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Original article

Knee surgery trends and projections in France from 2008 to 2070

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ABSTRACT

Introduction: Knee surgery makes up a large share of the orthopedic surgery practice. Data on how this activity has changed over time is not available in France, thus we wanted to do a study to determine 1) how many knee surgeries were performed in France in 2018, 2) how this changed between 2012 and 2018, and 3) how it is projected to change by 2070. The hypothesis is that the number of knee surgeries will increase over the next 50 years.
Methods: This was an epidemiology study analysing coding data for surgical procedures in France between 2012 and 2018. Two scenarios were defined to assess the change over time: the first only considered population growth and how the age distribution changes over time, and the second extrapolated the trends observed over the past few years.
Results: In 2018, 321,179 procedures were coded as a main knee surgery procedure. The three most frequent were primary knee arthroplasty with 113,600 procedures (31.2% of procedures) then meniscus surgery (110,510 procedures or 30.3%) and then ligament surgery (57,053 procedures or 15.7%). The number of primary knee arthroplasty procedures increased by 32.2% between 2012 and 2018. Between 2018 and 2050, the different scenarios suggested an increase of 30.8% to 152.8%. The number of ligament surgery procedures increased by 17.3% between 2012 and 2018. Between 2018 and 2050, an increase of 1.2% to 49.2% is expected. The number of meniscus procedures decreased by 14.2% between 2012 and 2018. Between 2018 and 2050, scenario 1 projects a 5.6% increase and scenario 2 a 73.6% reduction.
Discussion: The number of knee surgery procedures per year has increased over the past few years in France and should continue to increase.
Level of evidence: IV, descriptive epidemiology study.

1. Introduction

The number of orthopedic surgery procedures has increased over the past decades throughout the world [1–3]. This can be attributed to multiple factors, including better outcomes due to improvements in the devices, techniques and perioperative care [4]. Knee surgery consists of ligament and meniscus surgery in a younger population and also knee arthroplasty surgery in an older population. The French population is increasing in size and age [5]. Thus, it would be useful to know how many of these surgeries are being done and how this will change in the future. In Nordic countries, this analysis is done using registries [6–8]. In France, this analysis is done by looking at procedure coding and procedure-based pricing.

To our knowledge, this data has not been generated for knee surgery in France. This led us to carry out a study to determine:

- how many knee surgeries were performed in France in 2018;
- how this changed between 2012 and 2018;
- how it is projected to change by 2070.

We hypothesised that the number of knee surgeries will increase over the next 50 years.

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Table 1
Examples of the multipliers for each procedure based on the distribution of the population changes for each age group impacted by this procedure.

Procedure – No. of procedures, main one only	2020	2025	2030	2035	2040	2050	2060	2070
NFMC001 – Cruciate ligaments reconstruction, knee arthroscopy	1.002	0.999	0.992	0.993	1.003	1.011	1.008	1.016
NFEC002 – Suture repair of 1 meniscus, knee arthroscopy	1.002	0.999	0.992	0.993	1.003	1.010	1.008	1.015
NFGA002 – Removal 1 knee implant	1.027	1.102	1.185	1.245	1.274	1.324	1.373	1.409
NFJA001 – Joint lavage, knee arthrotomy	1.021	1.077	1.138	1.183	1.208	1.257	1.306	1.342
NFKA006 – Unicompartmental knee arthroplasty	1.021	1.080	1.144	1.190	1.216	1.252	1.286	1.313
NFKA007 – Total knee replacement for 1 deformity < 10° in frontal plane	1.026	1.099	1.179	1.236	1.265	1.306	1.344	1.374

2. Materials and methods

2.1. Materials

This was a descriptive epidemiology study. The data were generated using the same methodology as a recent article on hip surgery procedures [9]. The coding information was consulted in May 2019 to capture data from 2018 in its entirety.

3. Methods

The data were placed in different categories: knee arthroplasty (unicompartmental or total), ligament surgery (reconstruction or repair), meniscus surgery (suture or resection), synovectomy, osteochondral fixation, surgery on the patella, osteotomy, lavage of knee joint, revision knee arthroplasty, mobilisation under anesthesia, reduction of dislocation and arthrodesis. All the procedure codes included in each category are listed in Appendix 1.

For each category, two scenarios were defined based on the method outlined by DREES (French Directorate for Research, Studies, Assessment and Statistics of Ministry of Health) [10]:

- scenario 1: This scenario has fixed characteristics. It exactly reproduces the parameters measured during the last year of PMSI (French hospital discharge database) data available (2018) and assumes they are identical over time. It only considers how the population grows and how the age distribution changes over time. In some ways, it acts as a reference. In this scenario, the model was adjusted for each procedure, with weighing based on the expected change in each age distribution according to INSEE data (French National Institute for Statistics and Economic Studies). For example, procedures done in younger patients increase less than procedures done in older patients because the population as a whole tends to be older in the coming years. Thus, for each procedure and for each decade going forward, we came up with a multiplication factor based on the age distribution for each procedure and the INSEE data. A few examples are shown in Table 1;
- scenario 2: This scenario captures the projected changes. It reuses the trends observed in the 2012–2018 period while integrating the population changes from scenario 1. In this scenario, for each procedure, the changes in the number of procedures done were estimated using a linear regression over the prior available years and the equation used for future projections.

