BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2015-008423
Article Type:	Research
Date Submitted by the Author:	07-Apr-2015
Complete List of Authors:	Engen, Cathrine; Norwegian School of Sports Sciences, Oslo Sports Trauma Research Center Årøen, Asbjørn; Akershus University Hospital, Department of Orthopedic Surgery Engebretsen, Lars; Oslo University Hospital, Orthopaedic Center
Primary Subject Heading:	Sports and exercise medicine
Secondary Subject Heading:	Epidemiology, Health services research
Keywords:	Knee < ORTHOPAEDIC & TRAUMA SURGERY, Orthopaedic sports trauma < ORTHOPAEDIC & TRAUMA SURGERY, EPIDEMIOLOGY

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Incidence of Knee Cartilage Surgery in Norway, 2008-11

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Key words: Cartilage surgery, articular cartilage, cartilage repair, knee, incidence

Word count: 3989

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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 is to establish the nationwide burden of knee cartilage surgery, defined for this purpose as knee surgery in patients with an FCD. We will also identify any geographical differences in incidence rates, patient demographics or trends within this type of surgery. **Setting:** Retrospective cohort study on patients undergoing knee cartilage surgery in Norway through a mandatory public health database from 2008-11. **Participants:** All patients undergoing cartilage surgery, or other knee surgery in patients with an FCD were identified. All eligible surgeries were assessed for inclusion based on certain types of ICD-10 and NCSP 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 odds between geographical areas were also calculated. **Results:** A total of 10,830 cases of knee cartilage surgery were identified, with a slight and significant decreases from 2008-11 (p <.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 2,500 annual cases with an age-adjusted incidence rate of 68.8 per 100,000 inhabitants. There are significant geographical variations in incidence and trends of surgery and also in trends between public and private hospitals. We suggest that a national surveillance system would be beneficial for the future evaluation of the surgical procedures of these patients.

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ARTICLE SUMMARY

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 NCSP surgical codes to the inclusion criteria.

- Compliance and validity is a limitation for the data quality in most registry studies. The Register included in the present study is shown to both over- and underestimate clinical conditions.

3

INTRODUCTION

Focal cartilage defects within the knee (FCDs) is a well-known condition after the introduction of knee arthroscopy and MRI and may lead to a chronic osteoarthritic stage with pain and reduced function. We know from arthroscopic studies that FCDs within the knee occur in 5-20 % of patients with painful knees.[1-4] A systematic review that included studies performed with arthroscopy, magnetic resonance imaging or both found a prevalence of 36 % in athletes.[5] We suspect FCDs to be common also in the general population.

Several years of research on cartilage surgery have still not lead to a clear gold standard treatment of focal cartilage defects (FCDs) within the knee. The results from RCTs are variable,[6-14] the patient population is heterogeneous[15] and a group 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.[16;17] Bearing the helpful results from other orthopedic registries in mind, we are currently looking into the potential benefits, and also the 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 disease.

To our knowledge, no nationwide study has presented the incidence or demonstrated the trends of cartilage surgery yet. Two studies from the United States have calculated incidence rates from an insurance database and one of these further estimated national incidences on cartilage surgery from these numbers.[18;19] The study of Montgomery et al showed incidence rates ranging from 1.27-1.57/10,000 from 2004-2009, while the study of McCormick et al looked at years 2004-2011 and present incidence rates ranging from 63-104/10,000. These numbers would represent 635-

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76   52,000 yearly procedures when applied to the number of inhabitants in Norway, an interval too wide

77   to use as basis for a potential registry.

78

79   The aim of this study is to establish the nation-wide burden of surgery on knees with focal

80   articular cartilage pathology in Norway. This will play an important role in the evaluation of the

81   possible establishment of a National Knee Cartilage Defect Register in Norway. We will additionally

82   calculate the national and regional incidences and aim to detect any geographical variations. The

83   latter will be of major interest for health development research, medical industry as well as health

84   care providers. Our hypothesis is that cartilage surgery is uncommon and performed mainly in

85   hospitals around the larger cities and that advanced cartilage surgery is performed only at University

86   hospitals.

5

PATIENTS AND METHODS

Data source

91   The current study is descriptive with data collected from years 2008-2011 in Norway. The

92   study design is classified as a retrospective cohort study through the continuous data collection done

93   by the Norwegian Patient Registry (NPR). Norway has approximately 5 million inhabitants. The

94   country is divided into four health regions and 19 administrative counties. The largest proportion of

95   the population lives in the Southeast region and is further followed by the West, Mid and North

96   regions. Norway has a national public health care system aiming at the same level of health service to

97   all inhabitants regardless of their income or private insurances. Also, there is a growing number of

98   private hospitals and surgical centers that offer mainly elective orthopedic surgery to patients with

99   private insurance, reimbursed by public funding through government contracts or paying out of

100   pocket (previously 10-15 % of specific elective surgeries, however influenced by substantial

101   geographical variation[20]).

103   In Norway we are able to extract data on the activity in specialist health services from an

104   administrative database run by the Norwegian Directorate of Health, the NPR. The database contains

105   reports on the International Statistical Classification of Diseases and Related Health Problems (ICD)

106   code and the NOMESKO Classification of Surgical Procedures (NCSP) code along with several other

107   reported factors. All hospitals report their activity on admittances and treatment to the NPR and it is

108   obligatory for all public hospitals to report to NPR, and also for private hospitals with a contract with

109   the public health care system. The arrangements thereby involve all major private hospitals. The

110   present patient pool consists of all Norwegian patients who had knee surgery performed 2008-2011

111   in relation to any of the specified ICD-10 codes.

6

112   Table 1 gives an overview of surgical procedures on knee and calf defined as cartilage surgery, from NCSP [21] and the

113   predefined ICD-10-codes.The two explorative procedures (NGA11 and NGA 12) are included due to the group of patients

114   with specific cartilage diagnosis, but without specific knee cartilage surgery.

NCSP-Code	Explanation	Corresponding surgical procedure and/or abbreviation	ICD-10-code	Disease/Injury
NGA11	Endoscopic exploration		M17	Osteoarthritis (OA) of the knee
NGA12	Open exploration		M22.4	Chondromalacia patellae
NGF21	Endoscopic fixation of corpus	Fixation of Corpus Librum (fCL)	M23.4	Loose body within the knee
NGF22	Open fixation of corpus librum,	fCL	M23.8	Other internal derangements of the knee
NGF31	Endoscopic resection of	Chondroplasty (CP)	M23.9	Internal derangement of the knee, unspecified
NGF32	Open resection of articular cartilage	CP	M24	Other specific joint derangements
NGF91	Other endoscopic procedure on	Mosaic Plasty (MP) and Osteochondral	M93.2	Osteochondritis dissecans (OCD)
NGF92	Other open procedure on	MP and OAT	M94.8	Other specific pathology in cartilage
NGH41	Endoscopic removal of corpus	Removal of Corpus Librum (rCL)	M94.9	Unspecific pathology in cartilage
NGH42	Open removal of corpus librum	rCL	S83.3	Acute tear of articular cartilage of the knee
NGK29	Drilling of bone in knee or calf	Microfracture (MF)		
NGK59+69	High tibial osteotomy	HTO		
NGN	Transplantation of cartilage, bone,	Autologous Chondrocyte		

115

116   Cases were identified from the NPR through predefined codes for surgical procedures (all

117   NCSP-code constituting surgery on knee and/or calf) and diagnosis as ICD-10-codes (table 1) of knee

118   cartilage surgery and retrieved as eligible for inclusion. The list (table 1) of specific diagnosis was

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119   chosen after a consensus meeting between head orthopedic surgeons of the largest hospital in our

120   region. We received the anonymous data contained within an SPSS-file and recognized all patients

121   with an FCD within the knee who underwent knee surgery. Cases more likely to constitute OA (M17)

122   were excluded, therefore patients aged 67 years or more, patients undergoing prosthesis surgery

123   and patients with M17 in combination with non-cartilage procedures, high tibial osteotomy (HTO) or

124   debridement were excluded. Patients with M17 and procedures classified as cartilage repair of

125   restoration were included (figure 1). Dialogues with experienced orthopedic surgeons from other

126   hospitals also contributed to the further identification of specific procedures with the aim of each

127   diagnosing, palliating, repairing or restoring articular cartilage defects and pathology in the knee.

128   The final number after age and OA exclusion was 10,830 in the four-year period.

129

130   **Variables and data**

131

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

133   Additionally, we requested data on the health region, county and institution where the procedure

134   was performed and received geographical variables for the years 2008-09.

135

136   **Statistics**

137

138   NCSP-codes were defined as specific for cartilage surgery, meniscal surgery, or other types of

139   surgery and distributed into subclasses based upon these definitions. The different types of cartilage

140   surgery were defined as palliative, repairing or restorative and also divided into subgroups.

141   Chondroplasty or debridement were defined as palliative surgery, cartilage repair included

142   microfracture (MF) and cell-based repair with either chondrocytes or stem-cells and restorative

8

143   techniques included techniques aiming at restoring the articular cartilage without cartilage repair

144   tissue produced on-site and include mosaic plasty (MP) and allograft transplantation (which is

145   currently not in use in Norway). All cases defined as direct cartilage surgery in addition to other types

146   of surgery, but with a specific ICD-10 code for a cartilage defect or OCD lesion, were transferred into

147   an individual worksheet. The final work sheet represented the included cases for this study.

148

149   The data was sorted and analyzed with IBM SPSS Statistics (version 22.0). We assessed the

150   distribution of the data with age as the dependent value and concluded with a non-normality

151   distribution of the data (skewness -.58 and kurtosis - .52). The categorical variables on events of

152   cartilage surgery were assumed to fulfill the criteria of a Poisson distribution, as they are counted as

153   events over a period of time. We did not collect data on patient-related outcomes and confounders

154   have thereby not been considered.

155

156   Patients were stratified by age, sex, health region, county and year of surgery. Incidences of

157   cartilage surgery were given per 100,000 inhabitants and were adjusted to age group, region or

158   county by calculation based on population data from Statistics Norway (SSB), which is an

159   academically independent organization administered under the Ministry of Finance in Norway. The

160   data was assembled from their web-pages and transferred directly into Excel sheets. The incidences

161   for the each of the four years were compared to each other using rate ratios and tested for

162   significance using Wald tests. The Cochran-Armitage trend test was used for exploring the surgical

163   trend in the current study compared to the trends illustrated by existing literature.

164

165   Demographics were considered by descriptive statistics and graphs were drawn using the

166   chart builder in SPSS. Associations between the different categorical variables on age group, gender

9

167 and subgroup of cartilage surgery were calculated with odds ratios and tested with Pearson chi-

168 square tests with geographical localization as the dependent variable. Age differences between

169 different subgroups were explored with box plots and a Kruskal-Wallis test was performed to test the

170 statistical difference in age between seven subgroups. A Bonferroni correction adjusted the new

171 alpha level to .0125 with four independent analyses (CP vs MF, MF vs ACI, CP vs ACI, MF vs MP)

172 before Mann-Whitney U tests were performed.

173

174 **Ethics**

175

176   We received anonymous data from the NPR, which acts under approvals in accordance with

177 the Norwegian Directorate of Health. The study was evaluated by the Regional Committees for

178 Medical and Health Research Ethics (REC) (ref: 2010/777) as not obliged for notification. Due to the

179 collection of anonymous data, the study is neither obliged for notification to the Norwegian data

180 Protection Authority.

181

182   **RESULTS**

183

184   A total of 47,078 cases matched our eligibility criteria whereas 10,830 cases matched our

185   inclusion criteria for cartilage surgery for the years 2008-11 and a flowchart is presented in figure 1.

186   These cases were distributed with 2,897 in 2008, 3,114 in 2009, 2,732 in 2010 and 2,087 in 2011. A

187   total of 21,173 procedures were reported throughout the four years which results in a mean of 1.96

188   procedures per case. The most common non-cartilage surgery was meniscal surgery closely followed

189   by synovectomy. The mean age was 45.0 (SD 13.7), whereas the mean age for 2011 was 43.1 (SD

190   14.2) which was significantly lower than for the other three years with a p-value less than .0001. The

191   male ratio varied from 55.2% to 58.7%.

192

193   **Incidences**

194

195   The incidence rate of having experienced cartilage surgery in Norway throughout 2008 - 2011

196   is 56 per 100,000 inhabitants and age-adjusted incidence rate is 68 per 100,000 inhabitants between

197   4-66 years of age. The age-adjusted incidence rates for the different years and age groups are

198   displayed in table 2. The incidence rate from 2008 was used as the reference when calculating the

199   rate ratios (RR) for the different years. The RR of 2009 was 1.05 (95 % CI 1.00 to 1.10), the RR of 2010

200   was 0.92 (95 % CI 0.88-0.97) and for 2011 it was 0.69 (95 % CI 0.65-0.73, p-value <.0003).

201

202   Table 2 shows the distribution of number of cases with regards to year and age group and the age-adjusted yearly

203   incidence rates (with 95 % CI in parenthesis) for all three age groups. When analyzing the rates for each year within the

204   age groups, we found a significant decrease from 2008-11 for the two oldest age groups; no significant change was

205   evident for the patients between 0-20 years.

