

# 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<sup>5</sup> persons/year, 95% CI 314–323) and the lowest in 2018 (173 per 10<sup>5</sup> 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 Statistic 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 Statistic 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<sup>5</sup> 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 2. Primary and secondary procedures in the period 2006–2018 in Denmark. Values are count (%)**

Procedure	Total	Surgical procedure	
		primary	secondary
Diagnostic arthroscopy <sup>a</sup>	21,410	21,410 (100)	–
Arthroscopic			
meniscal surgery	182,782	151,614 (83)	31,168 (17)
ACL reconstruction	35,942	35,075 (98)	867 (2)
synovectomy	122,145	68,313 (56)	53,832 (44)
cartilage resection	51,974	22,855 (44)	29,119 (56)
Total	414,253	299,267	114,986

<sup>a</sup> Diagnostic procedures were included only if they were the only procedure registered on a separate surgery date.

more than 1 knee arthroscopic surgery during the 13-year period. The patients with 1 surgery and multiple surgeries were similar in procedure categories, sex, and sector distribution. However, patients with multiple surgeries were somewhat younger compared with patients with only 1 surgery (Table 1, see Supplementary data). The majority of procedures (72%) were coded as the primary surgical procedure (Table 2), and most surgeries consisted of only 1 procedure code (Table 3, see Supplementary data).

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).

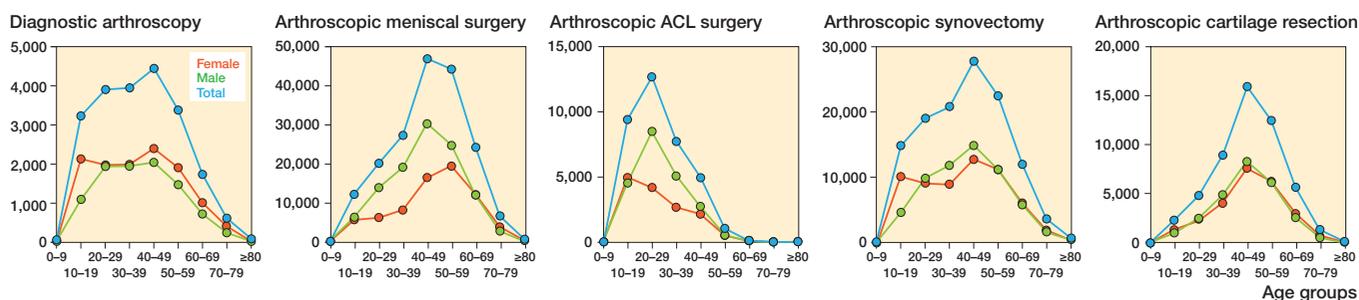
Arthroscopic knee procedures were more often registered for males than females across all procedure categories except for diagnostic arthroscopic procedures. For all procedures except ACL reconstruction, most procedures were registered on patients in their 40s, whereas ACL reconstruction was most often 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 4. Incidences of procedure categories, number of procedures, mean age at surgery, sex, and sector distribution 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
Incidence per 10 <sup>5</sup> persons/year (95% CI)													
Diagnostic													
arthroscopy	56	51	48	45	38	32	26	26	19	17	11	8.6	7.4
(CI)	(54–58)	(50–54)	(46–50)	(43–46)	(36–39)	(31–34)	(25–28)	(25–28)	(18–20)	(16–18)	(10–12)	(7.9–9.4)	(6.7–8.2)
Arthroscopic													
meniscal surgery	214	235	239	301	319	308	304	300	276	230	192	178	173
(CI)	(210–218)	(231–239)	(235–243)	(296–305)	(314–323)	(303–312)	(300–309)	(295–304)	(271–280)	(226–234)	(188–196)	(175–182)	(169–176)
ACL reconstruction	54	53	47	56	57	51	48	51	50	48	48	44	35
(CI)	(52–56)	(51–54)	(45–49)	(54–58)	(55–59)	(50–53)	(47–50)	(49–53)	(48–52)	(46–49)	(46–50)	(42–46)	(34–37)
synovectomy	159	172	160	209	212	203	207	199	179	145	123	113	105
(CI)	(155–162)	(169–176)	(157–164)	(205–213)	(208–216)	(199–206)	(204–211)	(195–203)	(176–183)	(142–148)	(120–126)	(110–115)	(103–108)
cartilage resection	66	71	66	83	86	87	91	84	76	63	54	52	50
(CI)	(64–68)	(68–73)	(64–68)	(81–86)	(84–89)	(85–90)	(89–94)	(82–87)	(74–79)	(61–65)	(52–56)	(50–53)	(48–52)
Procedures, n	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
Age, mean (SD)	41 (15)	42 (15)	42 (16)	42 (15)	43 (16)	43 (16)	43 (16)	43 (16)	42 (16)	41 (16)	41 (16)	41 (16)	42 (16)
Diagnostic													
arthroscopy	38 (16)	38 (16)	39 (16)	39 (16)	38 (16)	39 (16)	39 (17)	39 (16)	39 (17)	39 (17)	38 (17)	39 (17)	39 (18)
Arthroscopic													
meniscal surgery	44 (15)	45 (15)	46 (15)	46 (15)	46 (15)	46 (15)	46 (15)	46 (15)	45 (15)	44 (15)	43 (15)	44 (15)	44 (15)
ACL reconstruction	30 (11)	29 (10)	29 (11)	29 (11)	29 (11)	28 (11)	27 (11)	27 (10)	27 (10)	26 (10)	27 (10)	27 (10)	27 (11)
synovectomy	41 (16)	41 (16)	41 (16)	41 (16)	41 (16)	41 (16)	41 (17)	41 (16)	41 (16)	40 (16)	40 (16)	41 (16)	42 (16)
cartilage resection	44 (13)	44 (14)	45 (14)	45 (13)	45 (14)	45 (13)	46 (13)	46 (13)	45 (14)	45 (14)	44 (14)	45 (13)	45 (13)
Sex, n (%)													
Female	13,379 (45)	14,404 (45)	14,005 (46)	17,171 (45)	18,192 (46)	17,501 (46)	17,378 (46)	16,739 (45)	14,942 (44)	12,458 (44)	10,618 (43)	10,014 (44)	9,511 (44)
Male	16,484 (55)	17,345 (55)	16,765 (54)	21,189 (55)	21,294 (54)	20,441 (54)	20,535 (54)	20,337 (55)	18,941 (56)	16,036 (56)	13,886 (57)	12,766 (56)	11,958 (55)
Hospital, n (%)													
Private hospital	2,720 (9)	5,703 (18)	10,652 (35)	11,689 (30)	11,073 (28)	9,902 (26)	9,538 (25)	9,568 (26)	8,377 (25)	6,838 (24)	5,879 (24)	5,977 (26)	6,858 (32)
Public hospital	27,107 (93)	26,046 (82)	20,118 (65)	26,671 (70)	28,413 (72)	28,040 (74)	28,375 (75)	27,508 (74)	25,506 (75)	21,656 (76)	18,625 (76)	16,803 (74)	14,611 (68)