The geographic descriptions were done with the raw data by taking an average of the number of procedures over the 2012–2018 period. For each region, the share of procedures done at each type of hospital (pubic, private for profit, private not-for-profit) was determined. The total number of procedures and number per resident were calculated for each region.

Table 2
Number of knee surgery procedures in 2018.

Class	Sub-class	Number in 2018
Meniscus	Total	110510
	Suture repair	10703
	Meniscectomy	99807
Ligament	Total	57053
	Suture repair	3501
	Reconstruction	53552
Synovectomy	25244	
Osteochondral fixation	249	
Patella	9721	
Primary knee replacement	Total	113600
	UKA	12743
	TKA	100857
Osteotomy	3072	
Joint lavage	14475	
rTKA	Total	11900
	Implant removal	893
Knee mobilisation	13201	
Reduction	671	
Arthrodesis	179	
TOTAL	364436	

TKA: Total knee arthroplasty; UKA: Unicompartmental knee arthroplasty; rTKA: Revision of total knee arthroplasty.

3.1. Statistical methods

Statistical calculations were done using Excel™ software (Microsoft, Redmond, USA) and XLSTAT™ software (Addinsoft, New York, USA). The overall projections for each procedure are the sum of the individual projections for each age bracket weighted by the INSEE data. Thus, independent models were created for each procedure as a function of its target population and the age brackets affected by a certain procedure. The results are presented as raw counts or mean ± standard deviation with minimum and maximum values for the quantitative variables. The 95% confidence intervals were calculated. There was no missing data and all the data were included in the analysis.

4. Results

4.1. Year 2018

In 2018, the last year of data available in France, there were 364,436 procedures coded as primary knee surgery procedures. The three main procedures were primary knee arthroplasty with 113,600 procedures (31.2% of procedures) then meniscus surgery (110,510 procedures or 30.3%) and then ligament surgery (57,053 procedures or 15.7%) (Table 2).

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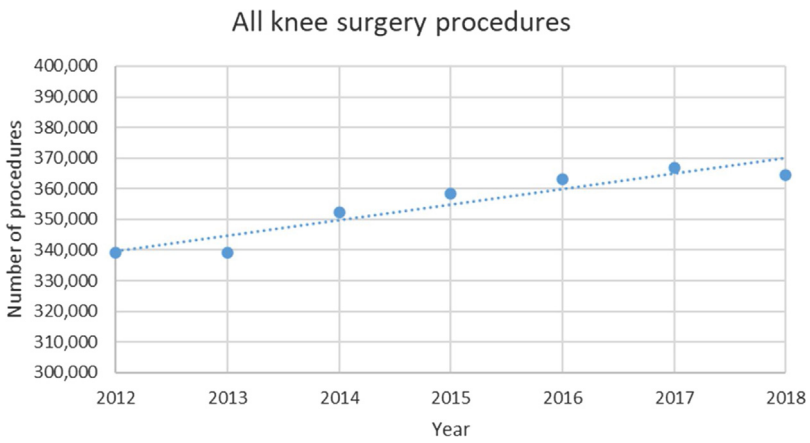

Fig. 1. Change in the number of knee surgery procedures annually between 2012 and 2018 fitted with linear regression.

4.2. Period 2012 to 2018

Overall, an average of 354,811 procedures ± 11,619 [339,263–366,718] were performed annually between 2012 and 2018, with the numbers increasing year after year (Fig. 1). The mean growth rate was 1.21% ± 1.55% [−0.6%; 3.8%] per year.

These procedures were done at a public hospital facility in 86,960 cases (24.5%), not-for-profit hospital in 23,000 cases (6.5%) and for-profit hospital in 244,851 cases (69.0%). The procedures were performed in women in 44.1% of cases (156,616 procedures).

The geographic distribution of the average number of primary knee arthroplasty procedures in the years 2012 to 2018 are shown on Fig. 2. The geographic distribution of meniscus surgery and ligament surgery in the same period in France is shown in Fig. 3.

There were large regional differences for the knee arthroplasty surgery and for meniscus and ligament surgery. The frequency of primary knee arthroplasty ranged from 0 to 19.7 per 10,000 residents, with the frequency of revisions ranging from 0 to 3.6 per 10,000 residents. The frequency of ligament reconstruction ranged from 0.3 to 11.4 per 10,000 residents while that of meniscus procedures ranged from 0.2 to 24.4 per 10,000 residents. The distribution of primary or revision knee arthroplasty, meniscus or ligament surgery in public, not-for-profit and for-private hospitals was significantly different between regions ($p < 0.0001$).

Primary knee arthroplasty procedures increased by 32.2% between 2012 and 2018 (Fig. 4). On average, between 2012 and 2018, the procedures were done in women in 61.1% of cases (61,047/99,941). On average, 17 knee arthroplasty procedures were done per 10,000 residents in France in 2018.

Knee ligament surgical procedures increased 17.3% since 2012. The projections are shown in Fig. 5. On average, between 2012 and 2018, the procedures were done in women in 28.8% of cases (15,273/52,950).