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Year	Total, 4-66 years			0-20 years			20-50 years			50-66 years		
	Cases	Inhabitants	Incidence (95% CI)	Cases	Inhabitants	Incidence (95% CI)	Cases	Inhabitants	Incidence (95% CI)	Cases	Inhabitants	Incidence (95% CI)
2008	2,897	3,888,191	74.5 (71.8-77.3)	225	1,281,185	17.6 (15.4-20.1)	1,347	1,881,409	71.6 (67.9-75.5)	1,325	960,849	137.9 (130.7-145.5)
2009	3,114	3,943,356	79.0 (76.3-81.8)	225	1,293,171	17.4 (15.3-19.8)	1,532	1,905,524	80.4 (76.5-84.5)	1,357	983,943	137.9 (130.8-145.4)
2010	2,732	3,988,476	68.5 (66.0-71.1)	191	1,303,549	14.7 (12.7-16.9)	1,319	1,926,981	68.5 (65.0-72.3)	1,222	1,002,526	121.9 (115.3-128.9)
2011	2,087	4,035,623	51.7 (49.5-54.0)	198	1,311,696	15.1 (13.1-17.4)	1,109	1,954,251	56.8 (53.6-60.2)	780	1,017,321	76.7 (71.5-82.3)

12

208   The incidences of cartilage surgery in the four different health regions display great diversity

209 as it is twice as common having experienced cartilage surgery within the Northern region as opposed

210 to the South-East region (figure 2). The incidences throughout the 19 different counties also display

211 large variations (figure 2). The incidences range from 7.5 to 210.3 per 100,000 inhabitants.

212

213 **Trends**

214

215   The trends for type of surgery varied between private and public hospitals (table 3). Whereas

216 private hospitals had nearly 90% debridement, this represented only approximately half of the

217 procedures in public hospitals. Repair- or restorative techniques accounted for almost 400

218 procedures per year. The middle health region had the lowest proportion of cartilage repair- or

219 restorative techniques (13.4 %) in 2009. In comparison the northern region had a share of 42.6 % the

220 same year. The corresponding numbers for 2008 were 11.7% and 49.6%. The odds ratio of having

221 specific cartilage surgery performed in the northern region compared to the other regions was 7.44

222 (6.11-9.06). Nationwide the MP/OAT was the most frequent procedure for all years, ranging from

223 57.6% - 62.8%. Only 4.2% - 6.6% of the yearly procedures were cell transplantation techniques.

224

225 Table 3 displays the distribution for all the public cases from 2008 and 2009, among the different subgroups within the

226 regions and for the private institutions.

	CP	MF	MP/OAT	rCL/fCL	ACI	HTO	Other/no	Total
2008+2009 nationwide	1,763 (50.9)	184 (5.3)	387 (11.1)	525 (15.2)	71 (2.0)	329 (9.5)	205 (5.9)	3,464
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

13

North	186 (37.6)	19 (3.8)	183 (37.0)	44 (8.9)	25 (5.1)	16 (3.2)	21 (4.3)	496
Private	2,338 (89.3)	70 (2.7)	87 (3.3)	82 (3.1)	1 (0.0)	0 (0)	40 (1.5)	2,618

227

228

229   A substantial part of all included cases of cartilage surgery were performed in private

230   institutions, whereas only 6.0% of the specific reparative or restorative procedures were performed

231   by private institutions (table 3). The odds ratio of being treated with these methods in private

232   institutions rather than public was 0.28 (0.24-0.34). A Pearson chi-square confirmed a highly

233   significant association between the regions and also between private and public hospitals, meaning a

234   true difference exists. Most patients are treated in an outpatient setting and this accounted

235   especially for private institutions.

236

237   Specific cartilage surgery (reparative or restorative procedures) was not exclusively

238   performed at University hospitals, which accounted for only 44.5 % of these procedures. University

239   hospitals performed 57.5 % of all transplantation techniques, 56.8 % of MP-procedures and only 13.6

240   % of MF-procedures.

241

242   *Age*

243

244   The age between the seven different subgroups were statistically significant different ($p <$

245   .001), whereas the CP group (median 51.0) was significantly older than both MF (median 39.0) and

246   ACI group (median 29.0), the MF group was older than the ACI group and not statistically significant

247   different from the MP group (median 42.0). The distribution of specific cartilage repair or restoration,

248   meaning that palliative surgery is excluded, showed that he majority of procedures are performed on

14

249   patients within the 20-50 years age group. Transplantation procedures seldom performed in the

250   oldest age group (50-67 years of age), whereas the youngest group (<20 years of age) is more

251   commonly treated with microfracture followed by transplantation. Odds ratios with confidence

252   intervals between groups > or <20 years and > or < 50 years demonstrated significant differences

253   where MP/OAT and ACI were more commonly performed in patients under 50 years of age, whereas

254   MF and MP/OAT were more commonly performed in patients under the age of 20.

255

DISCUSSION

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257

258   A total of 10,830 cases matched our definition and represents the nationwide load of

259   cartilage surgery in Norway throughout 2008-2011. More than 2,500 cartilage surgeries are

260   performed yearly and 400 of these are reparative or restorative techniques. The total incidence of

261   cartilage surgery over these four years is 56 per 100,000. These numbers are within the same range

262   as with incidences for knee ligament surgery in Norway, which is considered a common surgery.

263   Granan et al found an incidence of ACL surgery of 34 per 100,000 inhabitants, whereas 85 per

264   100,000 in the age group 16-39 years of age, in Norway in their baseline study of the Scandinavian

265   Knee Ligament Registries.[22]

266

267   Although common, the yearly incidence varies greatly among age groups, health regions, and

268   counties, and cartilage surgery is not performed mainly around the largest cities or large regional

269   hospitals and University clinics. Furthermore the data demonstrate a significant reduced frequency of

270   reparative procedures for patients treated at private institutions (p <.001). It is not possible to

271   outline whether this is a case of reduced accessibility, but it is likely that procedures leading to more

272   overnight stays are less available at these institutions.

273

274   Few studies have explored the regional incidence of cartilage surgery   and none have, to our

275   knowledge, reported nationwide incidence rates. Two studies published in 2013 presented numbers

276   on this subject based on data from the PearlDiver Database in the USA. Montgomery et al[19] reports

277   an incidence rate of 1.27-1.57/10,000 patients and McCormick et al[18] reports an incidence rate of

278   90/10,000 from respectively 2004-2009 and 2004-2011. There is a remarkable difference in incidence

279   between these two studies. McCormick seems to calculate incidences based on all individual patients

280   within the database, whereas Montgomery calculates incidences based on all patient records which

281   may explain why different numbers are reported. Our incidence rates are within the same range as

16

282   Montgomery et al when compared to the number presented in the articles. However, when we

283   recalculated new incidence rates, based on the numbers of procedures and patients from the two

284   articles and applied the same approach as used in the current study, we found quite different

285   incidence rates from both those reported by the two authors. Consequently, the incidence rates

286   from the current study then appears in the vicinity of McCormick et al (table 4). Both these studies

287   focused on specific cartilage surgery only, and did not include patients where simply the diagnosis of

288   an FCD was present or where an osteotomy, in the absence of knee OA, was performed. These two

289   subgroups accounted for less than ten percent in the current study and were excluded for the

290   purpose of comparing incidence rates for years 2008-11 (table 4).

291

292   **Table 4 gives the incidence rates from two American studies on namely trends and incidences from a private database**

293   **for health insurance together with the incidence from the present study. The incidence rates are given per 10,000**

294   **patients/inhabitants and are calculated from the numbers of procedures and patients that are given by the two articles.**

295   **The reported numbers are presented in parenthesis.** *These numbers are calculated after exclusion of the patient group

296   without cartilage surgery and the patient group where osteotomy was performed alone or in addition to cartilage surgery

297   and thereby represents the same patient population as in the two published studies.

Year	Montgomery et al (reported)	McCormick et al (reported)	Present study*
2008	154.1 (1.54)	9.1 (91)	6.8
2009	152.7 (1.53)	9.3 (92)	7.2
2010	-	10.4 (104)	6.2
2011	-	9.3 (93)	4.6

298

299   **Trends**

300

301   We expected most of the surgeries to be performed in the largest public hospitals within the

302   central parts of the South-East region. However, we found that 43 % of the cases had surgery in

17

303   private institutions, whereas only 40 % of the public cases were performed in the South-East region.

304   We also suspected specific cartilage surgery (reparative or restorative procedures) to be exclusively

305   performed at University hospitals, which was either no true. These findings imply that if a cartilage

306   registry is developed, an important consideration is whether to include hospitals from several health

307   regions in addition to private hospitals.

308

309   Furthermore, we found that 56 hospitals performed some kind of cartilage surgery

310   throughout 2009. Fifteen hospitals operated less than ten cases within this one-year period.

311   Although not the same procedure, Katz et al found that patients operated in low-volume hospitals by

312   low-volume surgeons had worse functional outcomes two years after total knee replacement (TKR).[23]

313   The same group also found an association between lower socioeconomic status and the likeliness of

314   choosing low-volume hospitals. In the present study we do not have information on the experience

315   of the orthopedic surgeons nor the socioeconomic level of the patients. Cartilage surgery is a

316   complex treatment where several options exists, indicating that the availability of several techniques

317   as well as an optimized rehabilitation program is needed. Such extensive treatment options probably

318   requires a certain, but not yet defined, number of procedures yearly by the institution to maintain

319   adequate quality of care.

320

321   The reasons for the geographical differences cannot be explained in this study, but possible

322   factors might be differences between the orthopedic surgeons' personal preferences and experience

323   more than differences in the patient populations. A study aiming to describe the practice of MF

324   among Canadian orthopedic surgeons found widespread variation with regards to indication for

325   surgery.[24] Patient willingness to undergo surgery is also an important consideration and is

326   demonstrated to be higher in areas with already high incidence of surgery.[25]

327

18

328   There are several different techniques for palliating, repairing or restoring articular cartilage

329   defects and although attempts on recommendations have been made, there is no gold standard

330   treatment.[6-14;26] MF is traditionally chosen for smaller defects whereas OAT or ACI are chosen for

331   larger defects.[27] More specific recommendations do not exist, and we know little of the decision-

332   making for surgical technique other than size of the lesion. We do not have data on the size or

333   location of the lesions in the current study. The study by Montgomery et al found that MF and

334   chondroplasty are the preferred procedures in 98 % of cases with cartilage surgery.[19] These

335   procedures constituted 71.1% of all procedures in our material. We applied the trends from the

336   articles of Montgomery et al [19] as expected values and ran a chi square test on our material which

337   resulted in a p-value < .001 and thereby significantly different distribution of trends. The p-value was

338   still < .001 after excluding the groups who had either no cartilage surgery or osteotomies.

339

340   **Limitations**

341   The ICD-10 codes available for diagnosing FCDs do not reflect the complexity of the clinical

342   situation of these lesions. Location, size and depth probably matter greatly and these are not taken

343   into account in the ICD-10. And although the ICD-10 contains both "acute FCD" (S83.3) and

344   osteoarthritis of the knee (M17), there are no code for the quite common "non-acute FCD". We

345   initiated correspondence with the Norwegian Arthroscopic Association and found that our

346   predefined ICD-10-codes matched with 92.3 % of the reported codes. However, the response rate

347   was only 13.2 % even after two reminders. The low response rate has limited effect on our final

348   numbers since we have included most of the possible codes from the ICD-system, but these

349   challenges co-exist with the fact that some orthopedic surgeons might not code for FCDs if other

350   intraarticular pathology is recognized. This is probably the largest limitation and cannot be defeated

351   by any methodological changes, but by information and education of orthopedic surgeons.

352

19

353   The patient records or surgical protocols should be considered the gold standard. However,

354   large administrative databases allow the process of data-collection to be efficient, detailed and

355   precise, within its limitations. An article published in 1992 looked at the completeness of an

356   orthopedic database in England by comparing this with Hospital Activity Data and found that overall

357   completeness of the database was 62 % (and lower in the outpatient setting), whereas this increased

358   to nearly 80 % after audit and feedback.[28] They further suspected motivation to be the most effective

359   factor in promoting correct use of the database. Feedback is therefore an important factor for

360   achieving high compliance.

361

362   Studies have demonstrated that numbers extracted from electronic databases are being both

363   over- and underestimated. Lofthus et al found that hospitalization for hip fractures were

364   overestimated by 29 % by the national electronic database in Norway (NPR), although the number of

365   having surgery for hip fractures was underestimated.[29] Readmissions due to the same hip fracture

366   were registered as a new hospitalization for a new hip fracture by the NPR which again inflated the

367   number. In our material, 297 cases (4.9%) were duplicates and only 73 procedures (0.67%) were

368   classified as reoperations. Hagen et al found correct diagnosis in only 24.1% of cases where patients

369   were discharged from the hospital with ICD 8, 9 and 10 codes for traumatic spinal cord injury (SCI).[30]

370   The accuracy of coding for surgical procedures is also shown to be low,[31] but we believe that these

371   codes are reported in more detail in Norway as they are the basis of 60 % of the government

372   reimbursement, and as such are reviewed several times by hospital controllers to ensure correct

373   coding. We did not validate the numbers of the current study, and existing literature imply that our

374   numbers are not exact. An under- or overestimation might exist, however the main goal of this study

375   was to estimate the nation-wide burden of cartilage surgery with the numbers available in NPR.

376

20

Future clinical implications

377

378

379   Cartilage surgery concerns a large and severely troubled patient group. Numerous cohorts

380   and randomized controlled studies have published varying effects of the many existing procedures.

381   However, no nationwide surveillance currently exists to study the efficacy of treatment for this

382   patient group. Development of a cartilage registry emphasizing cartilage treatment being palliative,

383   reparative or regenerative, in addition to nonsurgical procedures will be essential for the clinical

384   progression in this field.

385

CONCLUSION

386

387

388   In Norway there are 2,500 annual procedures classified as cartilage surgery, resulting in an

389   age-adjusted incidence rate of 68.8 per 100.000 inhabitants. There are large variations between the

390   different regions. There are also differences in trends between public and private hospitals.

391

392   This illustrates the need for a larger surveillance database, for the evaluation of results,

393   calculation of costs and to secure high quality treatment for all knee cartilage patients.

394

Acknowledgements

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

Contributors

398   LE and AÅ conceived the study whereas the method was planned by all authors. CNE was responsible for data collection

399   and analyses, whereas all authors participated in the interpretation. CNE drafted the manuscript, whereas AÅ and LE

400   revised it. All authors approved the final version.

