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## Factors associated with the orthopaedic surgeon's decision to recommend total joint replacement in hip and knee osteoarthritis: an international cross-sectional study of 1905 patients

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**TITLE PAGE****Factors associated with the orthopaedic surgeon's decision to recommend total joint replacement in hip and knee osteoarthritis: an international cross-sectional study of 1905 patients**

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**ABSTRACT (248 words)**

**Objective** To determine factors associated with orthopaedic surgeons' decision to recommend total joint replacement (TJ R) in people with knee and hip osteoarthritis (OA).

**Design** Cross-sectional study in eleven countries. For consecutive outpatients with definite hip or knee OA consulting an orthopaedic surgeon, the surgeon's indication of TJ R was collected, as well as patients' characteristics including comorbidities and social situation, OA symptom duration, pain, stiffness and function (Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)), joint-specific quality of life, OARSI joint space narrowing radiographic grade (0-4), and surgeons' characteristics. Univariable and multivariable logistic regressions were performed to identify factors associated with the indication of TJ R, adjusted by country.

**Results** In total, 1905 patients were included: mean age was 66.5 (standard deviation, SD, 10.8) years, 1082 (58.0%) were women, mean OA symptom duration was 5.0 (SD 7.0) years. TJ R was recommended in 561/1127 (49.8%) knee OA and 542/778 (69.7%) hip OA patients. In multivariable analysis on 516 patients with complete data, the variables associated with TJ R indication were radiographic grade (Odds Ratio, OR for one grade increase, for knee and hip OA, respectively: 2.90, 95% confidence interval [1.69-4.97] and 3.30 [2.17-5.03]) and WOMAC total score (OR for 10 points increase: 1.65 [1.32-2.06] and 1.38 [1.15-1.66], respectively). After excluding radiographic grade from the analyses, on 1265 patients, greater WOMAC total score was the main predictor for knee and hip OA; older age was also significant for knee OA.

**Conclusion** Radiographic severity and patient-reported pain and function play a major role in surgeons' recommendation for TJ R.

**KEYWORDS** Knee, hip, osteoarthritis, total joint replacement, surgery.

**RUNNING HEADLINE** Total joint replacement in osteoarthritis

**3447 words, 6 tables, 3 online tables**

**1 INTRODUCTION**

2

3 With the global ageing and increasing obesity and sedentary lifestyle of the world's  
4 population, the prevalence of osteoarthritis (OA) is increasing along with its social  
5 and economic impacts [1,2]. Lower-extremity OA affects mainly the hip and the knee,  
6 which leads to pain and functional disability. In 2010, hip and knee OA were ranked  
7 as the 11th highest contributor condition to global disability worldwide and their  
8 disability burden keeps growing [2]. Total joint replacement (TJ R) is the current  
9 treatment for moderate to severe knee and hip OA that has failed to respond to non-  
10 surgical management, including pharmacologic and non-pharmacologic modalities,  
11 and has the potential for significant improvement of pain, functional capacity and  
12 quality of life [3-5]. However, not all patients with OA will benefit from TJ R. In the  
13 context of increasing burden of OA and consequent growing needs for this surgery,  
14 we need to better understand who receives an indication for TJ R. This is linked to the  
15 ongoing studies on appropriateness criteria to consider TJ R [6-13].

16 In studies exploring factors associated with TJ R [14-20], some factors were key in the  
17 decision for TJ R, such as levels of symptoms [5,14-19] and radiographic damage  
18 [14,15,18,19,21-23], whereas other factors were not linked to TJ R, including patients'  
19 gender and body mass index [15-20]. For several factors, the association with TJ R  
20 remained unclear, such as patients' age, comorbidities, and quality of life [16,19].  
21 Furthermore, other previously unexplored factors may play a relevant role, like  
22 patients' social situation and surgeons' characteristics.

