinical practice.

When investigating surgical procedural trends, it is important to consider that temporal changes in individual procedure codes may result from a change in coding practice. This has been observed in the United States and Finland as a simultaneous increase in the coding of one procedure alongside a decrease in another procedure (3,20). We therefore included in this study several other common arthroscopic knee procedural codes typically performed together with meniscal and ACL procedures (i.e., diagnostic arthroscopy, synovectomy, cartilage procedures). As similar trends of decreasing incidence of these procedures were observed we consider it unlikely that the observed decrease in meniscal procedures can be attributed to a shift in coding practice.

Even though we observed a larger relative reduction in the incidence of meniscal procedures for middle-aged (35–55 years) and older patients (over 55 years) compared with younger patients under 35 years, the distribution of patients in the different age groups did not appear to change much over the years, with about 75% of patients being over 35 years throughout the study period (Table 9, see Supplementary data). In spite of the decrease in the incidence of meniscal procedures for the middle-aged and older patients observed in this report, the current levels of this practice remain high in the face of high-level evidence speaking against. Continued efforts are needed to inform patients and health professionals of current evidence to support guideline implementation.

The incidence of arthroscopic synovectomy procedures followed the same trend as the incidence of meniscal procedures. A possible explanation is that around 40% of the arthroscopic synovectomy procedures were performed...
together with meniscal procedures and coded as secondary surgical procedures in the period when the incidence of meniscal procedures was highest (2009–2013) (Figure 4 and Figure 5, see Supplementary data). That said, the number of synovectomies performed, especially as a primary procedure was higher than expected. The most common diagnosis in relation to primary synovectomies was synovitis (32%), unspecified knee problem (25%), other (21%), and osteoarthritis (11%). Further review of surgical records is needed to better understand the indication for this procedure for these unspecified diagnoses.

In 2010, the first randomized controlled trial comparing ACL reconstruction with exercise therapy for patients with ACL tears reported that about half of ACL reconstructions in young adults could be avoided with similar outcomes if following a strategy of initial structured rehabilitation before considering surgery (7). Initial structured exercise before ACL reconstructions has been recommended in Denmark for several years (21). In 2020, the Danish clinical guidelines were published and recommended that the surgery should be considered in patients who do strenuous physical work or do pivoting sports, whereas the non-surgical approach is likely to be sufficient in other patient groups (22). We observed a decrease in the incidence of registered arthroscopic ACL reconstructions for both younger (under 35 years) and middle-aged patients (35–55 years) since 2010, especially from 2017 to 2018. This suggests that the clinical management of persons with ACL tears had begun to incorporate the new evidence before the publication of the new clinical guidelines. Contrary to our findings the number of ACL reconstructions in the UK increased fourfold from 2005 to 2017 in the UK, suggesting a limited impact of recent evidence (23).

The large variation in arthroscopic knee procedure trends over time observed between public and private hospitals in Denmark may be explained by different factors. The most likely reason would be that the arthroscopic knee procedures were influenced by changes in national health policy over the study period. On July 1, 2002 a law was introduced in Denmark that allowed patients to seek care at private hospitals if the waiting list at a public hospital was longer than 2 months for a surgical procedure (24,25). This treatment guarantee was reduced to 1 month on October 1, 2007, which likely is the main driver of the increase in arthroscopic procedures at private hospitals in 2008, shifting patients from the public sector as surgery could not be guaranteed within 1 month (25). Due to shifting governments in Denmark, this treatment guarantee was differentiated from January 1, 2013, meaning that for non-severe diseases (such as many knee surgeries) the treatment guarantee was extended to 2 months, and then changed back to 1 month again on October 1, 2016 (25). For most arthroscopic knee procedures these policy changes coincide with fluctuations in the number of arthroscopic procedures performed, particularly at private hospitals. Other potential factors that could also impact changes in knee procedures are changes in the use of MRI, the use of private health insurance, and the financial reimbursement in the Danish healthcare system (26,27).