Competing Interest

402   None

Funding

404   The study was supported through grants from the Oslo Sports Trauma Research Centre (OSTRC), where the corresponding

405   author is employed. The centre is financed by the South-Eastern Norway Regional Health Authority, the Royal Norwegian

406   Ministry of Education and Research, the Norwegian Olympic Committee & the Confederation of Sport and Norsk Tipping.

407   The work was also supported by the Faculty of Medicine, University of Oslo (UiO) as Cathrine N. Engen previously was a

408   student at the Medical Student Research Program at UiO and thereby received financial support by the Research Council of

409   Norway.

410   The research project did not receive any specific grant from any funding agency.

Data sharing statement

412   No additional data are provided.

413

22

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501

502

503   **FIGURE LEGENDS**

504

505   **Figure 1 illustrates the flowchart of patients eligible for inclusion.**

506

507   **Figure 2 illustrates the incidence rates in the four different health regions in Norway (top) and the incidence rates**

508   **throughout Norway`s 19 counties (bottom) in 2009. Numbers are based on the localization of the hospital, and not the**

509   **patient`s home-address. Activity from private hospitals is excluded. The incidence rates are age-adjusted to the**

510   **population included in this study, which ranged from four to 66 years of age. All surgeries performed in private**

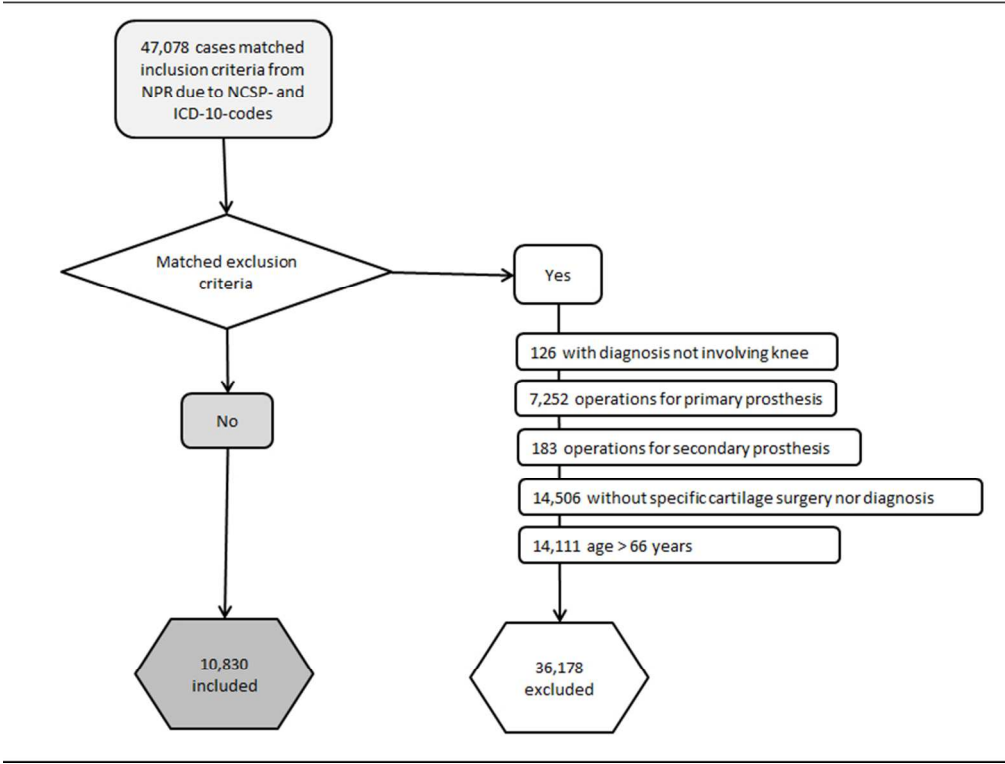511   **institutions are excluded from this material, which was 1 475 surgeries in 2009.**

512

26

Figure 1
215x164mm (96 x 96 DPI)

0-20/100 000
20-40/100 000
40-60/100 000
60-80/100 000

0-50/100 000
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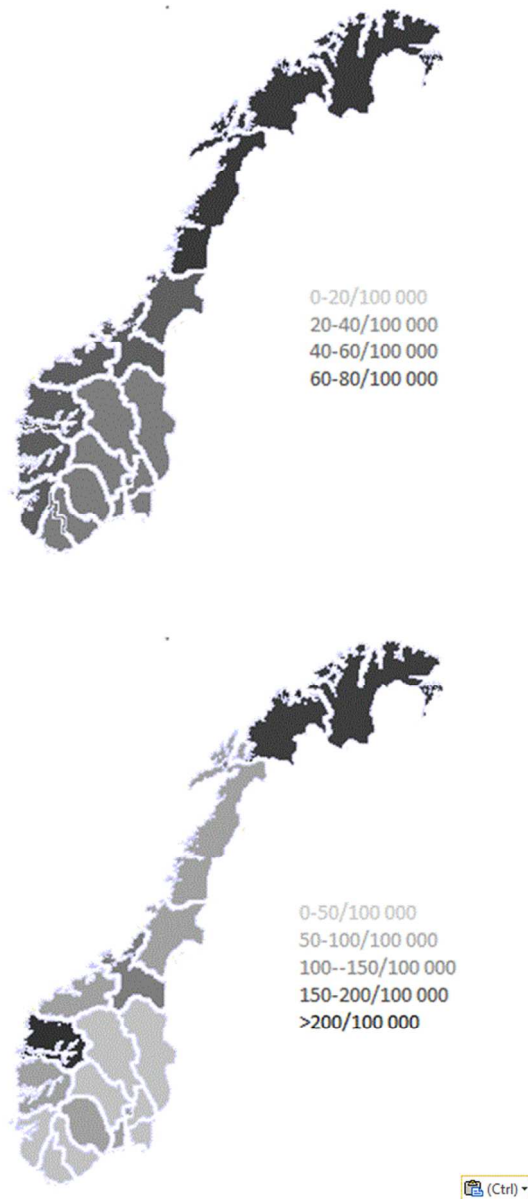100--150/100 000
150-200/100 000
>200/100 000

Figure 2
43x87mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed
		Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed
		Case-control study—If applicable, explain how matching of cases and controls was addressed
		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

From author:

All applicable items are reported in the article and marked in yellow. Item 15 is not relevant due to the fact that this is not an analytical epidemiologic study and we have not included measures of patient outcome.

BMJ Open

Incidence of Knee Cartilage Surgery in Norway, 2008-11

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Manuscripts

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Incidence of Knee Cartilage Surgery in Norway, 2008-11

2

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13

14   **Key words:** Cartilage surgery, articular cartilage, cartilage repair, knee, incidence

15   New word count: 4128

16   Abstract: 290 words

1

17 ## ABSTRACT

18

19 **Objective:** A systematic and long-term data collection on the treatment of focal cartilage defects

20 (FCDs) of the knee is needed. This can be achieved through the foundation of a National Knee

21 Cartilage Defect Registry. The aim of this study was to establish the nationwide burden of knee

22 cartilage surgery, defined as knee surgery in patients with an FCD. We also aimed to identify any

23 geographical differences in incidence rates, patient demographics or trends within this type of

24 surgery. **Setting:** Population based study with retrospective identification of patients undergoing

25 knee cartilage surgery in Norway through a mandatory public health database from 2008-11.

26 **Participants:** We identified all patients undergoing cartilage surgery, or other knee surgery in

27 patients with an FCD. All eligible surgeries were assessed for inclusion based on certain types of ICD-

28 10 and NCSP codes. **Primary and secondary outcome measures:** The variables were diagnostic and

29 surgical codes, geographic location of the performing hospital, age and sex of the patients. Yearly

30 incidence and incidence rates were calculated. Age-adjusted incidences for risk ratios and odds

31 between geographical areas were also calculated. **Results:** A total of 10,830 cases of knee cartilage

32 surgery were identified, with a slight, although significant decreases from 2008-11 (p <.0003). The

33 national incidence rate was 56/100,000 inhabitants and varied between regions, counties and

34 hospitals. More than 50% of the procedures were palliative and nearly 400 yearly procedures were

35 reparative or restorative. **Conclusions:** Knee cartilage surgery is common in Norway counting 2,500

36 annual cases with an age-adjusted incidence rate of 68.8/100,000 inhabitants. There are significant

37 geographical variations in incidence and trends of surgery and in trends between public and private

38 hospitals. We suggest that a national surveillance system would be beneficial for the future

39 evaluation of the treatment of these patients.

40

41

2

42 **ARTICLE SUMMARY**

43 **Strengths and limitations of this study:**

44 • This cohort study presents the national burden of knee cartilage surgery in Norway.

45 • The geographical differences and differences in trends are reliable as the data collection is

46 mandatory for all hospitals.

47 • ICD-codes were used for inclusion and this represents a limitation, as there are no specific

48 codes for "non-acute focal cartilage defect", which leads to unspecific diagnosis. This

49 limitation is partly corrected for by adding NCSP surgical codes to the inclusion criteria.

50 • Compliance and validity is a limitation for the data quality in most registry studies. The

51 Register included in the present study is previously shown to both over- and underestimate

52 clinical conditions, however studies that are more recent have demonstrated high validity.

3

INTRODUCTION

53 INTRODUCTION

54

55   Knee cartilage injury is a well-known condition after the introduction of knee arthroscopy

56 and MRI. Cartilage injury might consist of a single or several focal lesions or it might constitute

57 generalized degenerative changes within the knee. Focal lesions are classified as traumatic or

58 degenerative and some exist without causing symptoms. They are believed to lead to a chronic

59 osteoarthritic stage with pain and reduced function, however demonstrated only in animal models.[1;2]

60 Arthroscopic studies have shown that focal cartilage defects (FCDs) within the knee occur in 19-67%

61 of patients with painful knees.[3-6] A systematic review found a prevalence of 36% in athletes examined

62 by arthroscopy, MRI or both, whereas 14% were asymptomatic.[7] Another study conducted MRI of

63 the tibiofemoral joint in persons aged 50 or more from the general population (mean age of 62.3

64 years).[8] They found cartilage abnormalities in 69%. We suspect FCDs to be common also in the

65 general population including subjects under the age of 50.

66

67   Several years of research on cartilage surgery have still not lead to a clear gold standard

68 treatment of FCDs within the knee. The results from RCTs are variable,[9-16] the patient population is

69 heterogeneous[17] and a group of non-operated controls has still not been included in an RCT, making

70 it difficult to decide the role of rehabilitation alone. Also, the quality of clinical studies on cartilage

71 research is low.[18;19] The most common performed procedures on patients with knee cartilage injuries

72 are palliating procedures, such as chondroplasty and debridement, which have demonstrated

73 symptomatic relief in uncontrolled cohort studies but fail to do so in RCTs.[20;21] Unfortunately, in this

74 area of orthopedic surgery the practice of evidence-based medicine is lacking and the procedures are

75 still used for patients with degenerative changes within their knees.

76

77   Results from other orthopedic registries have led to improved treatment quality and we are

78 currently looking into the potential benefits and challenges of establishing a National Knee Cartilage

79 Defects Registry. Before establishing such a registry, several conditions must be explored. This study

80 intends to present the burden of surgery for the disease.

81

82   Two studies from the United States have calculated incidence rates from an insurance

83 database.[22;23] Montgomery et al showed incidence rates ranging from 1.27-1.57/10,000, while

84 McCormick et al presented incidence rates ranging from 63-104/10,000. These numbers would

85 represent 635-52,000 yearly procedures when applied to the number of inhabitants in Norway,

86 which is a very wide interval. In 2014 a study on trends of cartilage injuries documented by

87 arthroscopy in Denmark was published.[24] They excluded patients with osteoarthritis (OA) and found

88 an incidence of 40/100,000 person-years for the years 1996-2011.

89

90   The aim of this study was to establish the nation-wide burden of surgery on knees with knee

91 cartilage defects in Norway. This will play an important role in the evaluation of the possible

92 establishment of a National Knee Cartilage Defects Register in Norway. We calculated the national

93 and regional incidences and aimed at detecting any geographical variations. The latter is of major

94 interest for health development research, medical industry as well as health care providers. Our

95 hypothesis was that cartilage surgery is uncommon and performed mainly in hospitals around the

96 larger cities and that only University hospitals perform advanced cartilage surgery.

5

PATIENTS AND METHODS

Data source

101 The study is descriptive with population-based data from years 2008-2011 in Norway. It is a

102 retrospective cohort study through the continuous data collection done by the Norwegian Patient

103 Registry (NPR). The NPR is run by the Norwegian Directorate of Health and contains data on the

104 activity in specialist health services. Norway has approximately 5 million inhabitants. The country

105 consists of four health regions and 19 administrative counties. The South-East region is most

106 populous, followed by the West, Mid and North regions. Norway has a national public health care

107 system aiming at equal health services to all inhabitants regardless of their income or private

108 insurances. Also, a growing number of private hospitals and surgical centers offer mainly elective

109 orthopedic surgery to patients with private insurance, reimbursed by public funding through

110 government contracts or paying out of pocket (previously 10-15 % of specific elective surgeries,

111 however influenced by substantial geographical variation[25]).

113 The NPR contains reports on the International Statistical Classification of Diseases and

114 Related Health Problems (ICD) code and the NOMESKO Classification of Surgical Procedures (NCSP)

115 code along with other reported factors. It is obligatory for all public hospitals, and for private

116 hospitals with a contract with the public health care system, to report their activity to NPR. The

117 arrangements thereby involve also all major private hospitals. The present patient pool consists of all

118 Norwegian patients.

119 Table 1 gives an overview of surgical procedures on knee and calf defined as cartilage surgery, from NCSP [26] and the

120 predefined ICD-10-codes.The two explorative procedures (NGA11 and NGA 12) are included due to the group of patients

121 with specific cartilage diagnosis, but without specific knee cartilage surgery.