23 In 2010, a large international study was conducted under the auspices of the  
24 Osteoarthritis Research Society International (OARSI) and Outcome Measures in  
25 Rheumatology (OMERACT). The aim was to determine cut-offs for pain and

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26 functional impairment related to the indication for TJ R [24]. In the primary analyses,  
27 only pain and function were analysed: the main conclusions were that although both  
28 pain and function played a role in the surgeon's decision, because of substantial  
29 overlap no satisfactory cut-off values could be established to distinguish patients  
30 selected or not for TJ R with an area under the receiver operating characteristic  
31 (ROC) curve greater than 0.64 [0.61;0.67] [24]. This dataset gave us the  
32 opportunity to explore more completely criteria involved in the indication of TJ R,  
33 using the surgeon's opinion as the gold standard.

34 The objective of the present study was to determine the factors associated with the  
35 surgeon's recommendation to perform TJ R in people with both knee and hip OA, in  
36 the context of a large, international, multi-site study.

37

38

## 39 PATIENTS AND METHODS

40

### 41 Study design

42 The study design has been described previously [24]. Briefly, this was a large  
43 international, observational, cross-sectional study with prospective inclusion, in the  
44 orthopaedic departments of secondary-care and tertiary-care centers in Europe (12  
45 centers, one per country in Czech Republic, Italy, Spain, Sweden and the United  
46 Kingdom; two per country in France and the Netherlands; three in Germany),  
47 Canada (2 centers), the United States of America (2 centers), and Australia (2  
48 centers). Ethical approval was obtained in all participating centers. All patients gave  
49 informed consent. The research forms were completed during a routine patient visit  
50 and no queries were sent to the investigators in case of missing data.

51

52 Study population

53 Consecutive outpatients with a clinical diagnosis of hip or knee OA (according to  
54 the orthopaedic surgeon and based on symptoms and radiographs) consulting an  
55 orthopaedic surgeon in one of the participating centers to discuss potential surgery  
56 were included for this analysis. Exclusion criteria were: prior TJ R or prior osteotomy  
57 of the target joint, concomitant inflammatory joint disease, and patient inability to  
58 complete a questionnaire. Furthermore, among patients who had given data, only  
59 those with information on the surgeons' recommendations to perform TJ R or not  
60 were included in the analysis.

61

62 Gold standard: Indication for TJ R

63 The outcome analysed in the present study was the orthopaedic surgeon's indication  
64 regarding the requirement for TJ R, i.e., the surgeon stating "surgery is recommended  
65 for the patient". This answer defined the 'indication for TJ R', irrespective of whether  
66 the joint replacement surgery was performed or not.

67 Potential variables associated with surgeons' indication for TJ R

68 Demographic data comprising age, gender, and body mass index (BMI, calculated  
69 based on height and weight, then analysed both as a continuous variable and  
70 categorised) were collected. Due to the high mean BMI in this population, the  
71 decision was taken to analyse BMI as above or below 35 kg/m<sup>2</sup>. Comorbidities were  
72 reported using a modified Charlson Comorbidity Index, and were analysed as the  
73 sum of the number of comorbidities (range, 0-14) [25]. Symptom severity was  
74 collected through the Western Ontario and McMaster Universities Osteoarthritis

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75 (WOMAC) Index (total score; pain, function and stiffness subscales) [26]. WOMAC  
76 results were linearly transformed to a 0-100 score, where higher scores indicated  
77 worse status [24]. Patients' joint-related quality of life was evaluated by the Quality of  
78 Life subscale of the Hip disability and Osteoarthritis Outcome Score (HOOS) and  
79 Knee disability and Osteoarthritis Outcome Score (KOOS), as appropriate [27,28].  
80 The HOOS/KOOS are two valid and reliable instruments with five individually  
81 calculated subscales that can be used for short-term and long-term follow-up of  
82 several types of hip/knee injury including OA. HOOS/KOOS scores are reported on a  
83 0-100, worst to best, scale. Where radiographs of the target joint were available, the  
84 local investigator reported the OARSI joint space narrowing (J SN) radiological grade  
85 [29,30]. X-rays were taken in the context of usual care, according to local protocols.  
86 The score analyses J SN in categories from 0 to 4; (0) no narrowing, (1) < 25%, (2)  
87 25-50%, (3) 50-75%, (4) > 75% of J SN [21,22]. The patients' social situation was  
88 collected by the physician as "living alone" (yes/no) and "being responsible for  
89 another person" (yes/no). Surgeons' characteristics such as gender and years of  
90 experience (year of certification as an orthopaedic surgeon) were collected.