The number of meniscus-related procedures (repair or meniscectomy) has trended down since 2012, with a 14.2% decrease. This is shown in Fig. 6. On average, between 2012 and 2018, the procedures were done in women in 34.0% of cases (41,035/120,773).

The number of synovectomy procedures increased by 23.6% since 2012, as shown in Fig. 7. On average, between 2012 and 2018, the procedures were done in women in 44.6% of cases (10,472/23,479).

The number of patella-related surgeries increased by 26.4% between 2012 and 2018. On average, between 2012 and 2018, the procedures were done in women in 60.0% of cases (5345/8905).

There was an 11.1% reduction in the number of osteotomy procedures done around the knee between 2012 and 2018. On average, between 2012 and 2018, the procedures were done in women in 32.0% of cases (941/2936).

There was a 13.5% decrease in the number of joint lavage procedures done between 2012 and 2018. On average, between 2012 and 2018, the procedures were done in women in 40.1% of cases (6328/15,795).

Revision of total knee arthroplasty increased by 38.2% as shown in Fig. 8. On average, between 2012 and 2018, the procedures were done in women in 62.1% of cases (6281/10,107).

Knee mobilisation and arthrotomy increased by 18.7% between 2012 and 2018. On average, between 2012 and 2018, the procedures were done in women in 49.7% of cases (6240/12,561).

Overall, the number of surgical procedures increased by 8.2% between 2012 and 2018. This is summarised in Figs. 1–9. On average, between 2012 and 2018, the procedures were done in women in 44.0% of cases (151,218/343,701).

4.3. Future trends

The expected change over the coming years was determined using the two scenarios described previously.

4.3.1. Primary knee arthroplasty

Between 2018 and 2050, scenario 1 projects a 30.8% increase and scenario 2, a 152.8% increase ($p = 0.005$).

4.3.2. Ligaments

Between 2018 and 2050, scenario 1 projects a 1.2% increase and scenario 2, a 49.2% increase ($p < 0.0001$).

4.3.3. Meniscus

Between 2018 and 2050, scenario 1 projects a 5.6% increase and scenario 2, a 73.6% reduction ($p < 0.001$).

4.3.4. Synovectomy

Between 2018 and 2050, scenario 1 projects a 14.9% increase and scenario 2, a 178.6% increase ($p = 0.003$).

4.3.5. Patella surgery

Between 2018 and 2050, scenario 1 projects a 13.9% increase and scenario 2, a 116.1% increase ($p = 0.028$).

4.3.6. Osteotomy

Between 2018 and 2050, scenario 1 projects a 2.3% increase and scenario 2, a 61.3% reduction ($p = 0.055$).

4.3.7. Joint lavage

Between 2018 and 2050, scenario 1 projects a 15.2% increase and scenario 2, a 100% reduction ($p = 0.007$).

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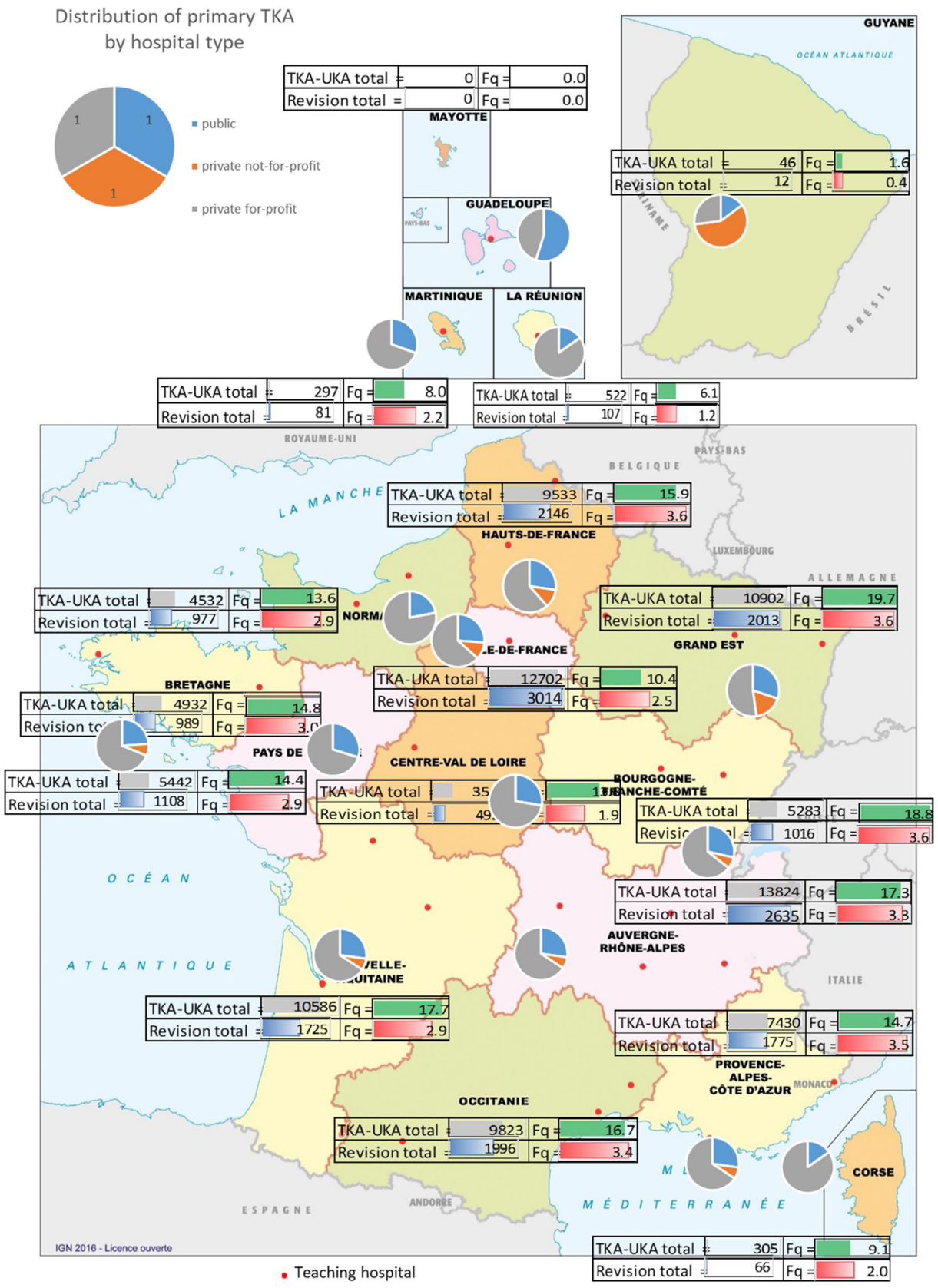