6

NCSP-Code	Explanation	Corresponding surgical procedure and/or abbreviation	ICD-10-code	Disease/Injury
NGA11	Endoscopic exploration		M17	Osteoarthritis (OA) of the knee
NGA12	Open exploration		M22.4	Chondromalacia patellae
NGF21	Endoscopic fixation of corpus	Fixation of Corpus Librum (fCL)	M23.4	Loose body within the knee
NGF22	Open fixation of corpus librum,	fCL	M23.8	Other internal derangements of the knee
NGF31	Endoscopic resection of	Chondroplasty (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	Mosaic Plasty (MP) and Osteochondral	M93.2	Osteochondritis dissecans (OCD)
NGF92	Other open procedure on	MP and OAT	M94.8	Other specific pathology in cartilage
NGH41	Endoscopic removal of corpus	Removal of Corpus Librum (rCL)	M94.9	Unspecific pathology in cartilage
NGH42	Open removal of corpus librum	rCL	S83.3	Acute tear of articular cartilage of the knee
NGK29	Drilling of bone in knee or calf	Microfracture (MF)		
NGK59+69	High tibial osteotomy	HTO		
NGN	Transplantation of cartilage, bone,	Autologous Chondrocyte		

122

123   We aimed at detecting cases undergoing surgery for knee cartilage defects. Distinguishing

124   between traumatic and degenerative lesions is often difficult clinically and the development from an

125   FCD to OA might be seen as a continuum. In addition, the ICD-10-coding system is unspecific and

126   further challenges this distinction. Cases were identified from the NPR through predefined surgical

127   procedure codes (all NCSP-code constituting surgery on knee and/or calf) and ICD-10-codes (table 1)

128 and retrieved as eligible for inclusion. ICD-10-codes for concomitant injuries are not included. The list

129 (table 1) was chosen after a consensus meeting between head orthopedic surgeons of the largest

130 hospital in our region. We also contacted experienced orthopedic surgeons from other hospitals by

131 mail in order to ensure that all possible codes were included. We included diagnosis M17 after these

132 interchanges as several stated that they use M17 also for FCDs. Patients coded with M17 may have

133 degenerative changes, although some have actual focal lesions. Therefore, we made an upper age

134 limit of 67 years for inclusion and presented descriptive analyses with a distinction between under

135 and above 50 years of age.

136

137 Our data was anonymous and considered statistical data rather than information on health

138 from individual participants. We received the dataset within an SPSS file and recognized all cases that

139 underwent knee cartilage surgery during the four years, 2008-11. Cases *more* likely to constitute OA

140 were excluded, therefore patients aged 67 years or more, patients undergoing prosthesis surgery

141 and patients with M17 in combination with non-cartilage procedures (only meniscal resection for

142 instance) or high tibial osteotomy (HTO) were excluded. Cases with M17 and procedures classified as

143 cartilage surgery were included. The final number after exclusion was 10,830 in the four-year period

144 (figure 1).

145

146 **Variables and data**

147

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

149 Additionally, we requested data on the health region, county and institution and received

150 geographical variables only for the years 2008-09.

151

8

152   **Statistics**

153

154   We defined NCSP-codes as cartilage surgery, meniscal surgery, or other types of surgery. The

155   different types of cartilage surgery were defined as palliative, repairing or restorative. All cases were

156   divided into subgroups based upon these definitions. We chose the term palliative as these

157   procedures are meant to decrease pain for the patients, although its efficacy is not proven for all

158   indications. Chondroplasty (CP) or debridement were defined as palliative surgery, cartilage repair

159   included microfracture (MF) and cell-based repair with either chondrocytes (ACI) or stem-cells and

160   restorative techniques included techniques aiming at restoring the articular cartilage without

161   cartilage repair tissue produced on-site and include mosaic plasty (MP) and allograft transplantation

162   (which is currently not in use in Norway). All included cases were transferred into an individual

163   worksheet.

164

165   The data was analyzed with IBM SPSS Statistics (version 22.0). We assessed the distribution

166   of the data with age as the dependent value and concluded with a non-normality distribution. The

167   categorical variables on events of cartilage surgery were assumed to fulfill the criteria of a Poisson

168   distribution. Cases were stratified by age, sex, health region, county and year of surgery. Incidences

169   of cartilage surgery were given per 100,000 inhabitants and were adjusted to age group, region or

170   county by calculation based on population data from Statistics Norway (SSB), which is an

171   academically independent organization administered under the Ministry of Finance in Norway. The

172   data was assembled from their web pages. We compared the incidences for each of the four years to

173   each other using rate ratios and tested for significance using Wald tests. We used the Cochran-

174   Armitage trend test for comparing trends in the current study with the existing literature.

175

9

176   Demographics were considered by descriptive statistics. Differences in categorical variables

177   were calculated with odds ratios (OR) and tested with Pearson chi-square tests with geographical

178   localization as the dependent variable. We explored age differences between subgroups with box

179   plots and performed a Kruskal-Wallis test to test the statistical difference. A Bonferroni correction

180   adjusted the new alpha level to .0125 with four independent analyses (CP vs MF, MF vs ACI, CP vs

181   ACI, MF vs MP) before Mann-Whitney U tests were performed. We were not able to address

182   potential confounders such as actual differences in the prevalence of knee cartilage defects,

183   differences in the willingness to seek medical assistance for painful knees or willingness to undergo

184   surgery.

185

186   **Ethics**

187

188   We received anonymous data from the NPR, who acts under approvals of the Norwegian

189   Directorate of Health. The study was evaluated by the Regional Committees for Medical and Health

190   Research Ethics (REC) (ref: 2010/777) as not obliged for notification. We consulted the Norwegian

191   Data Protection Authority and the study is not obliged for notification due to the collection of

192   anonymous data. The data are to be considered as statistical data rather than information on health

193   in individual participants.

194

10

195 ## RESULTS

196

197   A total of 10,830 cases matched our inclusion criteria for cartilage surgery for the years 2008-

198 11 and a flowchart is presented in figure 1. There were 2,897 cases in 2008, 3,114 in 2009, 2,732 in

199 2010 and 2,087 in 2011. A total of 21,143 procedures (appendix 1) were reported throughout the

200 four years which results in a mean of 1.96 procedures per included case. The most common cartilage

201 surgery was resection of articular cartilage (NGF3y) followed by fenestration or forage or bone/MF

202 (NGK29). The most common non-cartilage surgery was meniscal surgery followed by synovectomy.

203 The mean age for all years was 45.0 (SD 13.7), whereas the mean age for 2008 was 45.6 (SD 13.7)

204 and for 2011 was 43.1 (SD 14.2), which was significantly lower than for the other years (p-value <

205 .001). The male ratio varied from 55.2% to 58.7%.

206

207 ### Incidences

208

209   The incidence rate of having experienced cartilage surgery in Norway throughout 2008-11 is

210 56/100,000 inhabitants and age-adjusted incidence rate is 68/100,000 inhabitants between 4-66

211 years of age. Table 2 displays the age-adjusted incidence rates for the different years and age groups.

212 The incidence rate from 2008 was set as reference when calculating rate ratios (RR) between

213 included years. The only significant RR was that of 2011 which was 0.69 (95 % CI 0.65-0.73, p-value

214 <.0003).

215

11

216 Table 2 shows the distribution of number of cases about year and age group and the age-adjusted yearly incidence rates

217 (with 95 % CI in parenthesis) for all three age groups. When analyzing the rates for each year within the age groups, we

218 found a significant decrease from 2008-11 for the two oldest age groups; no significant change was evident for the

219 patients between 0-20 years.

220

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	2,897	3,888,191	74.5	225	1,281,185	17.6	1,347	1,881,409	71.6	1,325	960,849	137.9
2009	3,114	3,943,356	79.0	225	1,293,171	17.4	1,532	1,905,524	80.4	1,357	983,943	137.9
2010	2,732	3,988,476	68.5	191	1,303,549	14.7	1,319	1,926,981	68.5	1,222	1,002,526	121.9
2011	2,087	4,035,623	51.7	198	1,311,696	15.1	1,109	1,954,251	56.8	780	1,017,321	76.7

12

221   The incidences of cartilage surgery in public hospitals in the four different health regions

222   display great diversity as cartilage surgery is twice as common within the Northern region as opposed

223   to the South-East region (figure 2). However, when all the procedures performed privately are

224   included, the regional differences changes and the Western region becomes the region with the

225   highest incidence (figure 3). The incidence of the Western region (161/100,000 inhabitants) is four

226   times higher than in the South-East region, which has the lowest incidence (37/100,000 inhabitants).

227   The incidences throughout the 19 different counties also display large variations (figure 2). The

228   incidences range from 7.3 to 278.1/100,000 inhabitants.

229

230   **Trends**

231

232   The trends for type of surgery varied between both regions and between private and public

233   hospitals (table 3). Whereas private hospitals had nearly 90% debridement, this represented only

234   approximately half of the procedures in public hospitals. Advanced cartilage surgery (repair- or

235   restorative techniques) accounted for almost 400 procedures per year. The middle health region had

236   the lowest proportion of advanced cartilage surgery (13.4%) in 2009. In comparison, the northern

237   region performed 42.6% such procedures in 2009. The corresponding numbers for 2008 were 11.7%

238   and 49.6%. The OR of having advanced cartilage surgery performed in the northern region compared

239   to the other regions was 7.44 (6.11-9.06). Nationwide the MP/OAT was the most frequent of repair-

240   or restorative procedure for all years, ranging from 57.6% - 62.8%, whereas 4.2% - 6.6% were cell

241   transplantation techniques.

242

13

243 Table 3 displays the distribution for all the public cases, among the different subgroups within the regions and for the

244 private institutions from 2008 and 2009.

	CP	MF	MP/OAT	rCL/fCL	ACI	HTO	Other/no	Total
Public	1,763 (50.9)	184 (5.3)	387 (11.1)	525 (15.2)	71 (2.0)	329 (9.5)	205 (5.9)	3,464
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	2,338 (89.3)	70 (2.7)	87 (3.3)	82 (3.1)	1 (0.0)	0 (0)	40 (1.5)	2,618

245

246

247   A substantial part of all included cases of cartilage surgery was performed in private

248 institutions, whereas they performed 19.8% of the repair- or restorative procedures (table 3). The OR

249 of being treated with these methods over palliative procedures in private institutions rather than

250 public was 0.18 (0.08-0.43). A Pearson chi-square confirmed a highly significant association between

251 the regions and between private and public hospitals. Most patients were treated in an outpatient

252 setting and this accounted especially for private institutions. University hospitals performed only

253 44.5% of cases with advanced cartilage surgery. University hospitals performed 57.5 % of all

254 transplantation techniques, 56.8 % of MP-procedures and only 13.6% of MF-procedures.

255

256 *Age*

257

258   The age between the seven different subgroups were statistically significant different (p <

259 .001), whereas the CP group (median 51.0) was significantly older than both MF (median 39.0) and

260 ACI group (median 29.0), the MF group was older than the ACI group and not statistically significant

14

261   different from the MP group (median 42.0). The age-distribution of advanced cartilage surgery

262   showed that the majority of procedures are performed on patients aged 20-50 years. Transplantation

263   procedures were seldom performed in the oldest age group (50-67 years of age), whereas the

264   youngest group (<20 years of age) was more commonly treated with MF followed by transplantation.

265   ORs demonstrated that MP/OAT and ACI were more common for patients under 50 years of age,

266   whereas MF and MP/OAT were more common for patients under the age of 20.

267

15

268   ## DISCUSSION

269

270   A total of 10,830 cases were included and represents the nationwide load of knee cartilage

271   surgery in Norway throughout 2008-11. There are 2,500 cartilage surgeries yearly and 400 of these

272   are advanced cartilage surgery. The total incidence of all cartilage surgery over these four years is

273   56/100,000. These numbers are within the range of incidences for knee ligament surgery in Norway,

274   which is considered a common surgery. Granan et al found an incidence of ACL surgery of

275   34/100,000 inhabitants, although 85/100,000 in the age group 16-39 years of age, in Norway in their

276   baseline study of the Scandinavian Knee Ligament Registries.[27]

277

278   Although common, the yearly incidence varies greatly among age groups, health regions,

279   counties and between public and private hospitals. Cartilage surgery is not in use mainly around the

280   largest cities or regional hospitals and University clinics, in contrast to our hypothesis. Private

281   institutions accounted for 43% of all cases, whereas only 40% of the public cases were performed in

282   the South-East region. These findings imply that if a cartilage registry is developed, an important

283   consideration is whether to include hospitals from several health regions in addition to private

284   hospitals. Furthermore the data demonstrate a significant reduced frequency of advanced cartilage

285   surgery for patients treated at private institutions (p <.001). It is not possible to outline whether this

286   is a case of reduced accessibility, but it is likely that procedures leading to more overnight stays are

287   less available at these institutions.

288

289   Similar differences between public and private hospitals are seen in other Scandinavian

290   countries for meniscal surgery,[28] and these differences might also be due to financial incentives.

291   Codes for palliative procedures were mainly in use for middle-aged patients in combination with

292   M17. It is previously demonstrated in studies that debridement is no better than sham surgery [20] or

293   rehabilitative training with a Physiotherapist, [21] whereas the latter also failed to show the efficacy of

16

294 surgery in patients with mechanical symptoms. These studies changed the trends in surgery on

295 patients with OA as the rates of arthroscopy declined the following years, at least in the US.[29] It is

296 possible that a larger part of these procedures now is performed on patients with actual FCDs,

297 although these procedures are still used also in patients with knee OA. Based on recent literature,

298 this type of surgery should be abandoned.