91

92 Surgeon's reported reason(s) not to recommend TJR

93 If the surgeon selected "no indication for TJR", underlying reasons for not  
94 recommending surgery were collected from the surgeon as: symptoms not severe  
95 enough, patient declining surgery, comorbidity, main problem not being hip/knee  
96 OA, further investigations required, another treatment should be tried first.

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97 Patients not recommended for TJR who were considered « not severe enough »  
98 were compared in terms of WOMAC total score with patients not recommended for  
99 other reasons.

#### 100 Statistical analysis

101 Patient characteristics were described separately for knee and hip OA patients. To  
102 assess factors associated with indication for TJR, univariable analyses where OR  
103 with 95% confidence intervals have been calculated were performed in each patient  
104 population, evaluating each variable.

105 Forward multivariable logistic regressions were then performed, including variables  
106 with  $p < 0.20$  in univariable analyses and excluding colinear variables, eg WOMAC  
107 subscales (online supplementary table 1). Since OARSI JSN is a qualitative  
108 variable, radiographic severity was binarised as grade 1-2 versus 3-4. Surgeons'  
109 characteristics were analysed at the patient level rather than at the surgeon level.

110 There was no imputation of missing data. As there were many missing data for the  
111 radiographic grade and for surgeons' characteristics, a second multivariable logistic  
112 regression was performed excluding these variables, both for patients with knee  
113 and hip OA. All multivariable analyses were adjusted for country of residence as the  
114 objective was not to compare results between countries, given small sample sizes  
115 [24]. No formal testing was performed across countries.

116 All analyses were performed using R software, version 3.2.5.

117

118

119

120

121 **RESULTS**

122

123 Patient characteristics

124 In all, 1974 patients were enrolled between June 2008 and December 2010. Among  
125 them, 1905 patients (96.5%) had data for TJR indication and were analysed: 1127  
126 knee OA and 778 hip OA patients. Patients were from: Europe (N=1121), Australia  
127 (N=394), Canada (N=204) and the United States of America (N=186). Patient  
128 characteristics were typical of established OA cohorts ([Table 1](#)). Mean age was 66.5  
129 (standard deviation (SD) 10.8) years, 1082/1866 (58.0%) were women, mean OA  
130 symptom duration was 6.3 (SD 8.4) years in knee OA patients and 3.3 (SD 3.4) years  
131 in hip OA patients, mean BMI was 31.0 (SD 6.8) kg/m<sup>2</sup> in knee OA patients and 28.3  
132 (SD 5.1) kg/m<sup>2</sup> in hip OA patients. WOMAC subscale scores for pain and functional  
133 disability (0-100) were respectively 52.8 (SD 21.8) and 55.4 (SD 20.9) for knee OA;  
134 56.5 (SD 21.6) and 59.5 (SD 20.9) for hip OA. In all, 516 patients had all data  
135 available ([online supplementary Table 2](#)). Most patients for whom radiographic data  
136 were available had severe JSN: 351/512 (69.0%) knee OA patients and 311/403  
137 (82.9%) hip OA patients had an OARSI JSN radiographic grade of 3 or 4.