Fig. 2. Distribution in France of primary knee arthroplasty procedures, 2012–2018 average. TKA: Total knee arthroplasty; UKA: Unicompartmental knee arthroplasty; Fq: frequency.

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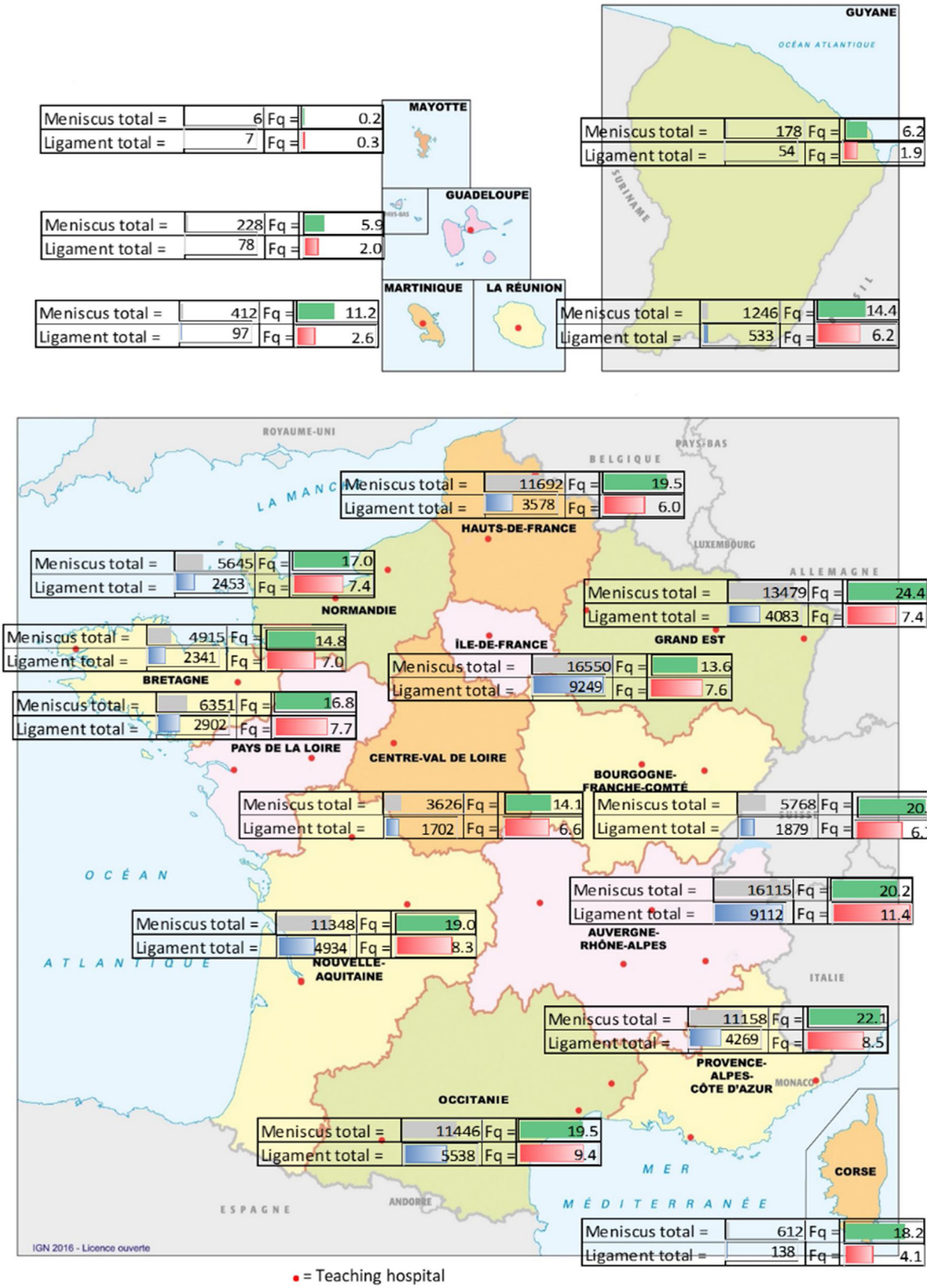

Fig. 3. Distribution in France of meniscus and knee ligament procedures, 2012–2018 average. Fq: frequency.