Our study has limitations. As for all register-based studies, the results are dependent on the validity and the coverage of the registries. The registration of orthopedic procedure codes in Denmark is considered to have the highest validity and accuracy of all clinical specialties (10). The registration by public hospitals has been assumed to be complete since 2000 (28). However, although reporting of all activity has been mandatory since 2003 from private hospitals and clinics, this registration is known to be incomplete. In 2008, the National Board of Health estimated that 5% of all surgeries were missing from the DNPR (28). Thus, the results of this study could be an underestimation of the number of arthroscopic procedures performed in Denmark between 2006 and 2018. Nevertheless, as the majority of arthroscopic procedures were registered in the public sector, combined with the nationwide registration in DNPR and the use of Danish population data, we expect that the time trends observed in this study are valid and reflect the real-time trends of the period.

In conclusion, we observed a 45% and 39% decrease in the incidence of arthroscopic meniscal procedures and arthroscopic ACL reconstruction from 2010 to 2018. Similar trends were observed for other common arthroscopic knee procedural codes typically performed together with meniscal procedures, which suggests that the potential shift in coding practice is minimal. The reduction in the number of arthroscopic meniscal procedures and ACL reconstructions over time may be a result of research evidence impacting clinical practice.

ML and JBT designed the study. JBT and JS were responsible for the collection of the data. ML performed the statistical analysis in collaboration with JBT. All authors participated in the interpretation of data. ML wrote the first draft of the manuscript. All authors contributed to critically reviewing, editing, and revising the manuscript. JBT is the guarantor.

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Figure 1. Flowchart.
Table 1. Demographic information of patients who had more than 1 arthroscopic surgery. Values are count (%) unless otherwise specified

| Factor | Total | 1 surgery | Multiple surgeries |
|--------|-------|-----------|--------------------|
| More than 1 arthroscopic surgery | | | |
| Patients | 242,113 | 186,917 | 55,196 |
| Procedures | 414,253 | 316,825 | 97,428 |
| Procedure categories | | | |
| Diagnostic arthroscopy | 21,410 (5) | 17,511 (6) | 3,899 (4) |
| Arthroscopic meniscal surgery | 187,782 (44) | 142,503 (45) | 40,279 (41) |
| Arthroscopic ACL reconstruction | 35,942 (9) | 25,496 (8) | 10,446 (11) |
| Arthroscopic synovectomy | 122,145 (29) | 92,315 (29) | 29,830 (31) |
| Arthroscopic cartilage resection | 51,974 (13) | 39,000 (12) | 12,974 (13) |
| Age, mean (SD) | 42 (16) | 43 (16) | 40 (15) |
| Age categories | | | |
| < 35 years | 133,009 (32) | 96,638 (31) | 36,371 (37) |
| 35–55 years | 194,277 (47) | 148,521 (47) | 45,756 (47) |
| > 55 years | 86,967 (21) | 71,666 (23) | 15,301 (16) |
| Sex | | | |
| Female | 186,312 (45) | 142,722 (45) | 43,590 (45) |
| Male | 227,974 (55) | 174,103 (55) | 53,838 (55) |
| Hospital | | | |
| Private hospital | 104,774 (25) | 80,565 (25) | 24,209 (25) |
| Public hospital | 309,479 (75) | 236,260 (75) | 73,219 (75) |