299

300 Few studies have explored incidences of cartilage surgery whereas one study presents

301 national numbers on cartilage injuries diagnosed with arthroscopy.[24] Two studies presented

302 remarkably different numbers based on data from the PearlDiver Database in the USA. Montgomery

303 et al[23] reports an incidence rate of 1.27-1.57/10,000 (2004-09) patients and McCormick et al[22]

304 reports an incidence rate of 90/10,000 (2004-11). McCormick seems to calculate incidences based on

305 all individual patients within the database, whereas Montgomery calculates incidences based on all

306 patient records, which may explain the different results. Our incidence rates are within the same

307 range as Montgomery et al when compared to the number presented in the articles. However, when

308 we recalculated new incidence rates based on the numbers provided by the two articles and applied

309 the same approach as used in the current study, we found quite different incidence rates from both

310 articles. Consequently, the incidence rates from the current study then appears in the vicinity of

311 McCormick et al (table 4). Both studies focused on cartilage surgery only, and excluded patients with

312 simply the diagnosis of an FCD or patients undergoing osteotomy in the absence of knee OA. These

313 two subgroups accounted for less than ten percent in the current study and were excluded when

314 comparing incidence rates for years 2008-11 (table 4). The same table display the numbers from the

315 Danish study, which are in close range with the numbers from the present study.

316

317 Table 4 gives the incidence rates from two American studies on trends and incidences from a private database for health

318 insurance, together with the national incidences from the Danish and the current study. Incidence rates are given per

319 10,000 patients/inhabitants and are calculated from the numbers of procedures and patients that are given by the two

320 articles. The reported numbers are presented in parenthesis. *These numbers are calculated after exclusion of the patient

17

321   group without cartilage surgery and the patient group where osteotomy was performed alone or in addition to cartilage

322   surgery and thereby represents the same patient population as in the two published studies.

Year	Montgomery et al (reported)	McCormick et al (reported)	Mor et al, 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

323

Trends

325

326   We found that 56 hospitals performed cartilage surgery whereas fifteen hospitals operated

327   less than ten cases throughout 2009. Katz et al found that patients operated in low-volume hospitals

328   by low-volume surgeons had worse functional outcomes two years after total knee replacement

329   (TKR).[30] When performing procedures that has failed to prove efficacy, the volume of the operating

330   surgeons means less. However, this is a field with many patients and presumably low evidence-based

331   adherence. Cartilage surgery is a complex treatment where several options exists, indicating that the

332   availability of several techniques as well as an optimized rehabilitation program is needed. In order

333   to form a standardized treatment for as many patients as possible, each hospital or surgeon probably

334   need to see certain, but not yet defined number of patients yearly to maintain adequate quality of

335   care. A discussion whether to make specific cartilage centers must be made.

336

337   The present study cannot explain the reasons for the geographical differences, but possible

338   factors might be differences between the orthopedic surgeons' personal preferences and experience

339   more than differences in the patient populations. A study aiming to describe the practice of MF

340   among Canadian orthopedic surgeons found widespread variation concerning indication for

18

341　surgery.[31] Patient willingness to undergo surgery is also an important consideration and is higher in

342　areas with already high incidence of surgery.[32]

343

344　　　　　Knee cartilage surgery consists of several different techniques and although attempts on

345　recommendations have been made, there is no gold standard treatment.[9-16;33] MF is traditionally

346　chosen for smaller defects whereas OAT or ACI are chosen for larger defects.[34] More specific

347　recommendations do not exist, and we know little of the decision-making for surgical technique

348　other than size of the lesion and the patient age. We do not have data on the size or location of the

349　lesions in the current study. CP is the most common procedure in our material and is performed for

350　both FCDs and in knees with developing degenerative changes. The study by Montgomery et al found

351　that MF and CP are the preferred procedures in 98 % of cases with cartilage surgery.[23] These

352　procedures constituted 71.1% of all procedures in our material. The study by Mor et al found repair

353　procedures (MF, osteochondral transplantation or chondrocyte transplantation) to be performed in

354　16.7% of the cases.[24] The trends from the articles of Montgomery et al [23] was significantly different

355　from the trends of our material when compared with a chi square test (p-value < .001). The

356　difference was still significant after excluding the groups who had no cartilage surgery or

357　osteotomies. Also, the trends in procedures from the study by Mor et al was different from the

358　trends of the present study with a lower proportion of palliative procedures, also after excluding the

359　cases with no cartilage surgery or osteotomies.

360

361　**Limitations**

362　　　　　The ICD-10 codes available for diagnosing FCDs do not reflect the complexity of the clinical

363　situation of these lesions. The distinction between focal lesions that are traumatic or degenerative is

364　often difficult clinically, and location, size and depth matter greatly. The ICD-10 does not account for

365　these conditions, and a distinction based on these codes is impossible. Although the ICD-10 contains

366　both "acute FCD" (S83.3) and several codes for knee cartilage pathology, there are no codes for the

19

367   common "non-acute FCD", which might be subacute or chronic. Our predefined codes matched with

368   92.3 % of the reported diagnostic codes from the Norwegian Arthroscopic Association. However, the

369   response rate was only 13.2%. The low response rate has limited effect on our final numbers since

370   we have included most of the possible codes from the ICD-system, but these challenges co-exist with

371   the fact that some orthopedic surgeons might not code for FCDs at all if other intraarticular

372   pathology is recognized. This is probably the largest limitation and cannot be defeated by any

373   methodological changes, but by information and education of orthopedic surgeons. This is therefore

374   a challenge concerning cartilage pathology and the ICD-system and is as such a problem for the

375   entire research field and not only for the current study.

376

377   Among 11,566 ICD-10-codes there are 789 coded as S83.3. The frequency of M17-codes

378   increase with age, however several orthopedic surgeons stated that they use M17 also for focal

379   lesions. The inclusion of patients with M17-diagnosis might lead to an overestimation of surgery for

380   cartilage injury. However, an exclusion of these would definitely lead to an underestimation. The

381   current study reports a lower portion of palliative procedures than the Danish study[24] (where they

382   excluded all patients with OA) which might imply that most of those included in the present study are

383   actual knee cartilage defects and not OA.[24] We did not include the ICD-10-code for "painful joint"

384   (M25.5) which might have underestimated the results.

385

386   The patient records or surgical protocols are considered the gold standard. However, large

387   administrative databases allow the process of data-collection to be efficient, detailed and precise,

388   within its limitations. The Norwegian health care system is public and tax-funded which balances out

389   possible geographic or socioeconomic differences. Studies have demonstrated that numbers

390   extracted from electronic databases are being both over- and underestimated. Lofthus et al found

391   that the Norwegian NPR overestimated hospitalization for hip fractures by 29%, although the

20

392　number of having surgery for hip fractures was underestimated.[35] Readmissions due to the same hip

393　fracture were registered as a new hospitalization for a new hip fracture by the NPR, which inflated

394　the number. In our material, 297 cases (4.9%) were duplicates and only 73 procedures (0.67%) were

395　classified as reoperations. We believe that *procedure* codes are reported in more detail as they are

396　the basis of 60 % of the government reimbursement in Norway, and as such are reviewed several

397　times by hospital controllers to ensure correct coding. For the current study, we were interested in

398　the burden of cartilage surgery and a combination of diagnostic and procedure codes seemed most

399　appropriate.

400

401　　　　The validity for the Norwegian NPR database was later assessed in a national study on hip

402　fractures and the accuracy was found to be 98.2 % (CI 96.5-99.9%) when diagnostic codes were

403　combined with procedure codes.[36] In that same study they suggested possible coding errors for the

404　current combination of diagnostic and procedure codes due to conservatively treated fractures or

405　missing if the patient died before operation. This does not apply for the current study, as the

406　diagnosis is set during operation. The study by Mor assessed the validity against surgical descriptions

407　in the medical records as gold standard and found the positive and negative predictive value to be

408　88% and 99%, respectively.[24] As for all studies with inclusion based on surgical procedures, FCDs

409　diagnosed with MRI and treated conservatively are not included. An under- or overestimation might

410　exist, however the main goal of this study was to estimate the nation-wide burden of cartilage

411　surgery with the numbers available in NPR.

412

413　**Future clinical implications**

414

21

415   Cartilage surgery concerns a large and severely troubled patient group with no gold standard

416   treatment. No nationwide surveillance currently exists to study the efficacy or effectiveness of

417   treatment for this patient group. Development of a cartilage registry emphasizing cartilage treatment

418   being palliative, reparative or regenerative, in addition to nonsurgical procedures will be essential for

419   the clinical progression in this field.

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

421

22

422 **CONCLUSION**

423

424 In Norway there are 2,500 annual procedures classified as cartilage surgery, resulting in an

425 age-adjusted incidence rate of 68.8/100.000 inhabitants. There are large variations between the

426 different regions and between public and private hospitals.

427

428 This illustrates the need for a larger surveillance database for evaluation of results and

429 calculation of costs in order to secure high quality treatment for all knee cartilage patients.

430

433 **Contributors**
434 LE and AÅ conceived the study whereas all authors planned the method. CNE was responsible for data collection and

435 analyses, whereas all authors participated in the interpretation. CNE drafted the manuscript, whereas AÅ and LE revised it.

436 All authors approved the final version.

437 **Competing Interest**
438 None

446 **Data sharing statement**
447 No additional data are provided.

448

23

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552
553

26

554 **FIGURE LEGENDS**

555

556 **Figure 1 illustrates the flowchart of patients eligible for inclusion.**

557

558 **Figure 2 illustrates the incidence rates in the four different health regions in Norway (top) and the incidence rates**

559 **throughout Norway`s 19 counties (bottom) in 2009. Numbers are based on the localization of the hospital, and not the**

560 **patient`s home-address. Activity from private hospitals is excluded for these figures as they mostly perform palliative**

561 **surgeries in middle-aged patients and thereby account more for degenerative surgery than cartilage surgery. The**

562 **incidence rates are age-adjusted to the population included in this study, which ranged from four to 66 years of age. All**

563 **surgeries performed in private institutions are excluded from this material, which was 1 475 surgeries in 2009. (The map**

564 **of Norway was downloaded from Wikipedia Commons and edited in Paint.)**

565

566 **Figure 3 illustrates the differences in incidences when excluding and including numbers from private institutions for the**
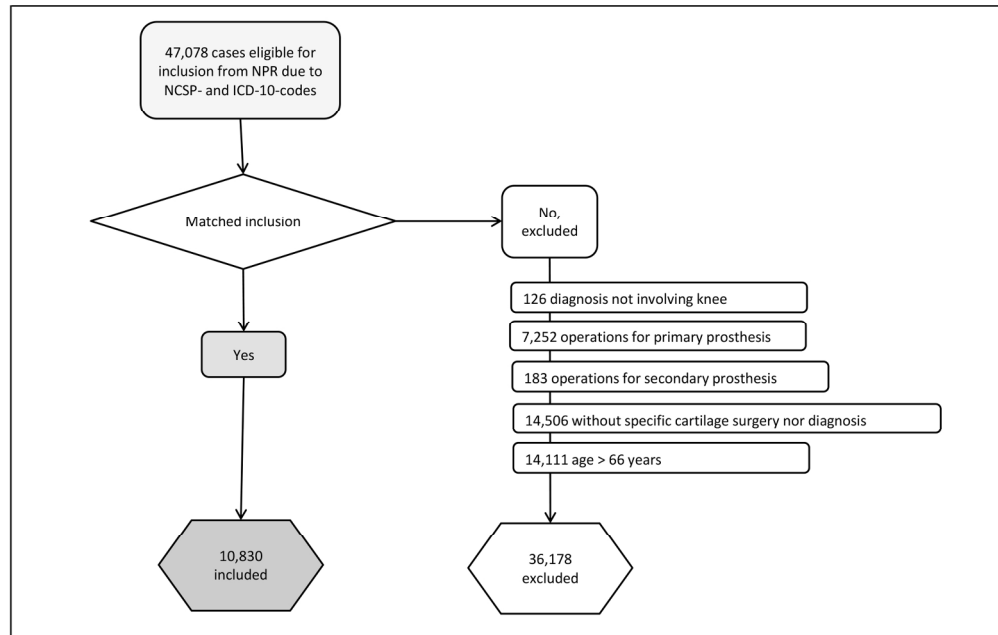
567 **year of 2009.**

568

27

Figure 1 illustrates the flowchart of patients eligible for inclusion.
170x107mm (300 x 300 DPI)

