

BMJ Open Incidence of knee cartilage surgery in Norway, 2008–2011

Cathrine Nørstad Engen,^{1,2} Asbjørn Årøen,^{1,3,4} Lars Engebretsen^{1,2,5}

To cite: Engen CN, Årøen A, Engebretsen L. Incidence of knee cartilage surgery in Norway, 2008–2011. *BMJ Open* 2015;5:e008423. doi:10.1136/bmjopen-2015-008423

► Prepublication history and additional material is available. To view please visit the journal (<http://dx.doi.org/10.1136/bmjopen-2015-008423>).

Received 7 April 2015

Revised 31 July 2015

Accepted 25 September 2015

ABSTRACT

Objective: A systematic and long-term data collection on the treatment of focal cartilage defects (FCDs) of the knee is needed. This can be achieved through the foundation of a National Knee Cartilage Defect Registry. The aim of this study was to establish the nationwide burden of knee cartilage surgery, defined as knee surgery in patients with an FCD. We also aimed to identify any geographical differences in incidence rates, patient demographics or trends within this type of surgery.

Setting: A population-based study with retrospective identification of patients undergoing knee cartilage surgery in Norway through a mandatory public health database from 2008 to 2011.

Participants: We identified all patients undergoing cartilage surgery, or other knee surgery in patients with an FCD. All eligible surgeries were assessed for inclusion on the basis of certain types of ICD-10 and NOMESKO Classification of Surgical Procedures codes.

Primary and secondary outcome measures: The variables were diagnostic and surgical codes, geographic location of the performing hospital, age and sex of the patients. Yearly incidence and incidence rates were calculated. Age-adjusted incidences for risk ratios and ORs between geographical areas were also calculated.

Results: A total of 10 830 cases of knee cartilage surgery were identified, with slight but significant decreases from 2008 to 2011 ($p < 0.0003$). The national incidence rate was 56/100 000 inhabitants and varied between regions, counties and hospitals. More than 50% of the procedures were palliative and nearly 400 yearly procedures were reparative or restorative.

Conclusions: Knee cartilage surgery is common in Norway, counting 2500 annual cases with an age-adjusted incidence rate of 68.8/100 000 inhabitants. There are significant geographical variations in incidence and trends of surgery and in trends between public and private hospitals. We suggest that a national surveillance system would be beneficial for the future evaluation of the treatment of these patients.

Strengths and limitations of this study

- This cohort study presents the national burden of knee cartilage surgery in Norway.
- The geographical differences and differences in trends are reliable as the data collection is mandatory for all hospitals.
- ICD codes were used for inclusion and this represents a limitation, as there are no specific codes for 'non-acute focal cartilage defect', which leads to unspecific diagnosis. This limitation is partly corrected for by adding NOMESKO Classification of Surgical Procedures surgical codes to the inclusion criteria.
- Compliance and validity are limitations for the data quality in most registry studies. The register included in the present study has previously been shown to both overestimate and underestimate clinical conditions; however, studies that are more recent have demonstrated high validity.

generalised degenerative changes within the knee. Focal lesions are classified as traumatic or degenerative and some exist without causing symptoms. They are believed to lead to a chronic osteoarthritic stage with pain and reduced function, which however has been demonstrated only in animal models.^{1 2} Arthroscopic studies have shown that focal cartilage defects (FCDs) within the knee occur in 19–67% of patients with painful knees.^{3–6} A systematic review found a prevalence of 36% in athletes examined by arthroscopy, MRI or both, whereas 14% were asymptomatic.⁷ Another study conducted MRI of the tibiofemoral joint in persons aged 50 years or more from the general population (mean age of 62.3 years).⁸ They found cartilage abnormalities in 69%. We suspect FCDs to be common also in the general population including participants under the age of 50 years.

Several years of research on cartilage surgery have still not led to a clear gold standard treatment of FCDs within the knee. The results from randomised controlled trials (RCTs) are variable,^{9–16} the patient population is heterogeneous¹⁷ and a group



CrossMark

For numbered affiliations see end of article.

Correspondence to

Dr Cathrine Nørstad Engen; c.n.engen@medisin.uio.no

INTRODUCTION

Knee cartilage injury is a well-known condition after the introduction of knee arthroscopy and MRI. Cartilage injury might consist of a single or several focal lesions or it might constitute

of non-operated controls has still not been included in an RCT, making it difficult to decide the role of rehabilitation alone. Also, the quality of clinical studies on cartilage research is low.^{18 19} The most commonly performed procedures on patients with knee cartilage injuries are palliating procedures, such as chondroplasty (CP) and debridement, which have demonstrated symptomatic relief in uncontrolled cohort studies but failed to do so in RCTs.^{20 21} Unfortunately, in this area of orthopaedic surgery, the practice of evidence-based medicine is lacking and the procedures are still used for patients with degenerative changes within their knees.

Results from other orthopaedic registries have led to improved treatment quality and we are currently looking into the potential benefits and challenges of establishing a National Knee Cartilage Defects Registry. Before establishing such a registry, several conditions must be explored. This study intends to present the burden of surgery for the disease.

Two studies from the USA have calculated incidence rates from an insurance database.^{22 23} Montgomery *et al* showed incidence rates ranging from 1.27 to 1.57/10 000, while McCormick *et al* presented incidence rates ranging from 63 to 104/10 000. These numbers would represent 635–52 000 yearly procedures when applied to the number of inhabitants in Norway, which is a very wide interval. In 2014, a study on trends of cartilage injuries documented by arthroscopy in Denmark was published.²⁴ It excluded patients with osteoarthritis (OA) and found an incidence of 40/100 000 person-years for the years 1996–2011.

The aim of this study was to establish the nationwide burden of surgery on knees with knee cartilage defects in Norway. This will play an important role in the evaluation of the possible establishment of a National Knee Cartilage Defects Register in Norway. We calculated the national and regional incidences and aimed at detecting any geographical variations. The latter is of major interest for health development research, the medical industry as well as healthcare providers. Our hypothesis was that cartilage surgery is uncommon and performed mainly in hospitals around the larger cities and that only University hospitals perform advanced cartilage surgery.