138

139 Factors associated with TJR recommendation in univariable analysis

140 TJR was recommended in 561/1127 (49.8%) knee OA and 542/778 (69.7%) hip OA  
141 patients ([Table 1](#)).

142 *Knee OA:* In univariable analysis for knee OA ([Table 2](#)), the variables related to the  
143 decision to recommend total knee replacement (TKR) were older age (with more  
144 indications for TJR in the range 60 to 79 years old, [online supplementary table 3](#)),  
145 male gender, longer OA symptom duration, history of another TJR, patient living

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146 alone, patient being responsible for another person, higher WOMAC total score and  
147 subscale scores, lower KOOS Quality of life subscale score, more severe OARSI  
148 J SN radiographic grade, surgeon's male gender and years of experience. In contrast,  
149 BMI (both continuous and categorized) and number of comorbidities were not  
150 associated with the indication of TKR.

151

152 *Hip OA:* In univariable analysis for hip OA ([Table 3](#)), factors associated with the  
153 decision to recommend total hip replacement (THR) were older age (again with most  
154 indications for TJ R between 60 and 79 years of age, [online supplementary table 3](#)),  
155 longer OA symptom duration, patient living alone, higher WOMAC total score and  
156 subscale scores, lower HOOS Quality of life subscale score, more severe OARSI  
157 J SN radiographic grade and surgeon's male gender. THR would not appear to be  
158 recommended if patients' BMI is greater than 35 kg/m<sup>2</sup>. Patients' gender, BMI (as a  
159 continuous variable), history of another TJ R, number of comorbidities, patient being  
160 responsible for another person and surgeon's experience were not associated with  
161 the indication for THR.

162

163 Factors associated with indication for TJ R in multivariable analysis

164 A first multivariate analysis adjusted by country was performed in the 516 patients for  
165 whom all data, including radiographic assessment, were available ([Tables 4 and 5](#)  
166 [and online supplementary table 1](#)). Independent factors associated with TJ R in  
167 both knee and hip OA patients were OARSI J SN grade (assessed for an increase of  
168 one point) and higher (i.e. more symptoms, disability and stiffness) WOMAC total  
169 score. The corresponding results were respectively for knee OA, Odds Ratio, for a 1-  
170 point increase of OARSI J SN radiographic grade, OR: 2.90, 95% Confidence Interval

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171 [1.69;4.97] and OR for a 10-point increase of WOMAC total score: 1.65 [1.32;2.06];  
172 and respectively for hip OA, OR: 3.30 [2.17;5.03] and OR: 1.38 [1.15;1.66]. The other  
173 demographic factors, including BMI (both continuous and categorized), patient's  
174 social situation or surgeon characteristics, were not independently associated with a  
175 TJ R indication.

176 As there were many missing data for the OARSI JSN radiographic grade and for  
177 surgeons' characteristics, a second multivariable logistic regression was performed  
178 excluding these variables, both for knee and hip OA ([Tables 4 and 5](#)). In these  
179 analyses, 1265 patients contributed (characteristics in [online supplementary table](#)  
180 [2](#)). Here, higher (i.e. more symptoms, disability and stiffness) WOMAC total score  
181 (knee: OR 1.25 [1.14;1.37] and hip: OR 1.49 [1.33;1.68]) was a significant factor  
182 associated with indication for TJ R in knee and hip OA. Patients' older age (knee: OR  
183 1.03 [1.01;1.04]) was a significant factor in knee OA. No other factors were  
184 independently associated with a TJ R indication.

185

186

#### 187 Surgeons' reasons to not recommend TJ R

188 For both knee and hip OA, almost half of patients for whom the surgeons did not  
189 recommend TJ R were considered by the surgeon to be "not symptomatic enough"  
190 (N=224/491 (45.6%) and N=102/219 (46.5%), respectively) ([Table 6](#)). For these  
191 patients, symptom levels were indeed less severe at the group level: in knee and hip  
192 OA, WOMAC total score was 42.2 (SD 19.9) and 35.3 (SD 19.7) respectively, vs 51.5  
193 (SD 20.3) and 55.6 (SD 19.9), in patients for whom surgery was not recommended  
194 because "symptoms were not severe enough" and those for whom TJ R was not  
195 indicated for "other reasons", respectively (both  $p < 0.0001$ ). The second most

196 frequent reason for the surgeon to not recommend TJ R was because "another  
197 treatment should be tried first", in both knee and hip OA ([Table 6](#)).