**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	45 (14)	46 (14)	46 (14)	47 (14)	47 (14)	47 (14)	48 (14)	47 (14)	47 (14)	46 (14)	46 (14)	46 (14)	47 (14)
KNGD21	29 (12)	29 (12)	29 (12)	29 (12)	27 (11)	27 (11)	27 (11)	27 (11)	27 (10)	27 (10)	27 (10)	27 (11)	28 (11)
Incidence per 10 <sup>5</sup> persons/year (95% CI)													
KNGD11	195	218	224	280	297	284	280	274	248	205	168	153	148
(CI)	(191–198)	(214–222)	(212–229)	(276–285)	(293–302)	(280–288)	(276–284)	(269–278)	(244–252)	(202–209)	(165–172)	(149–156)	(145–151)
KNGD21	17	14	13	17	19	21	23	23	26	23	22	22	22
(CI)	(16–18)	(13–15)	(12–14)	(16–19)	(18–20)	(20–23)	(22–24)	(22–24)	(25–28)	(22–24)	(21–23)	(21–23)	(21–23)
KNGD11													
< 35 years	102	106	107	121	126	117	119	118	111	99	86	76	68
(CI)	(197–106)	(101–110)	(102–111)	(117–126)	(122–131)	(113–122)	(115–124)	(113–122)	(107–116)	(95–103)	(82–89)	(73–80)	(64–71)
35–55 years	339	380	388	506	522	505	492	497	453	379	318	291	292
(CI)	(330–348)	(371–390)	(379–398)	(495–517)	(511–533)	(495–516)	(481–502)	(486–508)	(443–463)	(370–388)	(309–327)	(283–299)	(283–301)
> 55 years	186	218	230	284	319	301	299	275	241	187	142	130	128
(CI)	(179–193)	(211–226)	(222–238)	(275–292)	(310–328)	(293–310)	(291–308)	(267–283)	(233–248)	(180–193)	(136–147)	(125–135)	(123–133)
KNGD21													
< 35 years	28	24	21	29	31	38	42	42	49	43	41	41	39
(CI)	(26–30)	(22–27)	(20–23)	(27–31)	(31–36)	(35–40)	(40–45)	(40–45)	(46–52)	(40–46)	(38–44)	(39–44)	(36–41)
35–55 years	15	12	12	16	15	17	18	18	19	17	17	16	20
(CI)	(14–17)	(10–14)	(10–13)	(14–18)	(13–17)	(15–19)	(16–20)	(16–20)	(17–22)	(15–19)	(15–19)	(14–18)	(18–22)
> 55 years	1.6	1.5	1.2	2.0	1.7	1.7	0.9	1.2	0.8	0.7	0.4	1.1	1.2
(CI)	(1.0–2.3)	(1.0–2.2)	(0.8–1.9)	(1.4–2.8)	(1.1–2.4)	(1.1–2.5)	(0.5–1.5)	(0.7–1.9)	(0.4–1.3)	(0.4–1.2)	(0.2–0.8)	(0.7–1.7)	(0.7–1.8)