PATIENTS AND METHODS

Data source

The study is descriptive with population-based data from the years 2008 to 2011 in Norway. It is a retrospective cohort study through the continuous data collection done by the Norwegian Patient Registry (NPR). The NPR is run by the Norwegian Directorate of Health and contains data on the activity in specialist health services. Norway has approximately 5 million inhabitants. The country consists of 4 health regions and 19 administrative counties. The South East region is most populous, followed by the West, Mid and North regions. Norway has a national public healthcare system aiming at equal

health services to all inhabitants regardless of their income or private insurances. Also, a growing number of private hospitals and surgical centres offer mainly elective orthopaedic surgery to patients with private insurance, reimbursed by public funding through government contracts or paying out of pocket (previously 10–15% of specific elective surgeries, however, influenced by substantial geographical variation²⁵).

The NPR contains reports on the International Statistical Classification of Diseases and Related Health Problems (ICD) code and the NOMESKO Classification of Surgical Procedures (NCSP) code along with other reported factors. It is obligatory for all public hospitals, and for private hospitals with a contract with the public healthcare system, to report their activity to NPR. The arrangements thereby also involve all major private hospitals. The present patient pool consists of all Norwegian patients.

We aimed at detecting cases undergoing surgery for knee cartilage defects. Distinguishing between traumatic and degenerative lesions is often difficult clinically and the development from an FCD to OA might be seen as a continuum. In addition, the ICD-10 coding system is unspecific and further challenges this distinction. Cases were identified from the NPR through predefined surgical procedure codes (all NCSP codes constituting surgery on the knee and/or calf) and ICD-10 codes (table 1) and retrieved as eligible for inclusion if any combination of surgical and diagnostic codes, according to table 1, was present. ICD-10 codes for concomitant injuries are not included. The list (table 1) was chosen after a consensus meeting between head orthopaedic surgeons of the largest hospital in our region. We also contacted experienced orthopaedic surgeons from other hospitals by mail in order to ensure that all possible codes were included. We included diagnosis M17 after these interchanges as several stated that they use M17 also for FCDs. Patients coded with M17 may have degenerative changes, although some have actual focal lesions. Therefore, we made an upper age limit of 67 years for inclusion and presented descriptive analyses with a distinction between those under and above 50 years of age.

Our data were anonymous and considered as statistical data rather than information on health from individual participants. We received the data set within an SPSS file and recognised all cases that underwent knee cartilage surgery during the 4 years 2008–2011. Cases *more* likely to constitute OA were excluded; therefore, patients aged 67 years or more, patients undergoing prosthesis surgery and patients with M17 in combination with non-cartilage procedures (only meniscal resection for instance) or high tibial osteotomy were excluded. Cases with M17 and procedures classified as cartilage surgery were included. The final number after exclusion was 10 830 in the 4-year period (figure 1).

Variables and data

The variables were ICD code, NCSP code, age, gender and length of the hospital stay. Additionally, we

Table 1 An overview of surgical procedures on the knee and calf, defined as cartilage surgery, from NCSP²⁶ and the predefined ICD-10-codes

NCSP code	Explanation	Corresponding surgical procedure and/or abbreviation	ICD-10-code	Disease/injury
NGA11	Endoscopic exploration		M17	OA of the knee
NGA12	Open exploration		M22.4	Chondromalacia patellae
NGF21	Endoscopic fixation of corpus liberum, either traumatic or OCD	fCL	M23.4	Loose body within the knee
NGF22	Open fixation of corpus liberum, either traumatic or OCD	fCL	M23.8	Other internal derangements of the knee
NGF31	Endoscopic resection of articular cartilage	CP/debridement	M23.9	Internal derangement of the knee, unspecified
NGF32	Open resection of articular cartilage	CP/debridement	M24	Other specific joint derangements
NGF91	Other endoscopic procedure on synovia or articular cartilage	MP and OAT	M93.2	OCD
NGF92	Other open procedure on synovia or articular cartilage	MP and OAT	M94.8	Other specific pathology in cartilage
NGH41	Endoscopic removal of corpus liberum	rCL	M94.9	Unspecific pathology in cartilage
NGH42	Open removal of corpus liberum	rCL	S83.3	Acute tear of articular cartilage of the knee
NGK29	Drilling of bone in the knee or calf	MF		
NGK59	High tibial osteotomy	HTO		
+69				
NGN	Transplantation of cartilage, bone, muscle, etc	ACI		

The two explorative procedures (NGA11 and NGA 12) are included due to the group of patients with specific cartilage diagnosis, but without specific knee cartilage surgery.

ACI, autologous chondrocyte implantation; CP, chondroplasty; fCL, fixation of corpus liberum; ICD, International Classification of Diseases; MF, microfracture; MP, mosaicplasty; NCSP; NOMESKO Classification of Surgical Procedures; OA, Osteoarthritis; OAT, osteochondral allograft transplantation; OCD, osteochondritis dissecans; rCL, removal of corpus liberum.

requested data on the health region, county and institution and received geographical variables only for the years 2008–2009.

Statistics

We defined NCSP codes as cartilage surgery, meniscal surgery or other types of surgery. The different types of cartilage surgery were defined as palliative, repairing or restorative. All cases were divided into subgroups on the basis of these definitions. We chose the term palliative as these procedures are meant to decrease pain for the patients, although its efficacy is not proven for all indications. CP or debridement was defined as palliative surgery, cartilage repair included microfracture (MF) and cell-based repair with either autologous chondrocyte implantation (ACI) or stem cells and restorative techniques included techniques aiming at restoring the articular cartilage without cartilage repair tissue produced on-site as well as mosaicplasty (MP) and allograft transplantation (which is currently not in use in Norway).