0-20/100 000
20-40/100 000
40-60/100 000
60-80/100 000

0-50/100 000
50-100/100 000
100--150/100 000
150-200/100 000
>200/100 000

Figure 2 illustrates 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 localization 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 four to 66 years of age. All surgeries performed in private institutions are excluded from this material, which was 1 475 surgeries in 2009. (The map of Norway was downloaded from Wikipedia Commons and edited in Paint.)
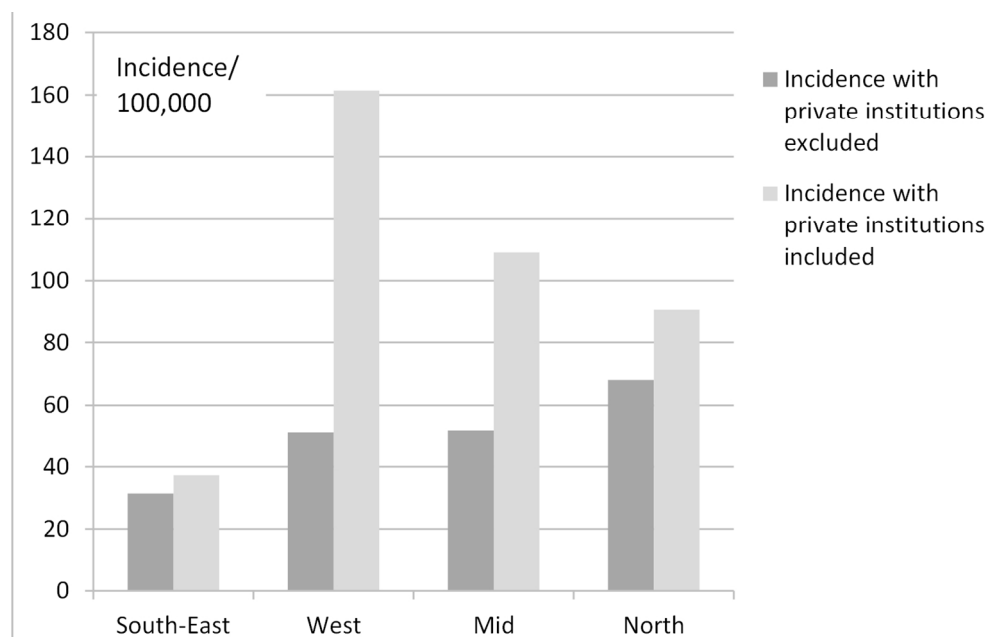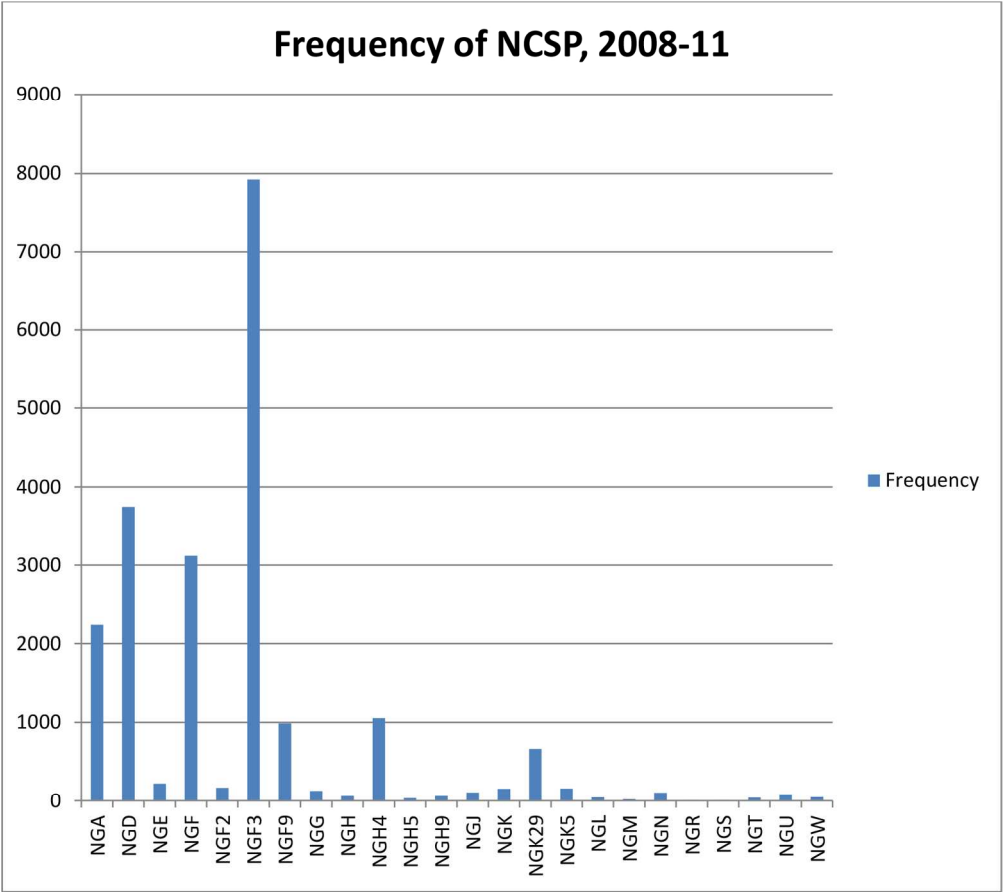
Figure 3 illustrates the differences in incidences when excluding and including numbers from private institutions for the year of 2009.
134x85mm (300 x 300 DPI)

Frequency of NCSP, 2008-11

Appendix displays frequencies of all included procedures.
160x142mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed
		Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed
		Case-control study—If applicable, explain how matching of cases and controls was addressed
		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Other information

| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

From author:

All applicable items are reported in the article and marked in yellow. Item 15 is not relevant due to the fact that this is not an analytical epidemiologic study and we have not included measures of patient outcome.

BMJ Open

Incidence of Knee Cartilage Surgery in Norway, 2008-11

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2015-008423.R2
Article Type:	Research
Date Submitted by the Author:	31-Jul-2015
Complete List of Authors:	Engen, Cathrine; Norwegian School of Sports Sciences, Oslo Sports Trauma Research Center Årøen, Asbjørn; Akershus University Hospital, Department of Orthopedic Surgery Engebretsen, Lars; Oslo University Hospital, Orthopaedic Center
Primary Subject Heading:	Sports and exercise medicine
Secondary Subject Heading:	Epidemiology, Health services research
Keywords:	Knee < ORTHOPAEDIC & TRAUMA SURGERY, Orthopaedic sports trauma < ORTHOPAEDIC & TRAUMA SURGERY, EPIDEMIOLOGY

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1

Incidence of Knee Cartilage Surgery in Norway, 2008-11

2

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13

14   **Key words:** Cartilage surgery, articular cartilage, cartilage repair, knee, incidence

15   New word count: 4101

16   Abstract: 290 words

1

17 **ABSTRACT**

18

19 **Objective:** A systematic and long-term data collection on the treatment of focal cartilage defects

20 (FCDs) of the knee is needed. This can be achieved through the foundation of a National Knee

21 Cartilage Defect Registry. The aim of this study was to establish the nationwide burden of knee

22 cartilage surgery, defined as knee surgery in patients with an FCD. We also aimed to identify any

23 geographical differences in incidence rates, patient demographics or trends within this type of

24 surgery. **Setting:** Population based study with retrospective identification of patients undergoing

25 knee cartilage surgery in Norway through a mandatory public health database from 2008-11.

26 **Participants:** We identified all patients undergoing cartilage surgery, or other knee surgery in

27 patients with an FCD. All eligible surgeries were assessed for inclusion based on certain types of ICD-

28 10 and NCSP codes. **Primary and secondary outcome measures:** The variables were diagnostic and

29 surgical codes, geographic location of the performing hospital, age and sex of the patients. Yearly

30 incidence and incidence rates were calculated. Age-adjusted incidences for risk ratios and odds

31 between geographical areas were also calculated. **Results:** A total of 10,830 cases of knee cartilage

32 surgery were identified, with a slight, although significant decreases from 2008-11 (p <.0003). The

33 national incidence rate was 56/100,000 inhabitants and varied between regions, counties and

34 hospitals. More than 50% of the procedures were palliative and nearly 400 yearly procedures were

35 reparative or restorative. **Conclusions:** Knee cartilage surgery is common in Norway counting 2,500

36 annual cases with an age-adjusted incidence rate of 68.8/100,000 inhabitants. There are significant

37 geographical variations in incidence and trends of surgery and in trends between public and private

38 hospitals. We suggest that a national surveillance system would be beneficial for the future

39 evaluation of the treatment of these patients.

40

41

2

ARTICLE SUMMARY

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 NCSP surgical codes to the inclusion criteria.

- Compliance and validity is a limitation for the data quality in most registry studies. The Register included in the present study is previously shown to both over- and underestimate clinical conditions, however studies that are more recent have demonstrated high validity.

3

53 ## INTRODUCTION

54

55 Knee cartilage injury is a well-known condition after the introduction of knee arthroscopy

56 and MRI. Cartilage injury might consist of a single or several focal lesions or it might constitute

57 generalized degenerative changes within the knee. Focal lesions are classified as traumatic or

58 degenerative and some exist without causing symptoms. They are believed to lead to a chronic

59 osteoarthritic stage with pain and reduced function, however demonstrated only in animal models.[1;2]

60 Arthroscopic studies have shown that focal cartilage defects (FCDs) within the knee occur in 19-67%

61 of patients with painful knees.[3-6] A systematic review found a prevalence of 36% in athletes examined

62 by arthroscopy, MRI or both, whereas 14% were asymptomatic.[7] Another study conducted MRI of

63 the tibiofemoral joint in persons aged 50 or more from the general population (mean age of 62.3

64 years).[8] They found cartilage abnormalities in 69%. We suspect FCDs to be common also in the

65 general population including subjects under the age of 50.

66

67 Several years of research on cartilage surgery have still not lead to a clear gold standard

68 treatment of FCDs within the knee. The results from RCTs are variable,[9-16] the patient population is

69 heterogeneous[17] and a group of non-operated controls has still not been included in an RCT, making

70 it difficult to decide the role of rehabilitation alone. Also, the quality of clinical studies on cartilage

71 research is low.[18;19] The most common performed procedures on patients with knee cartilage injuries

72 are palliating procedures, such as chondroplasty and debridement, which have demonstrated

73 symptomatic relief in uncontrolled cohort studies but fail to do so in RCTs.[20;21] Unfortunately, in this

74 area of orthopedic surgery the practice of evidence-based medicine is lacking and the procedures are

75 still used for patients with degenerative changes within their knees.

76

4

77   Results from other orthopedic registries have led to improved treatment quality and we are

78   currently looking into the potential benefits and challenges of establishing a National Knee Cartilage

79   Defects Registry. Before establishing such a registry, several conditions must be explored. This study

80   intends to present the burden of surgery for the disease.

81

82   Two studies from the United States have calculated incidence rates from an insurance

83   database.[22;23] Montgomery et al showed incidence rates ranging from 1.27-1.57/10,000, while

84   McCormick et al presented incidence rates ranging from 63-104/10,000. These numbers would

85   represent 635-52,000 yearly procedures when applied to the number of inhabitants in Norway,

86   which is a very wide interval. In 2014 a study on trends of cartilage injuries documented by

87   arthroscopy in Denmark was published.[24] They excluded patients with osteoarthritis (OA) and found

88   an incidence of 40/100,000 person-years for the years 1996-2011.

89

90   The aim of this study was to establish the nation-wide burden of surgery on knees with knee

91   cartilage defects in Norway. This will play an important role in the evaluation of the possible

92   establishment of a National Knee Cartilage Defects Register in Norway. We calculated the national

93   and regional incidences and aimed at detecting any geographical variations. The latter is of major

94   interest for health development research, medical industry as well as health care providers. Our

95   hypothesis was that cartilage surgery is uncommon and performed mainly in hospitals around the

96   larger cities and that only University hospitals perform advanced cartilage surgery.

5

PATIENTS AND METHODS

Data source

101 The study is descriptive with population-based data from years 2008-2011 in Norway. It is a
102 retrospective cohort study through the continuous data collection done by the Norwegian Patient
103 Registry (NPR). The NPR is run by the Norwegian Directorate of Health and contains data on the
104 activity in specialist health services. Norway has approximately 5 million inhabitants. The country
105 consists of four health regions and 19 administrative counties. The South-East region is most
106 populous, followed by the West, Mid and North regions. Norway has a national public health care
107 system aiming at equal health services to all inhabitants regardless of their income or private
108 insurances. Also, a growing number of private hospitals and surgical centers offer mainly elective
109 orthopedic surgery to patients with private insurance, reimbursed by public funding through
110 government contracts or paying out of pocket (previously 10-15% of specific elective surgeries,
111 however influenced by substantial geographical variation[25]).

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

119 Table 1 gives an overview of surgical procedures on knee and calf defined as cartilage surgery, from NCSP [26] and the
120 predefined ICD-10-codes.The two explorative procedures (NGA11 and NGA 12) are included due to the group of patients
121 with specific cartilage diagnosis, but without specific knee cartilage surgery.

6

NCSP-Code	Explanation	Corresponding surgical procedure and/or abbreviation	ICD-10-code	Disease/Injury
NGA11	Endoscopic exploration		M17	Osteoarthritis (OA) of the knee
NGA12	Open exploration		M22.4	Chondromalacia patellae
NGF21	Endoscopic fixation of corpus	Fixation of Corpus Librum (fCL)	M23.4	Loose body within the knee
NGF22	Open fixation of corpus librum,	fCL	M23.8	Other internal derangements of the knee
NGF31	Endoscopic resection of	Chondroplasty (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	Mosaic Plasty (MP) and Osteochondral	M93.2	Osteochondritis dissecans (OCD)
NGF92	Other open procedure on	MP and OAT	M94.8	Other specific pathology in cartilage
NGH41	Endoscopic removal of corpus	Removal of Corpus Librum (rCL)	M94.9	Unspecific pathology in cartilage
NGH42	Open removal of corpus librum	rCL	S83.3	Acute tear of articular cartilage of the knee
NGK29	Drilling of bone in knee or calf	Microfracture (MF)		
NGK59+69	High tibial osteotomy	HTO		
NGN	Transplantation of cartilage, bone,	Autologous Chondrocyte		

122

123   We aimed at detecting cases undergoing surgery for knee cartilage defects. Distinguishing

124   between traumatic and degenerative lesions is often difficult clinically and the development from an

125   FCD to OA might be seen as a continuum. In addition, the ICD-10-coding system is unspecific and

126   further challenges this distinction. Cases were identified from the NPR through predefined surgical

127   procedure codes (all NCSP-code constituting surgery on knee and/or calf) and ICD-10-codes (table 1)

7

128 and retrieved as eligible for inclusion if any combination of surgical and diagnostic codes, according

129 to table 1, was present. ICD-10-codes for concomitant injuries are not included. The list (table 1) was

130 chosen after a consensus meeting between head orthopedic surgeons of the largest hospital in our

131 region. We also contacted experienced orthopedic surgeons from other hospitals by mail in order to

132 ensure that all possible codes were included. We included diagnosis M17 after these interchanges as

133 several stated that they use M17 also for FCDs. Patients coded with M17 may have degenerative

134 changes, although some have actual focal lesions. Therefore, we made an upper age limit of 67 years

135 for inclusion and presented descriptive analyses with a distinction between under and above 50

136 years of age.

137

138 Our data was anonymous and considered statistical data rather than information on health

139 from individual participants. We received the dataset within an SPSS file and recognized all cases that

140 underwent knee cartilage surgery during the four years, 2008-11. Cases *more* likely to constitute OA

141 were excluded, therefore patients aged 67 years or more, patients undergoing prosthesis surgery

142 and patients with M17 in combination with non-cartilage procedures (only meniscal resection for

143 instance) or high tibial osteotomy (HTO) were excluded. Cases with M17 and procedures classified as

144 cartilage surgery were included. The final number after exclusion was 10,830 in the four-year period

145 (figure 1).