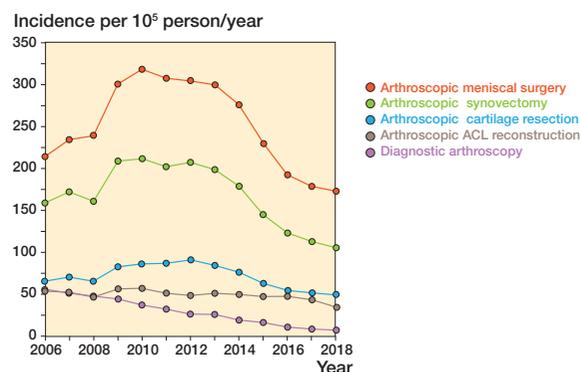
**Figure 2.** Number of primary and secondary procedures stratified by sex in the study period (2006–2018).

and patients older than 55 years accounted for 32% and 21%, respectively (Table 1, see Supplementary data).

### 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<sup>5</sup> persons/year, 95% CI 314–323) to 2018 (173 per 10<sup>5</sup> 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<sup>5</sup> persons/year, CI 55–59) to 2018 (35 per 10<sup>5</sup> 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).



**Figure 4.** Incidence (per 10<sup>5</sup> person/year) of the 5 most common types of arthroscopic knee procedure in the years 2006–2018 in Denmark (primary and secondary procedures combined).

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

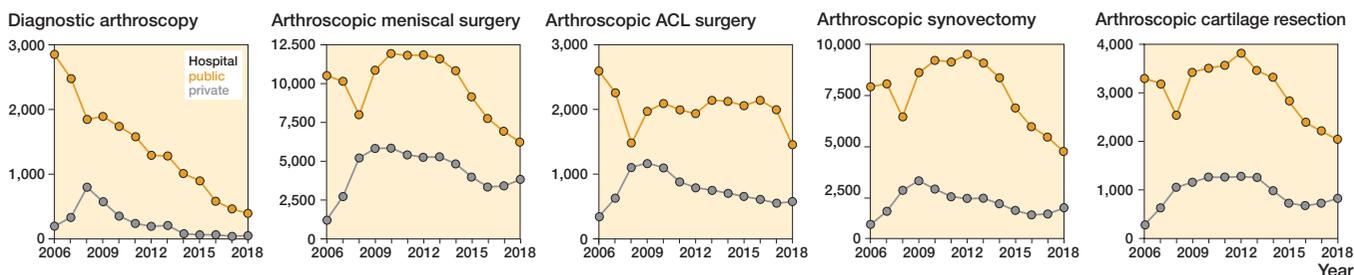


Figure 6. Number of procedures stratified by sector (public or private) in the study period from 2006–2018 (primary and secondary procedures combined).

decreased during the study period (Figure 4 and Table 8, see Supplementary data). The incidences followed the same pattern for arthroscopic meniscal surgery and arthroscopic ACL reconstructions when the procedures registered as secondary surgical procedures were removed (Figure 5, see Supplementary data).