The data were analysed with IBM SPSS Statistics (V.22.0). We assessed the distribution of the data with age as the dependent value and concluded with a non-normality distribution. The categorical variables on

events of cartilage surgery were assumed to fulfil the criteria of a Poisson distribution. Cases were stratified by age, sex, health region, county and year of surgery. Incidences of cartilage surgery were given per 100 000 inhabitants and were adjusted to age group, region or county by calculation based on population data from Statistics Norway, which is an academically independent organisation administered under the Ministry of Finance in Norway. The data were assembled from their web pages. We compared the incidences for each of the 4 years to each other using rate ratios (RRs) and tested for significance using Wald tests. We used the Cochran-Armitage trend test for comparing trends in the current study with the existing literature.

Demographics were considered by descriptive statistics. Differences in categorical variables were calculated with ORs and tested with Pearson χ^2 tests with geographical localisation as the dependent variable. We explored age differences between subgroups with box plots and performed a Kruskal-Wallis test to test the statistical difference. A Bonferroni correction adjusted the new α level to 0.0125 with four independent analyses (CP vs MF, MF vs ACI, CP vs ACI, MF vs MP) before Mann-Whitney U tests were performed. We were not able to address potential confounders such as actual differences in the

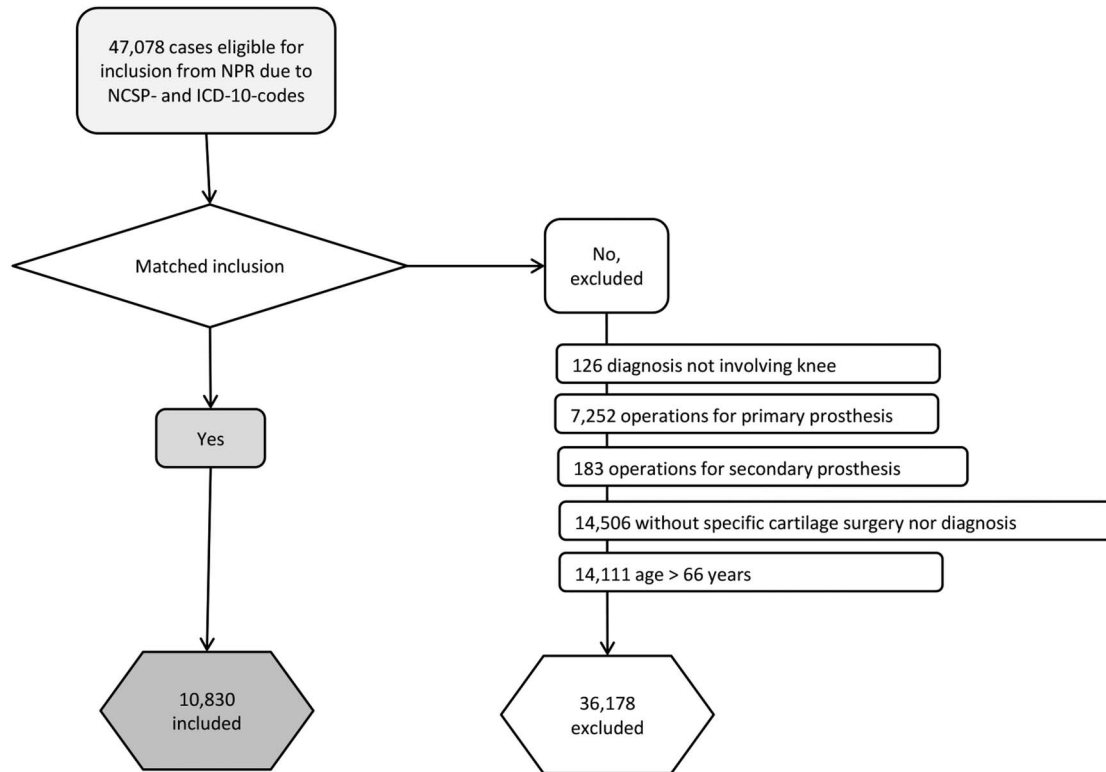


Figure 1 Flow chart of patients eligible for inclusion (ICD-10, International Classification of Diseases Tenth Revision; NCSP, NOMESKO Classification of Surgical Procedures; NPR, Norwegian Patient Registry).

prevalence of knee cartilage defects, or differences in the willingness to seek medical assistance for painful knees or the willingness to undergo surgery.

Ethics

We received anonymous data from the NPR, which acts under approvals of the Norwegian Directorate of Health. The study was evaluated by the Regional Committees for Medical and Health Research Ethics (REC) (ref: 2010/777) and approval is not necessary as the data are anonymous. We consulted the Norwegian Data Protection Authority and the study is not obliged for notification due to the collection of anonymous data. The data are to be considered as statistical data rather than information on health in individual participants.

RESULTS

A total of 10 830 cases matched our inclusion criteria for cartilage surgery for the years 2008–2011 and a flow chart is presented in [figure 1](#). There were 2897 cases in 2008, 3114 in 2009, 2732 in 2010 and 2087 in 2011. A total of 21 143 procedures (see online supplementary appendix 1) were reported throughout the 4 years, which results in a mean of 1.96 procedures per included case. The most common cartilage surgery was resection of the articular cartilage (NGF3y) followed by fenestration or forage or bone/MF (NGK29). The most common non-cartilage surgery was meniscal surgery followed by synovectomy. The mean age for all years was

45.0 (SD 13.7), whereas the mean age for 2008 was 45.6 (SD 13.7) and for 2011 was 43.1 (SD 14.2), which was significantly lower than for the other years (p value <0.001). The male ratio varied from 55.2% to 58.7%.

Incidences

The incidence rate of having experienced cartilage surgery in Norway throughout 2008–2011 is 56/100 000 inhabitants and age-adjusted incidence rate is 68/100 000 inhabitants between 4 and 66 years of age. [Table 2](#) displays the age-adjusted incidence rates for the different years and age groups. The incidence rate from 2008 was set as the reference when calculating RR between included years. The only significant RR was for 2011, which was 0.69 (95% CI 0.65 to 0.73, p value <0.0003).