Table 3. Primary and secondary surgical procedures in procedure categories

| Primary surgical procedure | Registered procedures, n (%) |
|---------------------------|------------------------------|
| Secondary surgical procedure | procedures, n (%) |
| Diagnostic arthroscopy | 21,410 (100) |
| Arthroscopic meniscal surgery | 1,017 (< 1) |
| Arthroscopic ACL reconstruction | 1,017 (< 1) |
| Arthroscopic synovectomy | 29,017 (19) |
| Arthroscopic cartilage resection | 11,783 (8) |
| None | 109,457 (72) |
| Arthroscopic ACL reconstruction | 9,172 (26) |
| Arthroscopic meniscal surgery | 60 (< 1) |
| Arthroscopic ACL reconstruction | 60 (< 1) |
| Arthroscopic synovectomy | 1,393 (4) |
| Arthroscopic cartilage resection | 617 (2) |
| None | 23,846 (68) |
| Arthroscopic synovectomy | 4,868 (7) |
| Arthroscopic meniscal surgery | 81 (< 1) |
| Arthroscopic synovectomy | 81 (< 1) |
| Arthroscopic cartilage resection | 5,778 (8) |
| None | 57,526 (84) |
| Arthroscopic cartilage resection | 2,481 (11) |
| Arthroscopic meniscal surgery | < 10 (< 1) |
| Arthroscopic ACL reconstruction | < 10 (< 1) |
| Arthroscopic synovectomy | 5,254 (23) |
| None | 15,117 (66) |

* Percentages of each surgical procedure do not always add up to exactly 100% because the percentages are rounded to the nearest whole number.

* Primary surgical procedure was coded without a secondary surgical procedure.

* Procedure codes were categorized in procedure categories and, therefore, the same primary and secondary surgical procedure could occur.
### Table 5. Number of arthroscopic knee procedures code per year from 2006 through 2018 (primary and secondary procedures combined)

| Procedure: Category | 2006   | 2007   | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | Total  |
|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| KNGA11: Diagnostic arthroscopy | 2,838  | 2,506  | 2,172  | 2,163  | 1,815  | 1,651  | 1,354  | 1,330  | 972    | 853    | 561    | 428    | 368    | 19,011 |
| KNGA1B: Diagnostic arthroscopy | 210    | 301    | 472    | 303    | 266    | 159    | 125    | 152    | 112    | 96     | 72     | 69     | 62     | 2,399  |
| KNGD01: Arthroscopic meniscal surgery | 59     | 61     | 59     | 89     | 59     | 30     | 29     | 44     | 39     | 38     | 60     | 168    | 97     | 832    |
| KNGD11: Arthroscopic meniscal surgery | 10,807 | 11,924 | 12,344 | 15,502 | 16,495 | 15,621 | 15,661 | 15,382 | 14,003 | 9,631  | 6,793  | 5,877  | 166,416 |
| KNGD21: Arthroscopic meniscal surgery | 930    | 788    | 712    | 965    | 1,056  | 1,191  | 1,292  | 1,305  | 1,476  | 1,301  | 1,265  | 1,283  | 1,280  | 14,844 |
| KNGD91: Arthroscopic meniscal surgery | 47     | 36     | 19     | 66     | 74     | 97     | 44     | 86     | 46     | 34     | 45     | 39     | 57     | 690    |
| KNGE45: Arthroscopic ACL reconstruction | 1,245  | 1,154  | 987    | 1,145  | 923    | 682    | 445    | 438    | 457    | 405    | 505    | 368    | 194    | 8,948  |
| KNGE45B: Arthroscopic ACL reconstruction | 88     | 82     | 137    | 88     | 107    | 18     | 23     | 23     | <10    | 12     | 16     | 23     | 23     | 646    |
| KNGE45C: Arthroscopic ACL reconstruction | 399    | 331    | 250    | 216    | 213    | 142    | 162    | 137    | 199    | 212    | 216    | 220    | 256    | 2,953  |
| KNGE45D: Arthroscopic ACL reconstruction | 861    | 913    | 863    | 1,303  | 1,546  | 1,709  | 1,739  | 1,937  | 1,805  | 1,712  | 1,580  | 1,451  | 1,106  | 18,525 |
| KNGE45E: Arthroscopic ACL reconstruction | 42     | 63     | 33     | 98     | 62     | 47     | 53     | 48     | 76     | 97     | 156    | 193    | 250    | 1,218  |
| KNGE45F: Arthroscopic ACL reconstruction | 28     | 36     | 27     | 34     | 75     | 93     | 118    | 128    | 105    | 99     | 88     | 98     | 1,081  |
| KNGE45G: Arthroscopic ACL reconstruction | 47     | 46     | 34     | 71     | 97     | 74     | 78     | 70     | 42     | 47     | 36     | 25     | 19     | 696    |
| KNGE45H: Arthroscopic ACL reconstruction | <10    | <10    | <10    | <10    | 12     | 17     | 18     | 17     | 36     | 49     | 66     | 99     | 33     | 380    |
| KNGE55: Arthroscopic ACL reconstruction | 208    | 232    | 229    | 159    | 141    | 82     | 75     | 84     | 71     | 59     | 67     | 66     | 52     | 1,525  |
| KNGF01: Arthroscopic synovectomy | 675    | 892    | 1,008  | 812    | 503    | 487    | 747    | 461    | 364    | 201    | 193    | 159    | 7,896  |
| KNGF11: Arthroscopic synovectomy | 7,846  | 8,525  | 7,802  | 10,431 | 10,944 | 10,778 | 11,102 | 10,417 | 9,642  | 7,840  | 6,828  | 6,305  | 5,446  | 114,506|
| KNGF31: Arthroscopic cartilage resection | 3,588  | 3851   | 3,613  | 4,603  | 4,789  | 4,848  | 5,108  | 4,731  | 4,308  | 3,574  | 3,100  | 2,969  | 2,892  | 51,974 |
| Total | 29,827 | 31,749 | 30,770 | 38,360 | 39,486 | 37,942 | 37,913 | 37,076 | 33,883 | 28,494 | 24,504 | 22,780 | 21,469 | 414,253|