198

199

## 200 **DISCUSSION**

201

202 The present study brings relevant information on the reasons for orthopaedic  
203 surgeons recommending TJ R. It confirmed the role of radiographic scores and  
204 symptoms as independent factors associated with surgeons' recommendation to  
205 perform TJ R. It appeared, on the sample of patients with available radiographic  
206 scores, that the orthopaedic surgeon's decision to recommend a TJ R was largely  
207 based on radiographic severity, i.e., a state of moderate-to-severe OA, in the present  
208 patients, who had pain and functional limitations. We also found that patient's age is  
209 an important factor in particular for knee OA. This study confirmed that some other  
210 factors were not associated with recommendation for TJ R, such as patients' gender,  
211 BMI and comorbidities. Finally, previously unexplored factors, linked to patients'  
212 social situation or surgeons' characteristics that could be analysed, did not appear to  
213 be associated with surgeon's recommendation for TJ R.

214

215 This study has strengths and limitations. The main limitation is the high rate of  
216 missing data, probably due to the large number of sites and the lack of queries sent  
217 to investigators for missing data. This led to a smaller analysed population in the  
218 multivariable logistic regressions. Nevertheless, to our knowledge, this is the only  
219 international study and among the largest, possibly explaining the difficulty to obtain  
220 information from all the involved participants (patients and practitioners). The factors

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221 that were most frequently missing were OARSI J SN radiographic grade and  
222 surgeons' characteristics. Missing data on radiographs could be explained by lack of  
223 availability of the radiograph, or a lack of standardised assessment. Surgeons'  
224 characteristics were given by orthopaedic surgeons themselves while filling case  
225 report forms during the visit but this page was often not completed. A second  
226 analysis was therefore performed excluding these two factors. Of note,  
227 characteristics of the multivariable populations were similar compared to the initial  
228 1905 included patients ([Online supplementary table 1](#)) which would be an  
229 argument in favour of random missing data. After excluding OARSI J SN radiographic  
230 grade and surgeons' characteristics, patient's age appeared to be a factor associated  
231 with indication for TJ R, in knee OA: in this study population of a mean age of 69.0  
232 years (SD 9.5), patients aged from 60 to 79 years were more likely to be  
233 recommended for TJ R than younger patients (<60 years old) or older patients (>80  
234 years old) ([Online supplementary table 3](#)). It is possible that older patients had  
235 more radiographic J SN however this is not the only factor given the U shape of the  
236 relationship. Restrictions in recommendation of TJ R in younger patients could also be  
237 explained by a higher revision rate (with subsequent poorer outcomes), as mentioned  
238 in Verra et al's study [31]. Other limitations include the incomplete nature of the data  
239 collection; for example, psychological distress, ethnicity and socioeconomic status  
240 were not collected although it has been suggested that they are predictors of patients  
241 being offered joint replacement [6-7]. Finally, as variables from the univariable  
242 analysis were selected for entry into the multivariable model rather than all entered,  
243 we recognise some variables may have been missed. However, this method avoided  
244 collinearity between the variables.

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245 In this group of patients with definite knee or hip OA, TJ R was recommended in  
246 49.8% and 69.7% respectively. These rates can be compared to prior studies which  
247 vary between 16% and 60% [14,15,18-20]. This indicates both the variability of  
248 surgery rates, and possibly differences between studies focused on surgery as the  
249 event, where rates were lower, and indication for surgery, where rates were  
250 comparable to the ones found here. Better clarity on appropriateness criteria for TJ R  
251 would reduce inappropriate referrals and decisions [6-13].

252 In the present study, differences across countries were not analysed although  
253 recommendations for TJ R may vary by country [14-20], due to differences in clinical  
254 practice and healthcare systems. Only a few centres participated in each country.  
255 Therefore, results of this present study cannot be considered representative of  
256 national practices. Furthermore, disparities among countries on pain and function  
257 evaluation have been previously pointed out within this cohort [24]. To account for  
258 national differences, results were adjusted by country.