The incidences of cartilage surgery in public hospitals in the four different health regions display great diversity as cartilage surgery is twice as common within the Northern region as opposed to the South East region ([figure 2](#)). However, when all the procedures performed privately are included, the regional differences change and the Western region becomes the region with the highest incidence ([figure 3](#)). The incidence in the Western region (161/100 000 inhabitants) is four times higher than that in the South East region, which has the lowest incidence (37/100 000 inhabitants). The incidences throughout the 19 different counties also display

Table 2 The distribution of number of cases about year and age group and the age-adjusted yearly incidence rates (with 95% CI in parenthesis) for all three age groups

Year	Total, 4–66 years			0–20 years			20–50 years			50–66 years		
	Cases	Inhabitants	Incidence	Cases	Inhabitants	Incidence	Cases	Inhabitants	Incidence	Cases	Inhabitants	Incidence
2008	2897	3 888 191	74.5	225	1 281 185	17.6	1347	1 881 409	71.6	1325	960 849	137.9
2009	3114	3 943 356	79.0	225	1 293 171	17.4	1532	1 905 524	80.4	1357	983 943	137.9
2010	2732	3 988 476	68.5	191	1 303 549	14.7	1319	1 926 981	68.5	1222	1 002 526	121.9
2011	2087	4 035 623	51.7	198	1 311 169	15.1	1109	1 954 251	56.8	780	1 017 321	76.7

When analysing the rates for each year within the age groups, we found a significant decrease from 2008 to 2011 for the two oldest age groups; no significant change was evident for the patients between 0 and 20 years.

large variations (figure 2). The incidences range from 7.3 to 278.1/100 000 inhabitants.

Trends

The trends for type of surgery varied between both regions and between private and public hospitals (table 3). Whereas private hospitals had nearly 90% debridement, this represented only approximately half of the procedures in public hospitals. Advanced cartilage surgery (repair or restorative techniques) accounted for almost 400 procedures per year. The middle health region had the lowest proportion of advanced cartilage surgery (13.4%) in 2009. In comparison, the northern region performed 42.6% of such procedures in 2009. The corresponding numbers for 2008 were 11.7% and 49.6%. The OR of having advanced cartilage surgery performed in the northern region compared to the other regions was 7.44 (6.11–9.06). Nationwide, the MP/OAT was the most frequent of the repair or restorative procedures for all years, ranging from 57.6% to 62.8%, whereas 4.2%–6.6% were cell transplantation techniques.

A substantial part of all included cases of cartilage surgery was performed in private institutions, whereas they performed 19.8% of the repair or restorative procedures (table 3). The OR of being treated with these methods over palliative procedures in private rather than public institutions was 0.18 (0.08–0.43). A Pearson χ^2 confirmed a highly significant association between the regions and between private and public hospitals. Most patients were treated in an outpatient setting and this accounted especially for private institutions. University hospitals performed 44.5% of cases with advanced cartilage surgery, whereas they performed 57.5% of all transplantation techniques, 56.8% of MP procedures and only 13.6% of MF procedures.

Age

The ages between the seven different subgroups were statistically significantly different ($p < 0.001$); whereas the CP group (median 51.0) was significantly older than both the MF (median 39.0) and ACI groups (median 29.0), the MF group was older than the ACI group and not statistically significant different from the MP group (median 42.0). The age distribution of advanced cartilage surgery showed that the majority of procedures are performed on patients aged 20–50 years. Transplantation procedures were seldom performed in the oldest age group (50–67 years of age), whereas the youngest group (<20 years of age) was more commonly treated with MF followed by transplantation. ORs demonstrated that MP/OAT and ACI were more common for patients under 50 years of age, whereas MF and MP/OAT were more common for patients under the age of 20 years.

DISCUSSION

A total of 10 830 cases were included and represent the nationwide load of knee cartilage surgery in Norway