### Private and public sector procedures

The majority (75%) of arthroscopic procedures in Denmark were registered in the public sector. The proportion of all procedures registered in the public sector decreased from 2006 to 2018, 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 2011 in Denmark (2), 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 variation 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 time 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%), unspecific 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 unspecific 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 health-care 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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## Supplementary data

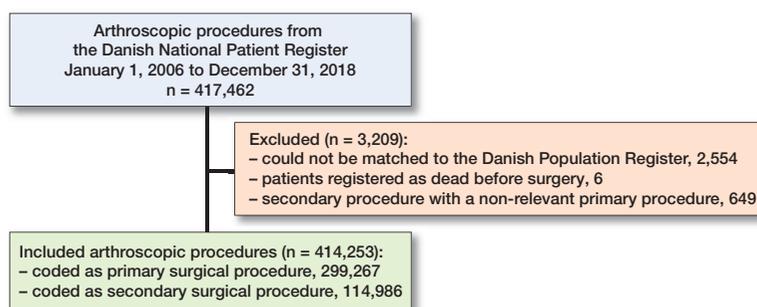


Figure 1. Flowchart.

**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 Secondary surgical procedure	Registered procedures, n (%) <sup>a</sup>
Diagnostic arthroscopy	
None <sup>b</sup>	21,410 (100)
Arthroscopic meniscal surgery	
Arthroscopic meniscal surgery <sup>c</sup>	1,017 (< 1)
Arthroscopic ACL reconstruction	340 (< 1)
Arthroscopic synovectomy	29,017 (19)
Arthroscopic cartilage resection	11,783 (8)
None <sup>b</sup>	109,457 (72)
Arthroscopic ACL reconstruction	
Arthroscopic meniscal surgery	9,172 (26)
Arthroscopic ACL reconstruction <sup>c</sup>	47 (< 1)
Arthroscopic synovectomy	1,393 (4)
Arthroscopic cartilage resection	617 (2)
None <sup>b</sup>	23,846 (68)
Arthroscopic synovectomy	
Arthroscopic meniscal surgery	4,868 (7)
Arthroscopic ACL reconstruction	60 (< 1)
Arthroscopic synovectomy <sup>c</sup>	81 (< 1)
Arthroscopic cartilage resection	5,778 (8)
None <sup>b</sup>	57,526 (84)
Arthroscopic cartilage resection	
Arthroscopic meniscal surgery	2,481 (11)
Arthroscopic ACL reconstruction	< 10 (< 1)
Arthroscopic synovectomy	5,254 (23)
None <sup>b</sup>	15,117 (66)

<sup>a</sup> Percentages of each surgical procedure do not always add up to exactly 100% because the percentages are rounded to the nearest whole number.

<sup>b</sup> Primary surgical procedure was coded without a secondary surgical procedure.

<sup>c</sup> 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
KNGA11B: 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	10,607	11,924	12,344	15,502	16,495	15,821	15,661	15,382	14,003	11,676	9,631	8,793	8,577	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	132	105	99	88	98	1,061
KNGE45G: Arthroscopic ACL reconstruction	47	46	34	71	97	74	78	70	42	47	36	25	19	686
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	1,117	812	503	487	747	461	384	201	193	159	7,639
KNGF11: Arthroscopic synovectomy	7,946	8,525	7,802	10,431	10,944	10,778	11,102	10,417	9,642	7,840	6,828	6,305	5,946	114,506
KNGF31: Arthroscopic cartilage resection	3,588	3,851	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 <sup>a</sup>	Traumatic meniscus tear <sup>b</sup>	Unspecific knee problems <sup>c</sup>	Osteo-arthritis <sup>d</sup>	Lesion/rupture of cruciate ligament <sup>e</sup>	Synovitis or tenosynovitis <sup>f</sup>	Other	Missing <sup>g</sup>
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 synovectomy	68,313	18 (< 1)	4,133 (6)	16,984 (25)	7,851 (11)	2,978 (4)	21,679 (32)	14,637 (21)	33 (< 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)	30,257 (10)	24,468 (8)	40,812 (14)	128 (< 1)

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

- <sup>a</sup> ICD-10 code—Old meniscus tear: DS232.
- <sup>b</sup> ICD-10 code—Traumatic tear: DS832.
- <sup>c</sup> ICD-10 codes—Unspecific knee problems: DM23 and DM24.
- <sup>d</sup> ICD-10 codes—Osteoarthritis DM17, DM190, and, DM199.
- <sup>e</sup> ICD-10 codes—Lesion/rupture of cruciate ligament: DS83.
- <sup>f</sup> ICD-10 codes—Synovitis or tenosynovitis: DM658, DM659, DM659B, DM672, DM673, DM678.
- <sup>g</sup> Not all surgical procedures had a diagnosis coded in combination.