### Table 7. Diagnosis coded in combination with the primary surgical procedure. The action diagnosis was used as this is the most important diagnosis for hospitalization per patient. Values are count (%)

| Factor | Total no. of primary procedures | Old meniscus tear | Traumatic meniscus tear | Unspecific knee problems | Osteoarthritis | Lesion/rupture of cruciate ligament | Synovitis or tenosynovitis | Other | Missing |
|--------|--------------------------------|-------------------|-------------------------|-------------------------|----------------|-----------------------------------|---------------------------|-------|---------|
| Diagnostic arthroscopy | 21,410 | <10 (<1) | 1,408 (7) | 7,381 (34) | 4,082 (19) | 1,075 (5) | 647 (3) | 6,801 (32) | <10 (<1) |
| Arthroscopic meniscal surgery | 151,614 | 146 (<1) | 41,218 (27) | 87,543 (58) | 9,407 (6) | 3,941 (3) | 1,303 (1) | 8,005 (5) | 51 (<1) |
| Arthroscopic ACL reconstruction | 35,075 | <10 (<1) | 862 (2) | 9,725 (28) | 58 (<1) | 21,762 (62) | 46 (<1) | 2,589 (7) | 28 (<1) |
| Arthroscopic cartilage resection | 22,855 | <10 (<1) | 1,375 (6) | 5,863 (26) | 5,527 (24) | 501 (2) | 793 (3) | 8,780 (38) | <10 (<1) |
| Sum of registered procedures/ diagnoses | 299,267 | 185 (<1) | 48,996 (16) | 127,496 (43) | 26,925 (9) | 12,780 (4) | 128 (<1) | 40,812 (14) | 128 (<1) |

Diagnoses coded according to the International Classification of Diseases and Related Health Problems (ICD-10 codes)

- a ICD-10 code—Old meniscus tear: DS232.
- b ICD-10 code—Traumatic tear: DS832.
- c ICD-10 codes—Unspecific knee problems: DM23 and DM24.
- d ICD-10 codes—Osteoarthritis DM17, DM190, and, DM199.
- e ICD-10 codes—Lesion/rupture of cruciate ligament: DS8:3.
- f ICD-10 codes—Synovitis or tenosynovitis: DM658, DM659, DM659B, DM672, DM673, DM678.
- g Not all surgical procedures had a diagnosis coded in combination.