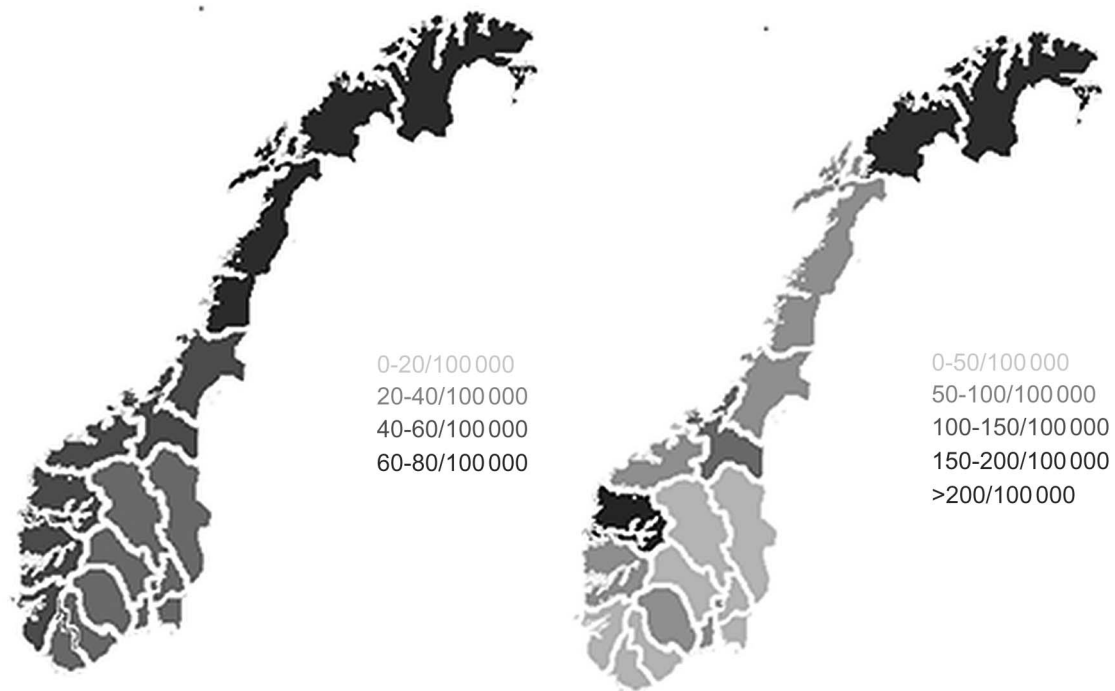


Figure 2 The incidence rates in the four different health regions in Norway (top) and the incidence rates throughout Norway's 19 counties (bottom) in 2009. Numbers are based on the localisation of the hospital and not the patient's home address. Activity from private hospitals is excluded for these figures as they mostly perform palliative surgeries in middle-aged patients and thereby account more for degenerative surgery than cartilage surgery. The incidence rates are age-adjusted to the population included in this study, which ranged from 4 to 66 years of age. All surgeries performed in private institutions are excluded from this material, which included 1475 surgeries in 2009. (The map of Norway was downloaded from Wikipedia Commons and edited).

throughout 2008–2011. There are 2500 cartilage surgeries yearly and 400 of these are advanced cartilage surgery. The total incidence of all cartilage surgery over these four years is 56/100 000. These numbers are within the range of incidences for knee ligament surgery in Norway, which is considered a common surgery. Granan *et al.*²⁷ found an incidence of ACL surgery of 34/100 000 inhabitants, although there were

85/100 000 in the age group 16–39 years of age in Norway in their baseline study of the Scandinavian Knee Ligament Registries.

Although common, the yearly incidence varies greatly among age groups, health regions, counties and between public and private hospitals. Cartilage surgery is not in use mainly around the largest cities or regional hospitals and University clinics, in contrast to our

Figure 3 The differences in incidences when excluding and including numbers from private institutions for the year 2009.

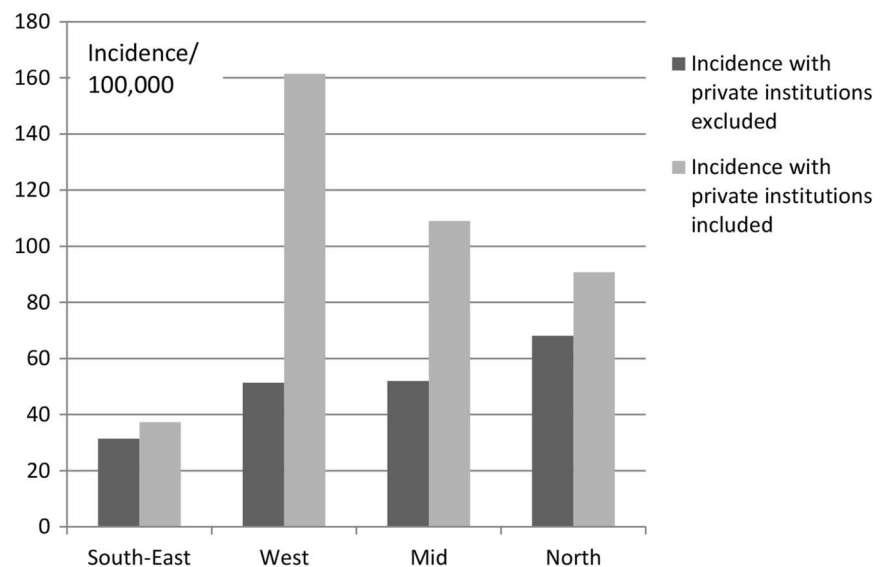


Table 3 The distribution for all the public cases, among the different subgroups within the regions and for the private institutions from 2008 to 2009

	CP	MF	MP/OAT	rCL/fCL	ACI	HTO	Other/no	Total
Public	1763 (50.9)	184 (5.3)	387 (11.1)	525 (15.2)	71 (2.0)	329 (9.5)	205 (5.9)	3464
South East	222 (57.7)	45 (11.7)	14 (3.6)	22 (5.7)	2 (0.5)	65 (16.9)	15 (3.9)	385
West	484 (54.6)	93 (10.5)	30 (3.4)	112 (12.6)	4 (0.5)	99 (11.2)	64 (7.2)	886
Mid	373 (59.6)	23 (3.7)	40 (6.4)	104 (16.6)	15 (2.4)	33 (5.3)	38 (6.1)	626
North	186 (37.6)	19 (3.8)	183 (37.0)	44 (8.9)	25 (5.1)	16 (3.2)	21 (4.3)	496
Private	2338 (89.3)	70 (2.7)	87 (3.3)	82 (3.1)	1 (0.0)	0 (0)	40 (1.5)	2618

ACI, autologous chondrocyte implantation; CP, chondroplasty; fCL, fixation of corpus liberum; HTO, high tibial osteotomy; MF, microfracture; MP, mosaicplasty; OAT, osteochondral allograft transplantation; rCL, removal of corpus liberum.

hypothesis. Private institutions accounted for 43% of all cases, whereas only 40% of the public cases were performed in the South East region. These findings imply that if a cartilage registry is developed, an important consideration is whether to include hospitals from several health regions in addition to private hospitals. Furthermore, the data demonstrate a significant reduced frequency of advanced cartilage surgery for patients treated at private institutions ($p < 0.001$). It is not possible to outline whether this is a case of reduced accessibility, but it is likely that procedures leading to more overnight stays are less available at these institutions.

Similar differences between public and private hospitals are seen in other Scandinavian countries for meniscal surgery,²⁸ and these differences might also be due to financial incentives. Codes for palliative procedures were mainly in use for middle-aged patients in combination with M17. It has been previously demonstrated in studies that debridement is no better than sham surgery²⁰ or rehabilitative training with a Physiotherapist,²¹ whereas the latter also failed to show the efficacy of surgery in patients with mechanical symptoms. These studies changed the trends in surgery on patients with OA as the rates of arthroscopy declined in the following years, at least in the USA.²⁹ It is possible that a larger part of these procedures is now performed on patients with actual FCDs, although these procedures are also still used in patients with knee OA. On the basis of the recent literature, this type of surgery should be abandoned.