146

147 **Variables and data**

148

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

150 Additionally, we requested data on the health region, county and institution and received

151 geographical variables only for the years 2008-09.

8

152

Statistics

154

155   We defined NCSP-codes as cartilage surgery, meniscal surgery, or other types of surgery. The

156   different types of cartilage surgery were defined as palliative, repairing or restorative. All cases were

157   divided into subgroups based upon these definitions. We chose the term palliative as these

158   procedures are meant to decrease pain for the patients, although its efficacy is not proven for all

159   indications. Chondroplasty (CP) or debridement were defined as palliative surgery, cartilage repair

160   included microfracture (MF) and cell-based repair with either chondrocytes (ACI) or stem-cells and

161   restorative techniques included techniques aiming at restoring the articular cartilage without

162   cartilage repair tissue produced on-site and include mosaic plasty (MP) and allograft transplantation

163   (which is currently not in use in Norway).

164

165   The data was analyzed with IBM SPSS Statistics (version 22.0). We assessed the distribution

166   of the data with age as the dependent value and concluded with a non-normality distribution. The

167   categorical variables on events of cartilage surgery were assumed to fulfill the criteria of a Poisson

168   distribution. Cases were stratified by age, sex, health region, county and year of surgery. Incidences

169   of cartilage surgery were given per 100,000 inhabitants and were adjusted to age group, region or

170   county by calculation based on population data from Statistics Norway (SSB), which is an

171   academically independent organization administered under the Ministry of Finance in Norway. The

172   data was assembled from their web pages. We compared the incidences for each of the four years to

173   each other using rate ratios and tested for significance using Wald tests. We used the Cochran-

174   Armitage trend test for comparing trends in the current study with the existing literature.

175

9

176   Demographics were considered by descriptive statistics. Differences in categorical variables

177   were calculated with odds ratios (OR) and tested with Pearson chi-square tests with geographical

178   localization as the dependent variable. We explored age differences between subgroups with box

179   plots and performed a Kruskal-Wallis test to test the statistical difference. A Bonferroni correction

180   adjusted the new alpha level to .0125 with four independent analyses (CP vs MF, MF vs ACI, CP vs

181   ACI, MF vs MP) before Mann-Whitney U tests were performed. We were not able to address

182   potential confounders such as actual differences in the prevalence of knee cartilage defects,

183   differences in the willingness to seek medical assistance for painful knees or willingness to undergo

184   surgery.

185

Ethics

187

188   We received anonymous data from the NPR, who acts under approvals of the Norwegian

189   Directorate of Health. The study was evaluated by the Regional Committees for Medical and Health

190   Research Ethics (REC) (ref: 2010/777) as not obliged for notification. We consulted the Norwegian

191   Data Protection Authority and the study is not obliged for notification due to the collection of

192   anonymous data. The data are to be considered as statistical data rather than information on health

193   in individual participants.

194

195 **RESULTS**

196

197   A total of 10,830 cases matched our inclusion criteria for cartilage surgery for the years 2008-

198   11 and a flowchart is presented in figure 1. There were 2,897 cases in 2008, 3,114 in 2009, 2,732 in

199   2010 and 2,087 in 2011. A total of 21,143 procedures (appendix 1) were reported throughout the

200   four years which results in a mean of 1.96 procedures per included case. The most common cartilage

201   surgery was resection of articular cartilage (NGF3y) followed by fenestration or forage or bone/MF

202   (NGK29). The most common non-cartilage surgery was meniscal surgery followed by synovectomy.

203   The mean age for all years was 45.0 (SD 13.7), whereas the mean age for 2008 was 45.6 (SD 13.7)

204   and for 2011 was 43.1 (SD 14.2), which was significantly lower than for the other years (p-value <

205   .001). The male ratio varied from 55.2% to 58.7%.

206

207 **Incidences**

208

209   The incidence rate of having experienced cartilage surgery in Norway throughout 2008-11 is

210   56/100,000 inhabitants and age-adjusted incidence rate is 68/100,000 inhabitants between 4-66

211   years of age. Table 2 displays the age-adjusted incidence rates for the different years and age groups.

212   The incidence rate from 2008 was set as reference when calculating rate ratios (RR) between

213   included years. The only significant RR was that of 2011 which was 0.69 (95% CI 0.65-0.73, p-value

214   <.0003).

215

216 Table 2 shows the distribution of number of cases about year and age group and the age-adjusted yearly incidence rates

217 (with 95%CI in parenthesis) for all three age groups. When analyzing the rates for each year within the age groups, we

218 found a significant decrease from 2008-11 for the two oldest age groups; no significant change was evident for the

219 patients between 0-20 years.

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	2,897	3,888,191	74.5	225	1,281,185	17.6	1,347	1,881,409	71.6	1,325	960,849	137.9
2009	3,114	3,943,356	79.0	225	1,293,171	17.4	1,532	1,905,524	80.4	1,357	983,943	137.9
2010	2,732	3,988,476	68.5	191	1,303,549	14.7	1,319	1,926,981	68.5	1,222	1,002,526	121.9
2011	2,087	4,035,623	51.7	198	1,311,696	15.1	1,109	1,954,251	56.8	780	1,017,321	76.7

220

12

221   The incidences of cartilage surgery in public hospitals in the four different health regions

222   display great diversity as cartilage surgery is twice as common within the Northern region as opposed

223   to the South-East region (figure 2). However, when all the procedures performed privately are

224   included, the regional differences changes and the Western region becomes the region with the

225   highest incidence (figure 3). The incidence of the Western region (161/100,000 inhabitants) is four

226   times higher than in the South-East region, which has the lowest incidence (37/100,000 inhabitants).

227   The incidences throughout the 19 different counties also display large variations (figure 2). The

228   incidences range from 7.3 to 278.1/100,000 inhabitants.

229

230   **Trends**

231

232   The trends for type of surgery varied between both regions and between private and public

233   hospitals (table 3). Whereas private hospitals had nearly 90% debridement, this represented only

234   approximately half of the procedures in public hospitals. Advanced cartilage surgery (repair- or

235   restorative techniques) accounted for almost 400 procedures per year. The middle health region had

236   the lowest proportion of advanced cartilage surgery (13.4%) in 2009. In comparison, the northern

237   region performed 42.6% such procedures in 2009. The corresponding numbers for 2008 were 11.7%

238   and 49.6%. The OR of having advanced cartilage surgery performed in the northern region compared

239   to the other regions was 7.44 (6.11-9.06). Nationwide the MP/OAT was the most frequent of repair-

240   or restorative procedure for all years, ranging from 57.6% - 62.8%, whereas 4.2% - 6.6% were cell

241   transplantation techniques.

242

13

243 Table 3 displays the distribution for all the public cases, among the different subgroups within the regions and for the

244 private institutions from 2008 and 2009.

	CP	MF	MP/OAT	rCL/fCL	ACI	HTO	Other/no	Total
Public	1,763 (50.9)	184 (5.3)	387 (11.1)	525 (15.2)	71 (2.0)	329 (9.5)	205 (5.9)	3,464
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	2,338 (89.3)	70 (2.7)	87 (3.3)	82 (3.1)	1 (0.0)	0 (0)	40 (1.5)	2,618

245

246

247 A substantial part of all included cases of cartilage surgery was performed in private

248 institutions, whereas they performed 19.8% of the repair- or restorative procedures (table 3). The OR

249 of being treated with these methods over palliative procedures in private institutions rather than

250 public was 0.18 (0.08-0.43). A Pearson chi-square confirmed a highly significant association between

251 the regions and between private and public hospitals. Most patients were treated in an outpatient

252 setting and this accounted especially for private institutions. University hospitals performed 44.5% of

253 cases with advanced cartilage surgery, whereas they performed 57.5% of all transplantation

254 techniques, 56.8% of MP-procedures and only 13.6% of MF-procedures.

255

256 *Age*
257

258 The age between the seven different subgroups were statistically significant different (p <

259 .001), whereas the CP group (median 51.0) was significantly older than both MF (median 39.0) and

260 ACI group (median 29.0), the MF group was older than the ACI group and not statistically significant

14

261 different from the MP group (median 42.0). The age-distribution of advanced cartilage surgery

262 showed that the majority of procedures are performed on patients aged 20-50 years. Transplantation

263 procedures were seldom performed in the oldest age group (50-67 years of age), whereas the

264 youngest group (<20 years of age) was more commonly treated with MF followed by transplantation.

265 ORs demonstrated that MP/OAT and ACI were more common for patients under 50 years of age,

266 whereas MF and MP/OAT were more common for patients under the age of 20.

267

15

DISCUSSION

A total of 10,830 cases were included and represents the nationwide load of knee cartilage surgery in Norway throughout 2008-11. There are 2,500 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 found an incidence of ACL surgery of 34/100,000 inhabitants, although 85/100,000 in the age group 16-39 years of age, in Norway in their baseline study of the Scandinavian Knee Ligament Registries.[27]

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 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 <.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 is previously demonstrated in studies that debridement is no better than sham surgery [20] or rehabilitative training with a Physiotherapist, [21] whereas the latter also failed to show the efficacy of

16

294 surgery in patients with mechanical symptoms. These studies changed the trends in surgery on

295 patients with OA as the rates of arthroscopy declined the following years, at least in the US.[29] It is

296 possible that a larger part of these procedures now is performed on patients with actual FCDs,

297 although these procedures are still used also in patients with knee OA. Based on recent literature,

298 this type of surgery should be abandoned.

299

300   Few studies have explored incidences of cartilage surgery whereas one study presents

301 national numbers on cartilage injuries diagnosed with arthroscopy.[24] Two studies presented

302 remarkably different numbers based on data from the PearlDiver Database in the USA. Montgomery

303 et al[23] reports an incidence rate of 1.27-1.57/10,000 (2004-09) patients and McCormick et al[22]

304 reports an incidence rate of 90/10,000 (2004-11). McCormick seems to calculate incidences based on

305 all individual patients within the database, whereas Montgomery calculates incidences based on all

306 patient records, which may explain the different results. Our incidence rates are within the same

307 range as Montgomery et al when compared to the number presented in the articles. However, when

308 we recalculated new incidence rates based on the numbers provided by the two articles and applied

309 the same approach as used in the current study, we found quite different incidence rates from both

310 articles. Consequently, the incidence rates from the current study then appears in the vicinity of

311 McCormick et al (table 4). Both studies focused on cartilage surgery only, and excluded patients with

312 simply the diagnosis of an FCD or patients undergoing osteotomy in the absence of knee OA. These

313 two subgroups accounted for less than ten percent in the current study and were excluded when

314 comparing incidence rates for years 2008-11 (table 4). The same table display the numbers from the

315 Danish study, which are in close range with the numbers from the present study.

316

317 **Table 4 gives the incidence rates from two American studies on trends and incidences from a private database for health**

318 **insurance, together with the national incidences from the Danish and the current study. Incidence rates are given per**

319 **10,000 patients/inhabitants and are calculated from the numbers of procedures and patients that are given by the two**

320 **articles. The reported numbers are presented in parenthesis.** *These numbers are calculated after exclusion of the patient

17

321   group without cartilage surgery and the patient group where osteotomy was performed alone or in addition to cartilage

322   surgery and thereby represents the same patient population as in the two published studies.

Year	Montgomery et al (reported)	McCormick et al (reported)	Mor et al, 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

323

324   **Trends**

325

326   We found that 56 hospitals performed cartilage surgery whereas fifteen hospitals operated

327   less than ten cases throughout 2009. Katz et al found that patients operated in low-volume hospitals

328   by low-volume surgeons had worse functional outcomes two years after total knee replacement

329   (TKR).[30] When performing procedures that has failed to prove efficacy, the volume of the operating

330   surgeons means less. However, this is a field with many patients and presumably low evidence-based

331   adherence. Cartilage surgery is a complex treatment where several options exists, indicating that the

332   availability of several techniques as well as an optimized rehabilitation program is needed. In order

333   to form a standardized treatment for as many patients as possible, each hospital or surgeon probably

334   need to see certain, but not yet defined number of patients yearly to maintain adequate quality of

335   care. A discussion whether to make specific cartilage centers must be made.

336

337   The present study cannot explain the reasons for the geographical differences, but possible

338   factors might be differences between the orthopedic surgeons' personal preferences and experience

339   more than differences in the patient populations. A study aiming to describe the practice of MF

340   among Canadian orthopedic surgeons found widespread variation concerning indication for

18

341   surgery.[31] Patient willingness to undergo surgery is also an important consideration and is higher in

342   areas with already high incidence of surgery.[32]

343

344   Knee cartilage surgery consists of several different techniques and although attempts on

345   recommendations have been made, there is no gold standard treatment.[9-16;33] MF is traditionally

346   chosen for smaller defects whereas OAT or ACI are chosen for larger defects.[34] More specific

347   recommendations do not exist, and we know little of the decision-making for surgical technique

348   other than size of the lesion and the patient age. We do not have data on the size or location of the

349   lesions in the current study. CP is the most common procedure in our material and is performed for

350   both FCDs and in knees with developing degenerative changes. The study by Montgomery et al found

351   that MF and CP are the preferred procedures in 98% of cases with cartilage surgery.[23] These

352   procedures constituted 71.1% of all procedures in our material. The study by Mor et al found repair

353   procedures (MF, osteochondral transplantation or chondrocyte transplantation) to be performed in

354   16.7% of the cases.[24] The trends from the articles of Montgomery et al [23] was significantly different

355   from the trends of our material when compared with a chi square test (p-value < .001). The

356   difference was still significant after excluding the groups who had no cartilage surgery or

357   osteotomies. Also, the trends in procedures from the study by Mor et al was different from the

358   trends of the present study with a lower proportion of palliative procedures, also after excluding the

359   cases with no cartilage surgery or osteotomies.