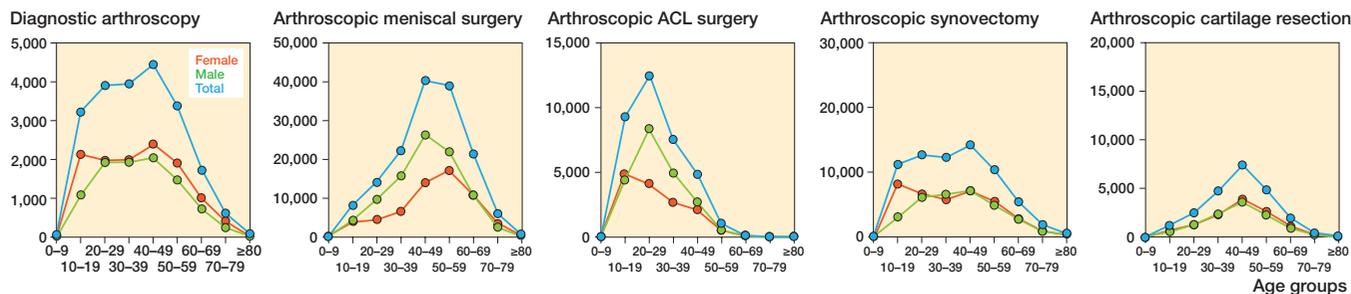


Figure 3. Number of primary procedures stratified by sex in the study period (2006–2018).