259 The use of validated scores such as WOMAC and OARSI JSN radiographic scores,  
260 not systematically used in prior studies [14,20] is a strength of this study, although the  
261 use of the WOMAC total score is still in discussion [26].

262

263 The level of symptoms, in terms of pain and disability, and the radiographic severity,  
264 were higher among patients for whom TJ R was indicated by the surgeon, which is in  
265 accordance with previous studies [15,18,19] and 4 national guidelines for assessing  
266 need for total knee and hip replacement : (1) the US National Institute of Health  
267 consensus guidelines, suggesting that knee and hip TJ R should be considered in  
268 patients with persistent pain, radiographic damage and limitation in daily activities  
269 [36,37]; (2) Canadian criteria, listed by Hawker et al in 2000, considering that a total



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270 WOMAC score  $\geq 39$ , and clinical and radiographic evidences of OA should lead to  
271 TJR [38]; (3) the French severity index for OA by Lequesne, composed of 3 criteria  
272 (pain, maximum distance walked and activities of daily living) and suggesting knee or  
273 hip TJR when  $\geq 14$  out of a possible 24 [39]; and (4) the New Zealand score,  
274 considering that levels of pain, functional activity, movement and deformity, and other  
275 factors such as multiple joint disease or ability to work could determine indication for  
276 knee or hip TJR [40]. These guidelines or consensus statements, although using pain  
277 and functional impairment criteria in majority, reveal some heterogeneity and difficulty  
278 in application in practice. This could explain in part why, to this day, no validated  
279 international guidelines exist. [6-13]. Of note, in the present study, JSN (a qualitative  
280 score) was analysed as a binary variable, thus losing some granularity; however,  
281 radiographic severity is usually considered as present/absent when deciding on TJR.  
282 [29-30] The present study also confirmed the substantial overlap in symptoms and  
283 function between patients oriented or not towards TJR.[24]

284

285 Similarly to previous studies [16,18-20], the present study found that gender and BMI  
286 were not associated with indication for TJR. Of note, BMI was analysed using a cut-  
287 off of 35 kg/m<sup>2</sup> but analyses with BMI as a continuous variable were similar. Factors  
288 which were doubtful or much less explored in previous studies appeared here not to  
289 be associated with indication for TJR, including comorbidities. Hawker et al also  
290 found no association with the number of comorbidities [16] although Maillefert et al  
291 concluded surgeons tended to indicate THR more often if patients had no severe  
292 cardiovascular comorbidity [19]. In the present study, each patient had around 3  
293 comorbidities, but this factor was not associated with indication for TJR. This might  
294 reflect improvements in TJR and anesthesiology techniques, leading to a shorter

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295 surgical time and less risks for the patient, regardless of medical history. In terms of  
296 quality of life, the present study did not find a link with indication for TJ R, unlike the  
297 studies performed by Hawker et al and Maillefert et al [16,19], perhaps due to the use  
298 of different scales. Furthermore, as joint-related quality of life is strongly related to  
299 pain and function, this variable was not entered in the multivariable analysis. Among  
300 the new factors that this study was able to explore, related to patients' social situation  
301 and surgeons' characteristics, no significant links were found; though such findings  
302 would need to be further confirmed.

303

304 This cohort gave us the opportunity to explore indication for TJ R rather than TJ R  
305 itself, hence excluding a subset of confounding factors such as socio-economic  
306 criteria or patients' willingness, but also patients' expectations or psychological  
307 distress in order to determine factors that influence a surgeon's decision to  
308 recommend or not recommend TJ R [32-35]. In this study, we collected the surgeon's  
309 reasons for not recommending TJ R, when surgery was not recommended. For both  
310 knee and hip OA, almost half of patients for whom the surgeons did not decide on  
311 TJ R were considered by them as "not symptomatic enough", and the second most  
312 frequent reason announced was "because another treatment should be tried first".  
313 These descriptive results suggest that patients might be referred perhaps too widely  
314 to orthopaedic surgeons. Other treatment options than surgery should be discussed  
315 first [41].