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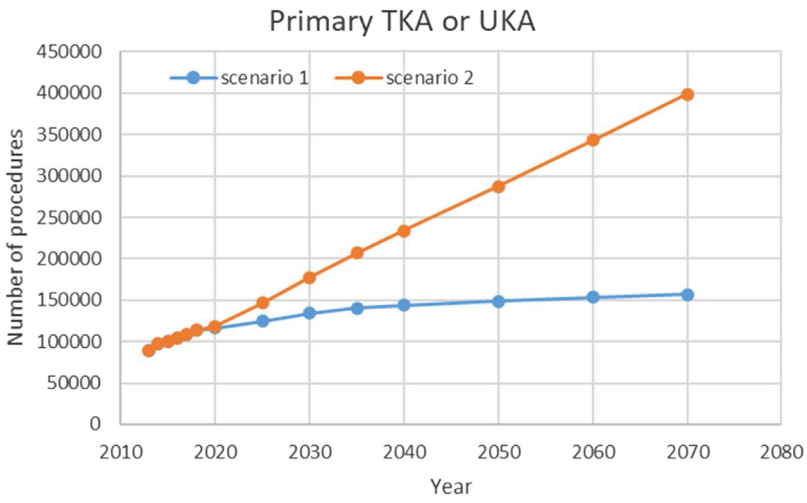

Fig. 4. Change in the number of primary knee arthroplasty procedures between 2012 and 2018 with trend out to 2070 according to scenarios 1 and 2.

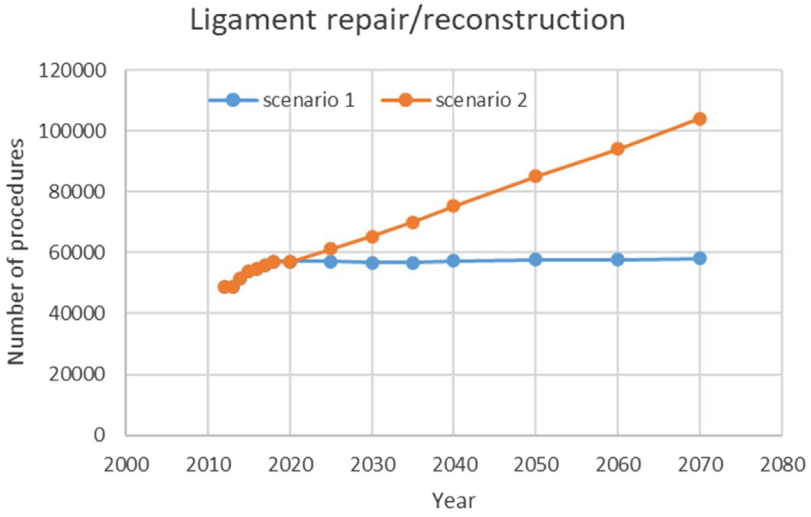

Fig. 5. Change in the number of ligament-related procedures between 2012 and 2018 with trend out to 2070 according to scenarios 1 and 2.

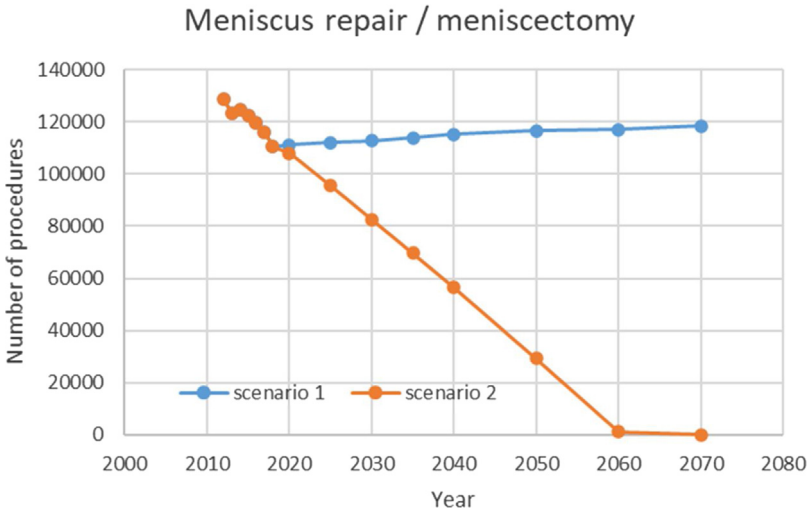

Fig. 6. Change in the number of meniscus-related procedures between 2012 and 2018 with trend out to 2070 according to scenarios 1 and 2.