Table 8. Incidences (per 10<sup>5</sup> 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
Diagnostic arthroscopy													
< 35 years	57	54	46	43	39	31	26	25	20	17	12	8.4	7.7
(CI)	(54–60)	(51–57)	(43–49)	(40–45)	(37–42)	(29–34)	(24–28)	(23–27)	(18–21)	(16–19)	(10–13)	(7.3–9.7)	(6.6–8.9)
35–55 years	77	68	69	63	53	46	37	38	26	23	16	12	9.8
(CI)	(73–81)	(64–72)	(65–74)	(59–67)	(49–56)	(43–50)	(34–40)	(35–41)	(24–29)	(20–25)	(14–18)	(11–14)	(8.4–12)
> 55 years	32	30	28	29	19	20	17	17	12	10	5.6	5.3	4.8
(CI)	(29–35)	(28–33)	(26–31)	(26–32)	(17–22)	(18–23)	(15–19)	(15–19)	(10–14)	(8.7–12)	(4.5–6.9)	(4.3–6.5)	(3.9–6.0)
Arthroscopic meniscal surgery													
< 35 years	131	131	129	153	162	157	162	163	162	143	128	121	108
(CI)	(127–136)	(127–136)	(124–134)	(148–158)	(157–168)	(152–162)	(157–168)	(158–168)	(157–167)	(139–148)	(124–133)	(116–125)	(104–112)
35–55 years	357	395	403	526	540	526	511	518	474	398	338	313	316
(CI)	(348–366)	(385–405)	(393–413)	(515–537)	(529–551)	(515–537)	(500–522)	(507–529)	(464–485)	(388–408)	(329–347)	(305–322)	(308–325)
> 55 years	189	221	233	288	322	304	301	277	242	188	143	133	132
(CI)	(182–196)	(214–229)	(225–240)	(279–296)	(313–331)	(296–313)	(292–309)	(269–285)	(235–250)	(182–195)	(137–149)	(128–139)	(126–137)
Arthroscopic ACL reconstruction													
< 35 years	83	82	76	92	94	88	85	92	93	89	87	82	64
(CI)	(79–87)	(79–86)	(73–80)	(88–96)	(91–98)	(85–92)	(82–89)	(89–96)	(89–97)	(85–93)	(85–92)	(78–85)	(61–67)
35–55 years	59	56	46	57	57	47	43	42	38	36	37	34	28
(CI)	(55–63)	(53–60)	(43–49)	(54–61)	(54–61)	(44–50)	(39–46)	(39–46)	(36–42)	(33–39)	(34–40)	(31–37)	(26–31)
> 55 years	2.3	1.7	2.2	1.7	1.7	1.6	0.9	1.5	1.3	0.8	0.9	0.9	1.1
(CI)	(1.6–3.2)	(1.1–2.5)	(1.5–3.1)	(1.1–2.5)	(1.1–2.4)	(1.0–2.3)	(0.5–1.5)	(1.0–2.3)	(0.8–1.9)	(0.5–1.4)	(0.5–1.4)	(0.5–1.5)	(0.7–1.8)
Arthroscopic synovectomy													
< 35 years	134	142	134	174	178	170	173	165	150	133	111	95	87
(CI)	(129–138)	(137–147)	(129–139)	(168–179)	(173–184)	(164–175)	(168–178)	(160–170)	(145–155)	(128–138)	(107–116)	(91–99)	(83–90)
35–55 years	240	260	241	323	320	305	309	306	280	220	189	183	172
(CI)	(232–247)	(252–268)	(233–248)	(314–332)	(312–329)	(297–314)	(300–317)	(298–315)	(272–288)	(213–227)	(182–196)	(176–190)	(166–179)
> 55 years	109	125	115	142	149	145	154	140	122	89	76	72	70
(CI)	(104–115)	(120–131)	(110–120)	(136–148)	(143–155)	(139–151)	(148–160)	(135–146)	(116–127)	(84–94)	(72–80)	(68–76)	(66–74)
Arthroscopic cartilage resection													
< 35 years	37	39	33	40	40	38	40	39	38	32	29	26	24
(CI)	(34–39)	(37–42)	(31–35)	(37–42)	(37–42)	(36–41)	(37–42)	(36–41)	(36–41)	(30–35)	(27–31)	(24–28)	(22–26)
35–55 years	125	131	126	163	167	175	180	168	153	126	113	110	106
(CI)	(119–130)	(126–137)	(120–131)	(156–169)	(161–173)	(169–182)	(173–186)	(162–174)	(147–159)	(121–132)	(108–118)	(105–115)	(101–111)
> 55 years	48	53	52	66	72	68	77	66	56	45	34	34	35
(CI)	(45–52)	(50–57)	(49–56)	(62–70)	(68–76)	(64–72)	(73–81)	(62–70)	(53–60)	(42–48)	(31–37)	(31–36)	(32–37)