Few studies have explored incidences of cartilage surgery, whereas one study presents national numbers on cartilage injuries diagnosed with arthroscopy.²⁴ Two studies presented remarkably different numbers based on data from the PearlDiver database in the USA. Montgomery *et al*²³ report an incidence rate of 1.27–1.57/10 000 (2004–2009) patients and McCormick *et al*²² report an incidence rate of 90/10 000 (2004–2011). McCormick seems to calculate incidences on the basis of all individual patients within the database, whereas Montgomery calculates incidences on the basis of all patient records, which may explain the different results. Our incidence rates are within the same range as those reported by Montgomery *et al* when compared to the

number presented in the articles. However, when we recalculated new incidence rates on the basis of the numbers provided by the two articles and applied the same approach as used in this study, we found quite different incidence rates from both articles. Consequently, the incidence rates from this study then appear in the vicinity of McCormick *et al* (table 4). Both studies focused on cartilage surgery only, and excluded patients with simply the diagnosis of an FCD or patients undergoing osteotomy in the absence of knee OA. These two subgroups accounted for <10% in this study and were excluded when comparing incidence rates for the years 2008–2011 (table 4). The same table displays the numbers from the Danish study, which are in close range with the numbers from this study.

Trends

We found that 56 hospitals performed cartilage surgery, whereas 15 hospitals operated <10 cases throughout 2009. Katz *et al*³⁰ found that patients operated in low-volume hospitals by low-volume surgeons had worse functional outcomes 2 years after total knee replacement. When performing procedures that have failed to prove efficacy, the volume of the operating surgeons means less. However, this is a field with many patients and presumably low evidence-based adherence. Cartilage surgery is a complex treatment where several options exist, indicating that the availability of several techniques as well as an optimised rehabilitation programme is needed. In order to form a standardised treatment for as many patients as possible, each hospital or surgeon probably needs to see a certain, but not yet defined, number of patients yearly to maintain adequate quality of care. A discussion on whether to make specific cartilage centres must be made.

This study cannot explain the reasons for the geographical differences, but possible factors might be differences between the orthopaedic surgeons' personal preferences and experience more than differences in the patient populations. A study aiming to describe the practice of MF among Canadian orthopaedic surgeons found widespread variation concerning indication for surgery.³¹ A patient's willingness to undergo surgery is also an important consideration and is higher in areas with an already high incidence of surgery.³²

Table 4 The incidence rates from two American studies on trends and incidences from a private database for health insurance, together with the national incidences from the Danish and the current studies

Year	Montgomery <i>et al</i> (reported)	McCormick <i>et al</i> (reported)	Mor <i>et al</i> , (numbers are reported for all years together)	Present study*
2008	154.1 (1.54)	9.1 (91)	4.0	6.8
2009	152.7 (1.53)	9.3 (92)		7.2
2010	–	10.4 (104)		6.2
2011	–	9.3 (93)		4.6

Incidence rates are given per 10 000 patients/inhabitants and are calculated from the numbers of procedures and patients that are given by the two articles. The reported numbers are presented in parentheses.

*These numbers are calculated after exclusion of the patient group without cartilage surgery and the patient group where osteotomy was performed alone or in addition to cartilage surgery and thereby represent the same patient population as in the two published studies.

Knee cartilage surgery consists of several different techniques and although attempts on recommendations have been made, there is no gold standard treatment.^{9–16 33} MF is traditionally chosen for smaller defects, whereas OAT and ACI are chosen for larger defects.³⁴ More specific recommendations do not exist, and we know little of the decision-making for surgical technique other than the size of the lesion and the patient's age. We do not have data on the size or location of the lesions in this study. CP is the most common procedure in our material and is performed for both FCDs and in knees with developing degenerative changes. The study by Montgomery *et al*²³ found that MF and CP are the preferred procedures in 98% of cases with cartilage surgery. These procedures constituted 71.1% of all procedures in our material. The study by Mor *et al*²⁴ found repair procedures (MF, osteochondral transplantation or chondrocyte transplantation) to be performed in 16.7% of the cases. The trends from the articles of Montgomery *et al*²³ were significantly different from the trends of our material when compared with a χ^2 test (p value<0.001). The difference was still significant after excluding the groups which had no cartilage surgery or osteotomies. Also, the trends in procedures from the study by Mor *et al* were different from the trends of this study with a lower proportion of palliative procedures, also after excluding the cases with no cartilage surgery or osteotomies.

Limitations

The ICD-10 codes available for diagnosing FCDs do not reflect the complexity of the clinical situation of these lesions. The distinction between focal lesions that are traumatic or degenerative is often difficult clinically, and location, size and depth matter greatly. The ICD-10 does not account for these conditions, and a distinction based on these codes is impossible. Although the ICD-10 contains both 'acute FCD' (S83.3) and several codes for knee cartilage pathology, there are no codes for the common 'non-acute FCD', which might be subacute or chronic. Our predefined codes matched with 92.3% of the reported diagnostic codes from the Norwegian Arthroscopic Association. However, the response rate was only 13.2%. The low response rate has limited effect on

our final numbers since we have included most of the possible codes from the ICD system, but these challenges coexist with the fact that some orthopaedic surgeons might not code for FCDs at all if other intra-articular pathology is recognised. This is probably the largest limitation and cannot be defeated by any methodological changes, but by the information and education of orthopaedic surgeons. This is therefore a challenge concerning cartilage pathology and the ICD system and is as such a problem for the entire research field and not only for this study.