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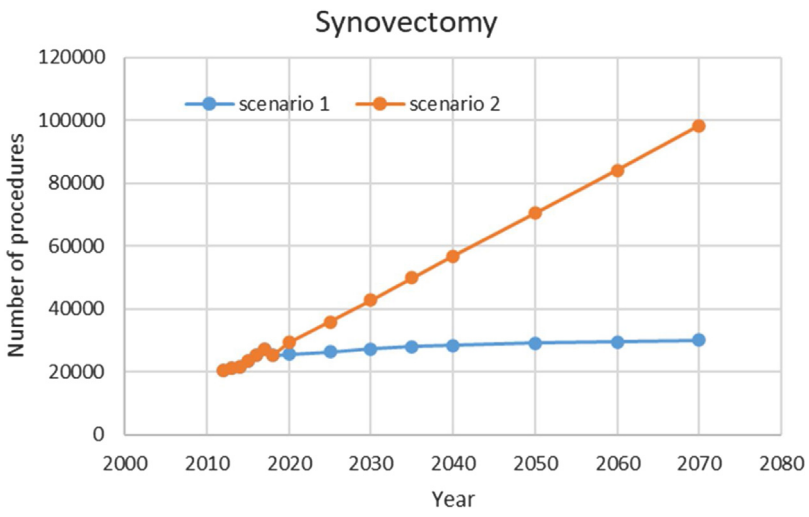

Fig. 7. Change in the number of knee synovectomy procedures between 2012 and 2018 with trend out to 2070 according to scenarios 1 and 2.

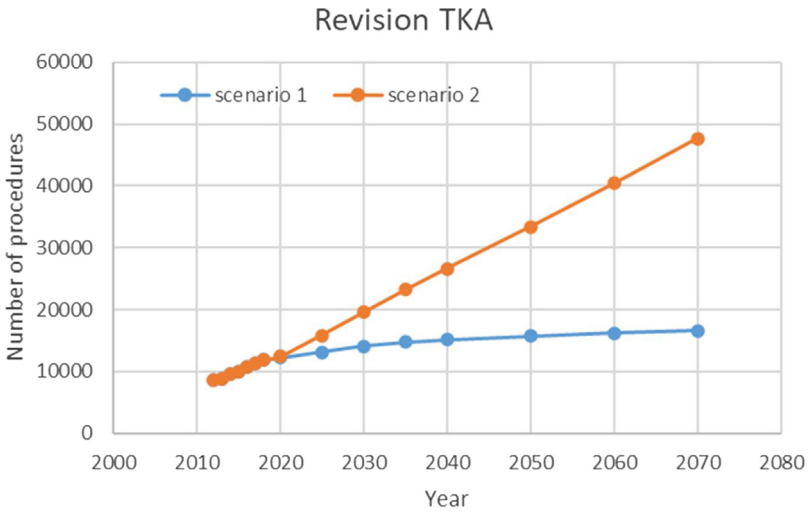

Fig. 8. Change in the number of revision knee arthroplasty procedures between 2012 and 2018 with trend out to 2070 according to scenarios 1 and 2.

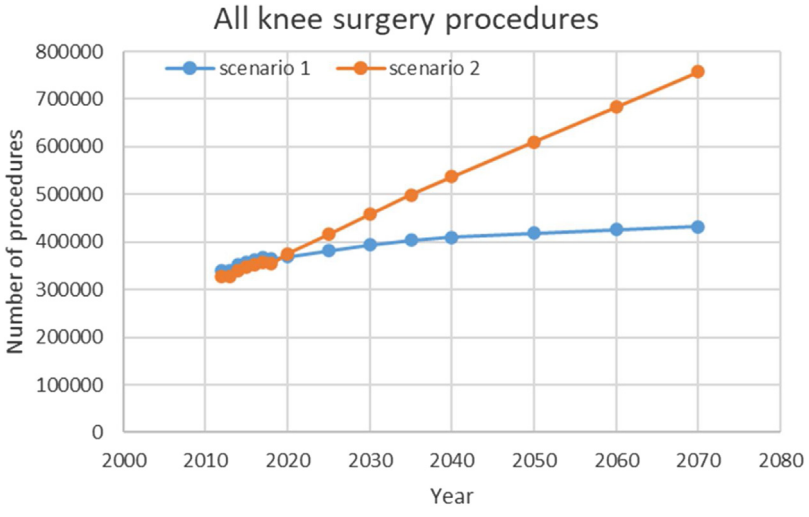

Fig. 9. Change in the total number of knee surgery procedures between 2012 and 2018 with trend out to 2070 according to scenarios 1 and 2.

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4.3.8. Revisions

Between 2018 and 2050, scenario 1 projects a 31.8% increase and scenario 2, a 180.2% increase ($p = 0.002$).

4.3.9. Mobilisation and arthrotomy

Between 2018 and 2050, scenario 1 projects a 12.7% increase and scenario 2, an 89.4% increase ($p = 0.126$).

4.3.10. Overall activity

Between 2018 and 2050, scenario 1 projects a 15.3% increase and scenario 2, a 78.2% increase ($p = 0.001$).

5. Discussion

The working hypothesis was confirmed: the number of surgical procedures on the knee will increase during the upcoming years. This study provides firm data on the current knee surgery activity throughout France and its expected change.