Figure 3. Number of primary procedures stratified by sex in the study period (2006–2018).
Table 8. Incidences (per 10^5 persons/year) (95% CI) of procedure categories per year from 2006 through 2018 (primary and secondary procedures combined)

| Factor                        | 2006      | 2007      | 2008      | 2009      | 2010      | 2011      | 2012      | 2013      | 2014      | 2015      | 2016      | 2017      | 2018      |
|-------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Arthroscopic cartilage resection | 35–55 years | 56 (43)   | 56 (40)   | 53 (39)   | 48 (34)   | 42 (31)   | 37 (30)   | 34 (28)   | 31 (25)   | 27 (21)   | 23 (19)   | 19 (16)   | 16 (14)   |
|                               | > 55 years | 71 (57)   | 70 (55)   | 69 (54)   | 65 (48)   | 61 (46)   | 57 (43)   | 53 (40)   | 49 (36)   | 44 (33)   | 39 (31)   | 35 (28)   | 31 (24)   |

Table 9. Number of arthroscopic knee procedure categories per year from 2006 through 2018 in age categories (primary and secondary procedures combined). Values are count (%)

| Age category     | 2006      | 2007      | 2008      | 2009      | 2010      | 2011      | 2012      | 2013      | 2014      | 2015      | 2016      | 2017      | 2018      |
|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Diagnostic arthroscopy | 35–55 years | 56 (37)   | 54 (36)   | 52 (35)   | 49 (33)   | 46 (31)   | 43 (30)   | 40 (28)   | 37 (26)   | 34 (24)   | 31 (22)   | 29 (20)   | 27 (18)   |
|                  | > 55 years | 72 (42)   | 70 (39)   | 68 (36)   | 65 (33)   | 62 (30)   | 59 (28)   | 56 (26)   | 53 (24)   | 50 (22)   | 47 (20)   | 44 (18)   | 41 (16)   |

Arthroscopic ACL reconstruction

| Age category     | 2006      | 2007      | 2008      | 2009      | 2010      | 2011      | 2012      | 2013      | 2014      | 2015      | 2016      | 2017      | 2018      |
|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Arthroscopic ACL reconstruction | 35–55 years | 55 (30)   | 53 (29)   | 51 (28)   | 49 (26)   | 47 (24)   | 45 (22)   | 43 (20)   | 41 (18)   | 39 (16)   | 37 (14)   | 35 (12)   | 33 (10)   |
|                  | > 55 years | 70 (43)   | 68 (39)   | 66 (36)   | 64 (33)   | 62 (30)   | 60 (28)   | 58 (26)   | 56 (24)   | 54 (22)   | 52 (20)   | 50 (18)   | 48 (16)   |

Arthroscopic ACL reconstruction

| Age category     | 2006      | 2007      | 2008      | 2009      | 2010      | 2011      | 2012      | 2013      | 2014      | 2015      | 2016      | 2017      | 2018      |
|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Arthroscopic ACL reconstruction | 35–55 years | 54 (29)   | 52 (28)   | 50 (27)   | 48 (26)   | 46 (24)   | 44 (22)   | 42 (20)   | 40 (18)   | 38 (16)   | 36 (14)   | 34 (12)   | 32 (10)   |
|                  | > 55 years | 69 (42)   | 67 (39)   | 65 (36)   | 63 (33)   | 61 (30)   | 59 (28)   | 57 (26)   | 55 (24)   | 53 (22)   | 51 (20)   | 49 (18)   | 47 (16)   |
Figure 5. Incidence (per 10\(^5\) person/year) of the 5 most common types of arthroscopic knee procedures in the years 2006–2018 in Denmark.