Among 11 566 ICD-10 codes, there are 789 coded as S83.3. The frequency of M17 codes increases with age; however, several orthopaedic surgeons have stated that they use M17 also for focal lesions. The inclusion of patients with an M17 diagnosis might lead to an overestimation of surgery for cartilage injury. However, an exclusion of these would definitely lead to an underestimation. This study reports a lower portion of palliative procedures than the Danish study²⁴ (where they excluded all patients with OA), which might imply that most of those included in this study are actual knee cartilage defects and not OA.²⁴ We did not include the ICD-10 code for 'painful joint' (M25.5) which might have underestimated the results.

The patient records or surgical protocols are considered the gold standard. However, large administrative databases allow the process of data collection to be efficient, detailed and precise, within its limitations. The Norwegian healthcare system is public and tax funded, which balances out possible geographic or socio-economic differences. Studies have demonstrated that numbers extracted from electronic databases are being both overestimated and underestimated. Lofthus *et al*³⁵ found that the Norwegian NPR overestimated hospitalisation for hip fractures by 29%, although the number of those having surgery for hip fractures was underestimated. Readmissions due to the same hip fracture were registered as a new hospitalisation for a new hip fracture by the NPR, which inflated the number. In our material, 297 cases (4.9%) were duplicates and only 73 procedures (0.67%) were classified as reoperations. We believe that *procedure* codes are reported in more detail as they are the basis of 60% of the government

reimbursement in Norway and, as such, are reviewed several times by hospital controllers to ensure correct coding. For this study, we were interested in the burden of cartilage surgery and a combination of diagnostic and procedure codes seemed most appropriate.

The validity for the Norwegian NPR database was later assessed in a national study on hip fractures and the accuracy was found to be 98.2% (CI 96.5% to 99.9%) when diagnostic codes were combined with procedure codes.³⁶ In that same study, the authors suggested possible coding errors from fractures that were treated conservatively or from patients that were admitted to hospital with such a fracture, but died before the operation. This does not apply to this study, as the diagnosis is set during the operation. The study by Mor *et al*²⁴ assessed the validity against surgical descriptions in the medical records as the gold standard and found the positive and negative predictive values to be 88% and 99%, respectively. As for all studies with inclusion based on surgical procedures, FCDs diagnosed with MRI and treated conservatively are not included. An underestimation or overestimation might exist; however, the main goal of this study was to estimate the nationwide burden of cartilage surgery with the numbers available in NPR.

Future clinical implications

Cartilage surgery concerns a large and severely troubled patient group with no gold standard treatment. No nationwide surveillance currently exists to study the efficacy or effectiveness of treatment for this patient group. Development of a cartilage registry emphasising cartilage treatment being palliative, reparative or regenerative, in addition to non-surgical procedures, will be essential for clinical progression in this field.

Our numbers indicate that CP or debridement is still performed in degenerative knees.

CONCLUSION

In Norway, there are 2500 annual procedures classified as cartilage surgery, resulting in an age-adjusted incidence rate of 68.8/100.000 inhabitants. There are large variations between the different regions and between public and private hospitals.

This illustrates the need for a larger surveillance database for evaluation of results and calculation of costs in order to secure high quality treatment for all knee cartilage patients.

Author affiliations

¹Oslo Sports Trauma Research Center (OSTRC), Norwegian School of Sports Sciences, Oslo, Norway

²Faculty of Medicine, Institute of Clinical Medicine, University of Oslo, Oslo, Norway

³Department of Orthopedic Surgery, Akershus University Hospital, Lørenskog, Norway

⁴Institute of Clinical Medicine, University of Oslo, Lørenskog, Norway

⁵Department of Orthopedic Surgery, Oslo University Hospital, Oslo, Norway

Acknowledgements The authors would like to thank Ingar Holme, PhD for his advice concerning relevant statistics.

Contributors LE and AA conceived the study, whereas all the authors planned the method. CNE was responsible for data collection and analyses, whereas all the authors participated in the interpretation. CNE drafted the manuscript, whereas AA and LE revised it. All the authors approved the final version.

Funding The study was supported through grants from the Oslo Sports Trauma Research Centre (OSTRC), where the corresponding author is employed. The South-Eastern Norway Regional Health Authority, the Royal Norwegian Ministry of Education and Research, the Norwegian Olympic Committee & the Confederation of Sport and Norsk Tipping finance the centre. The Faculty of Medicine, University of Oslo (UiO) also supported the work as CNE previously was a student at the Medical Student Research Programme at UiO and thereby received financial support from the Research Council of Norway.

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Open Access This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