316

317 In summary, determining when to recommend TJ R in knee and hip OA patients is  
318 difficult, but factors that help in such a decision are definitely the ones reflecting  
319 radiographic severity and higher levels of symptoms. Further studies are needed in

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320 particular to better define potential candidates for TJ R, in the context of high and  
321 increasing world-wide burden of OA.

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**AUTHOR CONTRIBUTIONS**

All the authors contributed to

- (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data
- (2) drafting the article or revising it critically for important intellectual content
- (3) final approval of the version to be submitted.

Laure Gossec (laure.gossec@aphp.fr) takes responsibility for the integrity of the work as a whole, from inception to finished article.

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The study sponsors played no role in the study design, in the collection, analysis and interpretation of data; in the writing of the manuscript; or in the decision to submit the manuscript for publication.

## CONFLICTS OF INTEREST

None relevant to the present work.

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**Table 1. Characteristics of 1905 patients with established knee or hip OA consulting an orthopedic surgeon.**

Variable	All patients N= 1905	Knee patients N= 1127	Hip patients N= 778
Indication for TJ R, N (%)	1103 (57.9)	561 (49.8)	542 (69.7)
Age, years, mean (SD)	66.5 (10.8)	67.6 (10.4)	65.0 (11.3)
Gender, female, N (%)	1082 (58.0)	654 (58.8)	428 (56.8)
Body mass index, kg/m <sup>2</sup> , mean (SD)	29.9 (6.3)	31.0 (6.8)	28.3 (5.1)
Body mass index > 35 kg/m <sup>2</sup> , N (%)	366 (18.8)	216 (16.7)	150 (22.8)
OA symptom duration, years, mean (SD)	5.0 (7.0)	6.3 (8.4)	3.3 (3.4)
Pain, WOMAC subscale (0-100), mean (SD)	54.5 (22.0)	52.8 (21.8)	56.5 (21.6)
Function, WOMAC subscale (0-100), mean (SD)	54.3 (19.9)	55.4 (20.9)	59.5 (20.9)
Stiffness, WOMAC subscale (0-100), mean (SD)	61.2 (26.1)	57.5 (25.6)	58.8 (23.8)
WOMAC total score (0-100), mean (SD)	56.6 (20.4)	55.1 (20.4)	58.6 (20.2)
HOOS/KOOS Quality of life subscale (0-100), mean (SD)	27.6 (19.0)	27.7 (18.7)	27.3 (19.5)
OARSI JSN radiographic grade (3-4), N (%)	662 (72.3)	351 (69.0)	311 (82.9)
Surgeon's gender, male, N (%)	1044 (90.9)	615 (90.5)	429 (91.2)
Surgeon's experience, years, mean (SD)	17.8 (9.2)	17.8 (9.0)	17.9 (9.4)

SD=standard deviation. WOMAC subscale and total scores were linearly transformed to 0-100 scores where 100=worst state. HOOS/KOOS Quality of life subscale were transformed to 0-100 scores where 0=worst state.

All % are % of available data. The most frequently missing data were OARSI JSN radiographic grade (for knee and hip OA respectively, 512 and 403 patients with data available), surgeon's experience (for knee and hip OA respectively, 662 and 460 patients with data available and surgeon's gender (for knee and hip OA respectively, 679 and 470 patients with data available).