These data are comparable to data from other countries and to prior studies with national data both for primary and revision total knee arthroplasty [3,6,11]. The Ackerman team reported a mean of 18.5 TKA/10,000 in Australia in 2013; 10.9/10,000 in Denmark in 2013; 17.6/10,000 in Finland in 2013; 7.9/10,000 in Norway in 2013; 12.5/10,000 in Sweden in 2013 versus 17.0/10,000 in France in 2018 according to the analysis [12]. Joint arthroplasty and its complications make up most knee-related surgeries. The variability observed in the different scenarios that we looked at point to the difficulty in estimating this type of change; however, the most likely is a 40% increase overall in the next decades. This finding follows the same trend as the study done on hip surgery in France, but may be more marked for knee surgery [9].

The number of knee surgery procedures is expected to increase in the coming years and decades. While these data are only estimates, it is likely the true number of each procedure will be between scenario 1 and 2 in most instances. The regional distribution in France varied greatly, which can be explained by the local availability of care with certain hospitals specialised in a certain type of surgery, by the patient demographics and by medical demographics. The increased activity should be related to the national capacity to carry out these procedures; although a consistent increase is possible, the capacity remains limited [13]. When we look at each category, some of the differences and curves may appear false, e.g. the meniscus and lavage procedures in scenario 2 that trend towards 0. This occurred when the activity tended to decrease, since the scenario 2 used a trend curve with linear regression, it was not possible to predict to which point it would be reduced. The reduction phenomenon for meniscus procedure has previously been described by Jacquet et al. [14]; it is due to a preference for performing meniscus suture repair when possible, instead of meniscectomy. Nevertheless, we cannot conclude that meniscectomy procedures will disappear completely. Similarly, while TKA is associated with less and less complications, we cannot state that complications will disappear completely over time [15–18]. Similarly, procedures that have the same name may be done on patients with different indications that may change over time [19].

The question of care opportunity was not considered here, although it is relevant. For example, it is reasonable to wonder whether mobilisation and arthrotomy will only increase in the coming years since surgery and rehabilitation will only improve. The same can be said for surgical procedures in knees with moderate osteoarthritis [20]. It is likely that part of the expected increases is related to how the procedures are coded. Also, there is a disparity in the distribution of the procedures, with a tendency to fewer meniscectomy and more meniscal repair procedures. Another major factor is the improvement in surgical practices and introduction of new technologies (impossible to estimate currently) that could completely alter the recourse to surgery. A good example is the reduction in the number of TKA in rheumatoid arthritis patients due to better treatment of the disease.

The primary limitation of this study is a potential bias related to lack of coding. Nevertheless, since coding a procedure triggers its payment, it is very likely that the procedures were coded most of the time. While this study sought to be exhaustive, some procedures may have been missed, especially the less common ones. We only looked at the procedures that were coded as the main procedure. Some procedures may have been underestimated since the main procedure is not always the one that spurred the patient to be operated. This is particularly true for meniscus procedures that are often done at the same time as ligament surgery. Another limitation of this study is that the changes in population are not homogeneous, they vary depending on the geographic location. This factor was not taken into consideration as it would have added too much complexity to the analysis. As stated in the methods section, the average scenario was used with the INSEE data, thus this scenario is not absolute and could lead to false estimates of the population's evaluation. While a linear regression was used in scenario 2, another type of growth pattern (exponential or logarithmic) is also possible. Lastly, the estimate was done by taking current medical data into account. If a medical treatment that completely cures osteoarthritis were discovered tomorrow, our findings would be profoundly altered. Thus, our results should be seen within the present state of medical knowledge.

6. Conclusion

The number of knee surgery procedures per year has increased over the past few years in France and should continue to increase. This increase mainly impacts ligament surgery and knee arthroplasty.

Disclosure of interest

RE, AT, GV and SD declare that they have no competing interest. SB is a consultant with Zimmer (outside this study). MO is a consultant with Arthrex, Stryker, Newclip (outside this study).

Funding

No funding was received for this study.

Author contributions

RE contributed to the design of this study, data collection, writing the article and corrections AT, GV, CJ and MO contributed to the design of this study and writing the article SD contributed to overseeing the project and writing the article SB contributed to overseeing the project.