REFERENCES

1. Jackson DW, Lalor PA, Aberman HM, *et al*. Spontaneous repair of full-thickness defects of articular cartilage in a goat model. A preliminary study. *J Bone Joint Surg Am* 2001;83-A:53–64.
2. Gratz KR, Wong BL, Bae WC, *et al*. The effects of focal articular defects on cartilage contact mechanics. *J Orthop Res* 2009;27:584–92.
3. Curl WW, Krome J, Gordon ES, *et al*. Cartilage injuries: a review of 31,516 knee arthroscopies. *Arthroscopy* 1997;13:456–60.
4. Widuchowski W, Widuchowski J, Trzaska T. Articular cartilage defects: study of 25,124 knee arthroscopies. *Knee* 2007;14:177–82.
5. Hjelle K, Solheim E, Strand T, *et al*. Articular cartilage defects in 1,000 knee arthroscopies. *Arthroscopy* 2002;18:730–4.
6. Aroen A, Loken S, Heir S, *et al*. Articular cartilage lesions in 993 consecutive knee arthroscopies. *Am J Sports Med* 2004;32:211–15.
7. Flanigan DC, Harris JD, Trinh TQ, *et al*. Prevalence of chondral defects in athletes' knees: a systematic review. *Med Sci Sports Exerc* 2010;42:1795–801.
8. Guermazi A, Niu J, Hayashi D, *et al*. Prevalence of abnormalities in knees detected by MRI in adults without knee osteoarthritis: population based observational study (Framingham Osteoarthritis Study). *BMJ* 2012;345:e5339.
9. Knutsen G, Drogset JO, Engebretsen L, *et al*. A randomized trial comparing autologous chondrocyte implantation with microfracture. Findings at five years. *J Bone Joint Surg Am* 2007;89:2105–12.
10. Horas U, Pelinkovic D, Herr G, *et al*. Autologous chondrocyte implantation and osteochondral cylinder transplantation in cartilage repair of the knee joint. A prospective, comparative trial. *J Bone Joint Surg Am* 2003;85-A:185–92.
11. Gudas R, Gudaite A, Pocius A, *et al*. Ten-year follow-up of a prospective, randomized clinical study of mosaic osteochondral autologous transplantation versus microfracture for the treatment of osteochondral defects in the knee joint of athletes. *Am J Sports Med* 2012;40:2499–508.
12. Bentley G, Biant LC, Vijayan S, *et al*. Minimum ten-year results of a prospective randomised study of autologous chondrocyte implantation versus mosaicplasty for symptomatic articular cartilage lesions of the knee. *J Bone Joint Surg Br* 2012;94:504–9.
13. Dozin B, Malpeli M, Cancedda R, *et al*. Comparative evaluation of autologous chondrocyte implantation and mosaicplasty: a multicentered randomized clinical trial. *Clin J Sport Med* 2005;15:220–6.
14. Saris DB, Vanlauwe J, Victor J, *et al*. Characterized chondrocyte implantation results in better structural repair when treating symptomatic cartilage defects of the knee in a randomized controlled trial versus microfracture. *Am J Sports Med* 2008;36:235–46.

15. Gooding CR, Bartlett W, Bentley G, *et al.* A prospective, randomised study comparing two techniques of autologous chondrocyte implantation for osteochondral defects in the knee: periosteum covered versus type I/III collagen covered. *Knee* 2006; 13:203–10.
16. Basad E, Ishaque B, Bachmann G, *et al.* 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;18:519–27.
17. Engen CN, Engebretsen L, Aroen A. Knee cartilage defect patients enrolled in randomized controlled trials are not representative of patients in orthopedic practice. *Cartilage* 2010;1:312–19.
18. Jakobsen RB, Engebretsen L, Slauterbeck JR. An analysis of the quality of cartilage repair studies. *J Bone Joint Surg Am* 2005;87:2232–9.
19. Worthen J, Waterman BR, Davidson PA, *et al.* Limitations and sources of bias in clinical knee cartilage research. *Arthroscopy* 2012;28:1315–25.
20. Moseley JB, O'Malley K, Petersen NJ, *et al.* A controlled trial of arthroscopic surgery for osteoarthritis of the knee. *N Engl J Med* 2002;347:81–8.
21. Kirkley A, Birmingham TB, Litchfield RB, *et al.* A randomized trial of arthroscopic surgery for osteoarthritis of the knee. *N Engl J Med* 2008;359:1097–107.
22. McCormick F, Harris JD, Abrams GD, *et al.* 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. *Arthroscopy* 2014;30:222–6.
23. Montgomery SR, Foster BD, Ngo SS, *et al.* Trends in the surgical treatment of articular cartilage defects of the knee in the United States. *Knee Surg Sports Traumatol Arthrosc* 2014;22:2070–5.
24. Mor A, Grijota M, Norgaard M, *et al.* Trends in arthroscopy-documented cartilage injuries of the knee and repair procedures among 15–60-year-old patients. *Scand J Med Sci Sports* 2015;25:e400–7.
25. Bogen H, Dahl E, Karlsen TK. Privatisering av helsetjenester—prosjektrapport. 37–48. Forskningsstiftelsen Fafo. 10–3–2015. 1996. http://www.fafo.no/media/com_netsukii/196.pdf
26. NCMP og NCSP: Klassifikasjon av helsefaglige prosedyrer 2011. KITH. 2011.
27. Granan LP, Forssblad M, Lind M, *et al.* The Scandinavian ACL registries 2004–2007: baseline epidemiology. *Acta Orthop* 2009;80:563–7.
28. Hare KB, Vinther JH, Lohmander LS, *et al.* Large regional differences in incidence of arthroscopic meniscal procedures in the public and private sector in Denmark. *BMJ Open* 2015;5:e006659.
29. Potts A, Harrast JJ, Harner CD, *et al.* Practice patterns for arthroscopy of osteoarthritis of the knee in the United States. *Am J Sports Med* 2012;40:1247–51.
30. Katz JN, Mahomed NN, Baron JA, *et al.* Association of hospital and surgeon procedure volume with patient-centered outcomes of total knee replacement in a population-based cohort of patients age 65 years and older. *Arthritis Rheum* 2007;56:568–74.
31. Theodoropoulos J, Dwyer T, Whelan D, *et al.* Microfracture for knee chondral defects: a survey of surgical practice among Canadian orthopedic surgeons. *Knee Surg Sports Traumatol Arthrosc* 2012;20:2430–7.
32. Hawker GA, Wright JG, Coyte PC, *et al.* Determining the need for hip and knee arthroplasty: the role of clinical severity and patients' preferences. *Med Care* 2001;39:206–16.
33. Harris JD, Siston RA, Pan X, *et al.* Autologous chondrocyte implantation: a systematic review. *J Bone Joint Surg Am* 2010;92:2220–33.
34. Harris JD, Brophy RH, Siston RA, *et al.* Treatment of chondral defects in the athlete's knee. *Arthroscopy* 2010;26:841–52.
35. Lofthus CM, Cappelen I, Osnes EK, *et al.* Local and national electronic databases in Norway demonstrate a varying degree of validity. *J Clin Epidemiol* 2005;58:280–5.
36. Hoiberg MP, Gram J, Hermann P, *et al.* The incidence of hip fractures in Norway -accuracy of the national Norwegian patient registry. *BMC Musculoskelet Disord* 2014;15:372.