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 years	1,336 (44)	1,249 (45)	1,080 (41)	997 (40)	915 (44)	732 (40)	603 (41)	588 (33)	458 (42)	409 (43)	279 (44)	204 (41)	187 (43)
35–55 years	1,244 (41)	1,101 (39)	1,132 (43)	1,025 (42)	865 (42)	758 (42)	611 (41)	621 (45)	431 (40)	368 (39)	258 (41)	201 (40)	158 (37)
> 55 years	468 (15)	457 (16)	432 (16)	444 (18)	301 (14)	320 (18)	265 (18)	273 (22)	195 (18)	172 (18)	96 (15)	92 (19)	85 (20)
Total	3,048	2,807	2,644	2,466	2,081	1,810	1,479	1,482	1,084	949	633	497	430
Arthroscopic meniscal surgery													
< 35 years	3,071 (26)	3,069 (24)	3,018 (23)	3,575 (22)	3,802 (21)	3,676 (21)	3,819 (22)	3,823 (23)	3,811 (24)	3,399 (26)	3,072 (28)	2,910 (28)	2,619 (26)
35–55 years	5,775 (50)	6,415 (50)	6,575 (50)	8,605 (52)	8,847 (50)	8,631 (50)	8,366 (49)	8,462 (50)	7,731 (50)	6,481 (50)	5,486 (50)	5,057 (49)	5,072 (51)
> 55 years	2,797 (24)	3,325 (26)	3,541 (27)	4,442 (27)	5,035 (28)	4,832 (28)	4,841 (28)	4,532 (27)	4,022 (26)	3,169 (24)	2,443 (22)	2,316 (23)	2,320 (23)
Total	11,643	12,809	13,134	16,622	17,684	17,139	17,026	16,817	15,564	13,049	11,001	10,283	10,011
Arthroscopic ACL reconstruction													
< 35 years	1,937 (66)	1,924 (67)	1,786 (70)	2,159 (69)	2,211 (70)	2,068 (72)	2,002 (74)	2,167 (75)	2,177 (77)	2,106 (78)	2,121 (77)	1,972 (78)	1,555 (77)
35–55 years	956 (33)	916 (32)	749 (29)	936 (30)	939 (30)	771 (27)	695 (26)	690 (24)	626 (22)	578 (21)	605 (22)	545 (22)	456 (22)
> 55 years	34 (1)	25 (1)	34 (1)	26 (1)	26 (1)	25 (1)	14 (1)	25 (1)	21 (1)	14 (1)	15 (1)	16 (1)	20 (1)
Total	2,927	2,865	2,569	3,121	3,176	2,864	2,711	2,882	2,824	2,698	2,741	2,533	2,031
Arthroscopic synovectomy													
< 35 years	3,123 (36)	3,314 (35)	3,134 (36)	4,070 (35)	4,179 (36)	3,971 (35)	4,054 (35)	3,867 (35)	3,520 (35)	3,151 (38)	2,665 (38)	2,293 (35)	2,102 (34)
35–55 years	3,877 (45)	4,219 (45)	3,926 (45)	5,280 (46)	5,249 (45)	5,011 (44)	5,053 (44)	5,004 (45)	4,564 (45)	3,577 (43)	3,067 (44)	2,952 (45)	2,766 (45)
> 55 years	1,621 (19)	1,884 (20)	1,750 (20)	2,198 (19)	2,328 (20)	2,299 (20)	2,482 (21)	2,293 (21)	2,019 (20)	1,496 (18)	1,297 (18)	1,253 (19)	1,237 (20)
Total	8,621	9,417	8,810	11,548	11,756	11,281	11,589	11,164	10,103	8,224	7,029	6,498	6,105
Arthroscopic cartilage resection													
< 35 years	861 (24)	919 (24)	769 (21)	925 (20)	930 (19)	890 (18)	928 (18)	907 (19)	893 (21)	763 (21)	696 (22)	616 (21)	583 (20)
35–55 years	2,015 (56)	2,134 (55)	2,048 (57)	2,659 (58)	2,731 (57)	2,876 (59)	2,941 (58)	2,744 (58)	2,486 (58)	2,058 (58)	1,830 (59)	1,772 (60)	1,700 (59)
> 55 years	712 (20)	798 (21)	796 (22)	1,019 (22)	1,128 (24)	1,082 (22)	1,239 (24)	1,080 (23)	929 (22)	753 (21)	574 (19)	581 (20)	609 (21)
Total	3,588	3,851	3,613	4,603	4,789	4,848	5,108	4,731	4,308	3,574	3,100	2,969	2,892

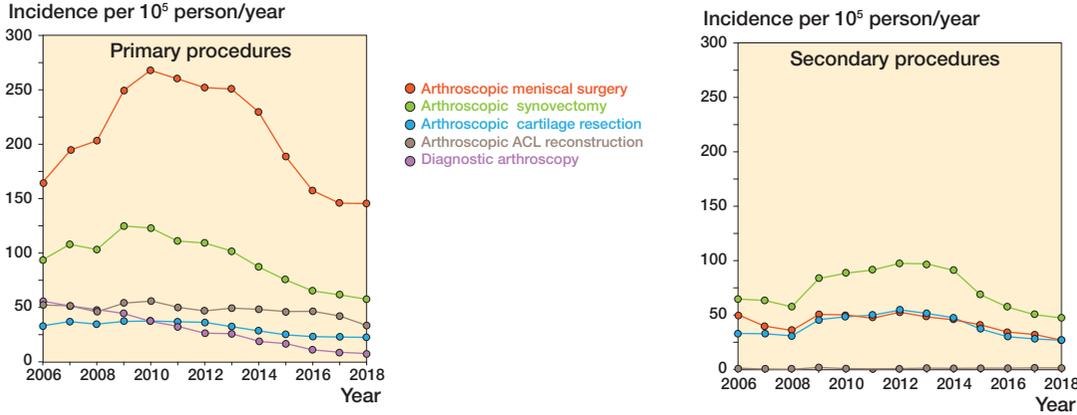


Figure 5. Incidence (per 10<sup>5</sup> person/year) of the 5 most common types of arthroscopic knee procedures in the years 2006–2018 in Denmark.