360

361   **Limitations**

362   The ICD-10 codes available for diagnosing FCDs do not reflect the complexity of the clinical

363   situation of these lesions. The distinction between focal lesions that are traumatic or degenerative is

364   often difficult clinically, and location, size and depth matter greatly. The ICD-10 does not account for

365   these conditions, and a distinction based on these codes is impossible. Although the ICD-10 contains

366   both "acute FCD" (S83.3) and several codes for knee cartilage pathology, there are no codes for the

19

367 common "non-acute FCD", which might be subacute or chronic. Our predefined codes matched with

368 92.3% of the reported diagnostic codes from the Norwegian Arthroscopic Association. However, the

369 response rate was only 13.2%. The low response rate has limited effect on our final numbers since

370 we have included most of the possible codes from the ICD-system, but these challenges co-exist with

371 the fact that some orthopedic surgeons might not code for FCDs at all if other intraarticular

372 pathology is recognized. This is probably the largest limitation and cannot be defeated by any

373 methodological changes, but by information and education of orthopedic surgeons. This is therefore

374 a challenge concerning cartilage pathology and the ICD-system and is as such a problem for the

375 entire research field and not only for the current study.

376

377   Among 11,566 ICD-10-codes there are 789 coded as S83.3. The frequency of M17-codes

378 increase with age, however several orthopedic surgeons stated that they use M17 also for focal

379 lesions. The inclusion of patients with M17-diagnosis might lead to an overestimation of surgery for

380 cartilage injury. However, an exclusion of these would definitely lead to an underestimation. The

381 current study reports a lower portion of palliative procedures than the Danish study[24] (where they

382 excluded all patients with OA) which might imply that most of those included in the present study are

383 actual knee cartilage defects and not OA.[24] We did not include the ICD-10-code for "painful joint"

384 (M25.5) which might have underestimated the results.

385

386   The patient records or surgical protocols are considered the gold standard. However, large

387 administrative databases allow the process of data-collection to be efficient, detailed and precise,

388 within its limitations. The Norwegian health care system is public and tax-funded which balances out

389 possible geographic or socioeconomic differences. Studies have demonstrated that numbers

390 extracted from electronic databases are being both over- and underestimated. Lofthus et al found

391 that the Norwegian NPR overestimated hospitalization for hip fractures by 29%, although the

20

392 number of having surgery for hip fractures was underestimated.[35] Readmissions due to the same hip

393 fracture were registered as a new hospitalization for a new hip fracture by the NPR, which inflated

394 the number. In our material, 297 cases (4.9%) were duplicates and only 73 procedures (0.67%) were

395 classified as reoperations. We believe that *procedure* codes are reported in more detail as they are

396 the basis of 60% of the government reimbursement in Norway, and as such are reviewed several

397 times by hospital controllers to ensure correct coding. For the current study, we were interested in

398 the burden of cartilage surgery and a combination of diagnostic and procedure codes seemed most

399 appropriate.

400

401   The validity for the Norwegian NPR database was later assessed in a national study on hip

402 fractures and the accuracy was found to be 98.2% (CI 96.5-99.9%) when diagnostic codes were

403 combined with procedure codes.[36] In that same study they suggested possible coding errors for the

404 current combination of diagnostic and procedure codes due to conservatively treated fractures or

405 missing if the patient died before operation. This does not apply for the current study, as the

406 diagnosis is set during operation. The study by Mor assessed the validity against surgical descriptions

407 in the medical records as gold standard and found the positive and negative predictive value to be

408 88% and 99%, respectively.[24] As for all studies with inclusion based on surgical procedures, FCDs

409 diagnosed with MRI and treated conservatively are not included. An under- or overestimation might

410 exist, however the main goal of this study was to estimate the nation-wide burden of cartilage

411 surgery with the numbers available in NPR.

412

413 **Future clinical implications**

414

415   Cartilage surgery concerns a large and severely troubled patient group with no gold standard

416   treatment. No nationwide surveillance currently exists to study the efficacy or effectiveness of

417   treatment for this patient group. Development of a cartilage registry emphasizing cartilage treatment

418   being palliative, reparative or regenerative, in addition to nonsurgical procedures will be essential for

419   the clinical progression in this field.

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

421

422   **CONCLUSION**

423

424   In Norway there are 2,500 annual procedures classified as cartilage surgery, resulting in an

425   age-adjusted incidence rate of 68.8/100.000 inhabitants. There are large variations between the

426   different regions and between public and private hospitals.

427

428   This illustrates the need for a larger surveillance database for evaluation of results and

429   calculation of costs in order to secure high quality treatment for all knee cartilage patients.

430

433   **Contributors**
434   LE and AÅ conceived the study whereas all authors planned the method. CNE was responsible for data collection and

435   analyses, whereas all authors participated in the interpretation. CNE drafted the manuscript, whereas AÅ and LE revised it.

436   All authors approved the final version.

437   **Competing Interest**
438   None

446   **Data sharing statement**
447   No additional data are provided.

448

23

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552
553

26

554 **FIGURE LEGENDS**

555

556 **Figure 1 illustrates the flowchart of patients eligible for inclusion.**

557

558 **Figure 2 illustrates the incidence rates in the four different health regions in Norway (top) and the incidence rates**

559 **throughout Norway`s 19 counties (bottom) in 2009. Numbers are based on the localization of the hospital, and not the**

560 **patient`s home-address. Activity from private hospitals is excluded for these figures as they mostly perform palliative**

561 **surgeries in middle-aged patients and thereby account more for degenerative surgery than cartilage surgery. The**

562 **incidence rates are age-adjusted to the population included in this study, which ranged from four to 66 years of age. All**

563 **surgeries performed in private institutions are excluded from this material, which was 1 475 surgeries in 2009. (The map**

564 **of Norway was downloaded from Wikipedia Commons and edited in Paint.)**

565

566 **Figure 3 illustrates the differences in incidences when excluding and including numbers from private institutions for the**
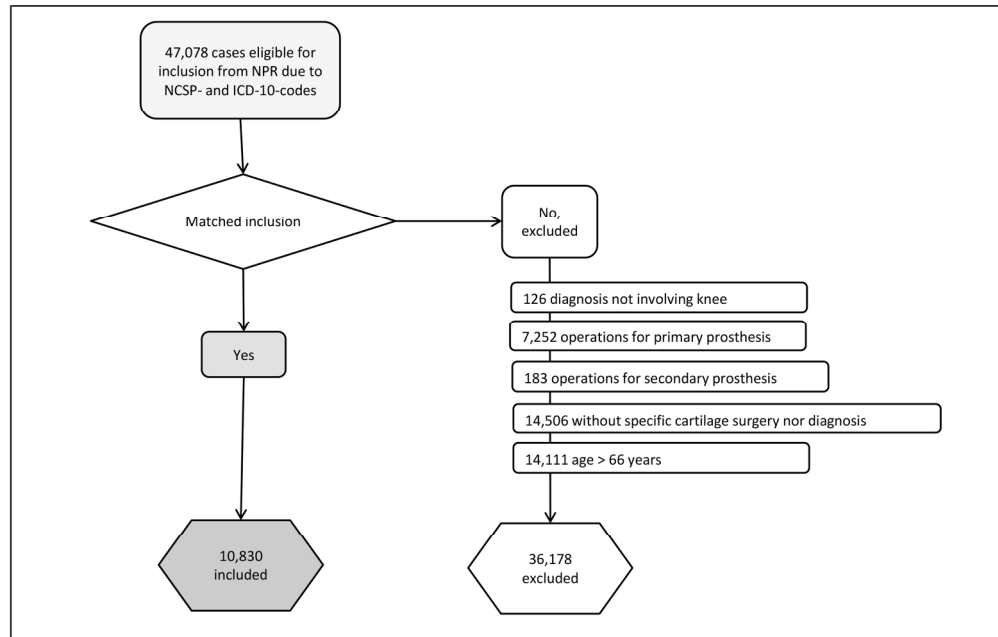
567 **year of 2009.**

568

27

Figure 1 illustrates the flowchart of patients eligible for inclusion.
170x107mm (300 x 300 DPI)

0-20/100 000
20-40/100 000
40-60/100 000
60-80/100 000

0-50/100 000
50-100/100 000
100--150/100 000
150-200/100 000
>200/100 000

Figure 2 illustrates 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 localization 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 four to 66 years of age. All surgeries performed in private institutions are excluded from this material, which was 1 475 surgeries in 2009. (The map of Norway was downloaded from Wikipedia Commons and edited in Paint.)
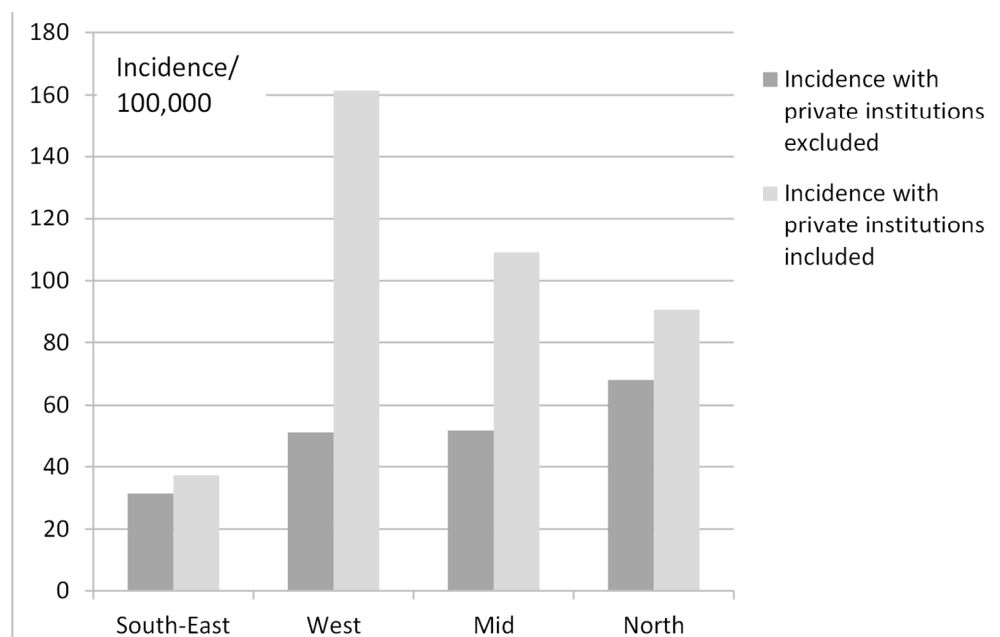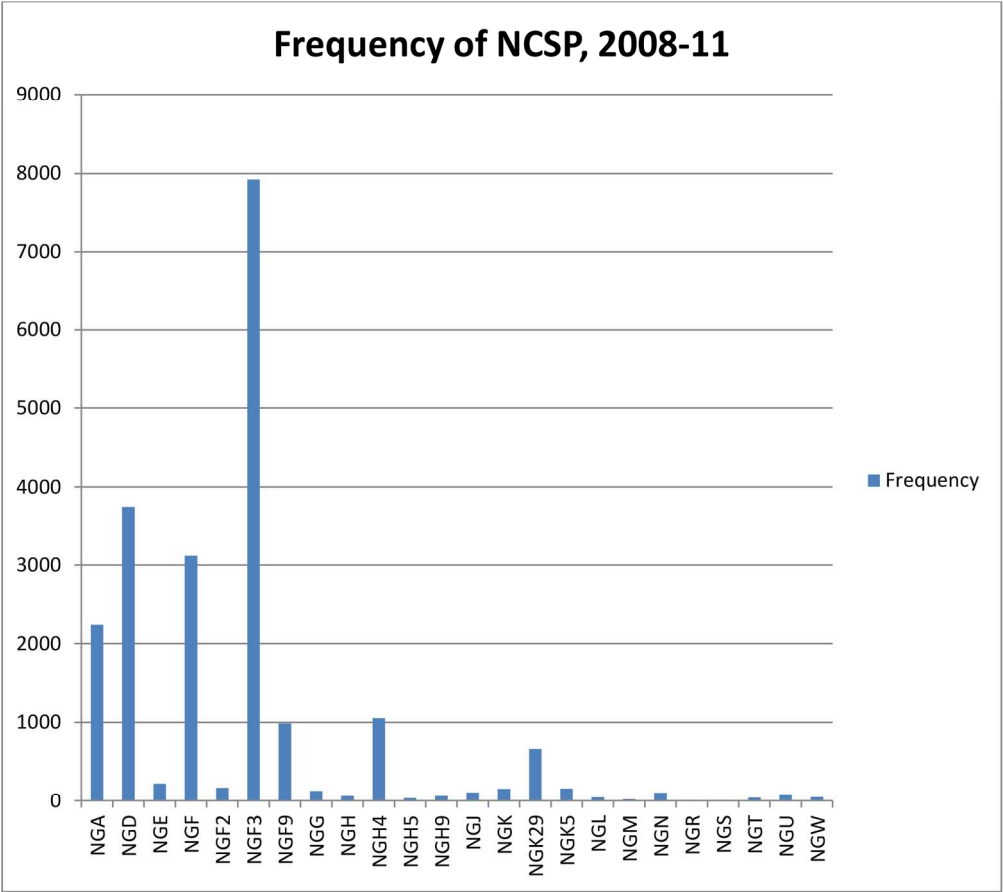
Figure 3 illustrates the differences in incidences when excluding and including numbers from private institutions for the year of 2009.
134x85mm (300 x 300 DPI)

Frequency of NCSP, 2008-11

Appendix displays frequencies of all included procedures.
160x142mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed
		Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed
		Case-control study—If applicable, explain how matching of cases and controls was addressed
		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

From author:
All applicable items are reported in the article and marked in yellow. Item 15 is not relevant due to the fact that this is not an analytical epidemiologic study and we have not included measures of patient outcome.