Appendix 1. Classification of procedure codes studies

Class	Sub-class	PMSI – CCAM procedure code
Meniscus	Suture repair	NFEA001 – Suture repair of 2 meniscus, knee arthrotomy NFEA002 – Suture repair of 1 meniscus, knee arthrotomy NFEC001 – Suture repair of 2 meniscus, knee arthroscopy NFEC002 – Suture repair of 1 meniscus, knee arthroscopy
	Meniscectomy	NFFA001 – Meniscectomy lateral + medial knee arthrotomy NFFA003 – Meniscectomy lateral or medial knee arthrotomy NFFC003 – Meniscectomy lateral + medial knee arthroscopy NFFC004 – Meniscectomy lateral or medial, knee arthroscopy
Ligament	Suture repair	NFCA001 – Suture repair/reattachment anterior cruciate ligament, knee arthrotomy NFCA002 – Suture repair/reattachment joint capsule, knee direct NFCA003 – Suture repair/reattachment cruciate ligaments, knee arthrotomy NFCA004 – Suture repair/reattachment ACL + periarticular capsule/ligament, knee arthrotomy NFCA005 – Suture repair/reattachment PCL + periarticular capsule/ligament, knee arthrotomy NFCA006 – Suture repair/reattachment posterior cruciate ligament, knee arthrotomy NFCC001 – Suture repair/reattachment posterior cruciate ligament, knee arthroscopy NFCC002 – Suture repair/reattachment anterior cruciate ligament knee arthroscopy
	Reconstruction	NFMA002 – Extra-articular lateral knee ligament reconstruction + fascia lata direct NFMA004 – Anterior cruciate ligament reconstruction with graft, knee arthrotomy NFMA008 – Repeat reconstruction posterior cruciate ligament with synthetic ligament, knee arthrotomy NFMA010 – PCL reconstruction with graft without synthetic reinforcement, knee, arthrotomy NFMA011 – Cruciate ligaments reconstruction, knee arthrotomy NFMC001 – Cruciate ligaments reconstruction, knee arthroscopy NFMC002 – PCL reconstruction with graft without synthetic reinforcement, knee, arthroscopy NFMC003 – Anterior cruciate ligament reconstruction with graft, knee arthroscopy NFMC005 – Repeat reconstruction posterior cruciate ligament with synthetic ligament, knee arthroscopy
Synovectomy		NFFA002 – Synovectomy knee, posterior + anterior arthrotomy, no change in patient position NFFA004 – Anterior synovectomy, knee arthrotomy NFFA005 – Anterior synovectomy, knee arthroscopy + posterior arthrotomy, 1 position NFFA006 – Synovectomy knee, posterior + anterior arthrotomy, with change in patient position NFFC001 – Anterior synovectomy, knee arthroscopy + posterior arthroscopy NFFC002 – Anterior synovectomy, knee arthroscopy
Osteochondral fixation		NFDA009 – Fixation osteochondral fragment in knee joint, arthrotomy
Patella		NFMA005 – Muscle capsule tendon reconstruction for patella recentering, knee arthrotomy NFPA002 – Transection lateral patellar retinaculum, arthrotomy NFPA004 – Transection lateral patellar retinaculum + osteotomy patellar surface, femur, arthrotomy NFPC001 – Transection lateral patellar retinaculum, arthroscopy NCPA001 – Recentering patella tibial tuberosity osteotomy/mobilisation patellar tendon, arthrotomy NCPA002 – Recentering patella tibial tuberosity osteotomy + muscle capsule tendon reconstruction, arthrotomy NCPA003 – Patellar recentering osteotomy by arthrotomy
Joint arthroplasty	UKA TKA	NFKA006 – Unicompartmental knee arthroplasty NFKA007 – Total knee replacement for 1 deformity < 10° in frontal plane NFKA008 – Total knee replacement for 1 deformity > 10° in frontal plane NFKA009 – Knee arthroplasty with fixed/rotating hinge NFMA006 – Custom/massive implant for knee arthroplasty due to segmental bone defect
Joint lavage		NFJA001 – Joint lavage, knee arthrotomy NFJA002 – Joint aspiration, knee arthrotomy NFJC001 – Joint lavage, knee arthroscopy NFJC002 – Joint aspiration, knee arthroscopy
rTKA		NFKA001 – Change of 1 total knee implant without bone reconstruction NFKA002 – Change of 1 total knee implant with bone reconstruction NFKA003 – Change of 1 unicompartmental knee implant NFKA004 – Change of knee arthroplasty insert NFKA005 – Change of 1 unicompartmental knee implant for 1 total knee implant NFLA001 – Replacement of 1 knee joint implant + bone reconstruction NFLA002 – Replacement of 1 knee joint implant without bone reconstruction
	Implant removal	NFGA001 – Removal of 1 knee implant + arthrodesis NFGA002 – Removal of 1 knee implant
Knee mobilisation		NFPA001 – Knee release, arthrotomy NFPA003 – Knee release, arthroscopy/arthrotomy + additional quadriceps release NFPC002 – Knee release, arthroscopy NFRP001 – Therapeutic knee joint mobilisation + general/regional anesthesia
Reduction		NFEP001 – Reduction 1 patellar dislocation NFEP002 – Reduction 1 dislocation/1 fracture-dislocation tibiofemoral joint
Arthrodesis		NFDA002 – Tibiofemoral arthrodesis, arthrotomy NFDA003 – Proximal tibiofibular arthrodesis, arthrotomy

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Class	Sub-class	PMSI – CCAM procedure code
		NFMA013 – Bone reconstruction at knee for segmental defect + arthrodesis + fixation
Osteotomy		NBPA001 – Simple bilateral osteotomy femur + tibia NBPA004 – Simple unilateral osteotomy femur + tibia NBPA009 – Derotation osteotomy distal femur/proximal tibia NBPA010 – Complex osteotomy distal femur NBPA017 – Simple osteotomy distal femur NCPA005 – Simple osteotomy proximal tibia + anterior cruciate ligament reconstruction NCPA014 – Complex osteotomy proximal tibia NCPA015 – Simple osteotomy proximal tibia

UKA: Unicompartmental knee arthroplasty; TKA: Total knee arthroplasty; rTKA: Revision of total knee arthroplasty; ACL: Anterior cruciate ligament; PCL: Posterior cruciate ligament.

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2020.02.018.

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