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**Table 2. Factors associated with indication for knee replacement in 1127 patients with knee OA: univariable analysis**

Variable	TKR recommended N= 561	TKR not recommended N= 566	OR [95% CI]	P value
Age, years, [N] mean (SD)	[447] 69.0 (9.5)	[434] 66.0 (11.0)	1.03 [1.17-1.52]	<0.0001
Gender, female, n/N (%)	210/553 (38.0)	249/560 (44.5)	0.76 [0.60-0.97]	0.03
BMI, kg/m <sup>2</sup> , [N] mean (SD)	[434] 30.9 (6.2)	[435] 31.0 (7.5)	1.00 [0.98-1.02]	0.81
BMI > 35kg/m <sup>2</sup> , n/N (%)	98/434 (22.6)	102/435 (23.4)	0.95 [0.69-1.31]	0.76
OA symptom duration, years, [N] mean (SD)	[296] 7.1 (8.0)	[332] 5.6 (8.7)	1.00 [1.00-1.01]	0.03
Comorbidities (KCS score), [N] mean (SD)	[474] 3.2 (1.7)	[358] 3.1 (1.7)	1.03 [0.95-1.12]	0.46
History of another joint replacement (yes), n/N (%)	122/542 (22.5)	73/528 (13.8)	1.81 [1.32-2.50]	<0.001
Patient living alone, n/N (%)	175/546 (32.1)	135/530 (25.5)	1.38 [1.06-1.80]	0.02
Patient being responsible for another person, n/N (%)	120/543 (22.1)	142/529 (26.8)	0.77 [0.58-1.02]	0.07
Pain, WOMAC subscale (0-100), [N] mean (SD)	[540] 57.0 (20.5)	[520] 48.0 (22.0)	1.11 [1.07-1.14]	<0.001
Function, WOMAC subscale (0-100), [N] mean (SD)	[479] 45.6 (14.5)	[480] 38.9 (16.2)	1.03 [1.02-1.04]	<0.001
Stiffness, WOMAC subscale (0-100), [N] mean (SD)	[536] 61.9 (25.0)	[507] 52.5 (25.2)	1.20 [1.12-1.28]	<0.001
WOMAC total score (0-100), [N] mean (SD)	[471] 57.0 (18.0)	[451] 48.7 (20.3)	1.02 [1.02-1.03]	<0.001
KOOS Quality of life subscale (0-100), [N] mean (SD)*	[518] 23.7 (19.6)	[536] 31.8 (16.8)	0.98 [0.97-0.98]	<0.0001
OARSI JSN radiographic grade (3-4), n/N (%)	187/206 (90.8)	164/306 (45.5)	8.52 [5.17-14.77]	<0.0001
Surgeon's gender, male, n/N (%)**	268/288 (93.0)	347/391 (88.7)	1.70 [0.90-3.01]	0.04
Surgeon's experience, years, [N] mean (SD)	[294] 19.1 (9.3)	[375] 16.8 (8.7)	1.03 [1.01-1.05]	0.001

% are % of available data. N=number of patients with available data.

\*Lower scales indicate worse status

\*\*This line indicates that 93.0% of patients recommended for surgery had seen a male surgeon

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**Table 3. Factors associated with indication for hip replacement in 778 patients with hip OA: univariable analysis**

Variable	THR recommended N= 542	THR not recommended N= 236	OR [95% CI]	P value
Age, years, [N] mean (SD)	[449] 65.8 (10.5)	[199] 63.1 (12.8)	1.02 [1.01-1.04]	0.004
Gender, female, n/N (%)	292/524 (55.7)	133/229 (58.1)	1.08 [0.79-1.47]	0.65
BMI, kg/m <sup>2</sup> , [N] mean (SD)	[449] 28.3 (4.8)	[182] 28.3 (5.9)	1.00 [0.97-1.04]	0.92
BMI > 35kg/m <sup>2</sup> , n/N (%)	42/446 (9.4)	24/181 (13.2)	0.68 [0.40-1.17]	0.16
OA symptom duration, years, [N] mean (SD)	[306] 3.7 (3.7)	[127] 2.3 (2.3)	1.00 [1.00-1.01]	<0.0001
Comorbidities (KCS score), [N] mean (SD)	[466] 3.1 (1.6)	[163] 2.9 (1.6)	1.04 [0.93-1.17]	0.51
History of another joint replacement (yes), n/N (%)	122/526 (23.2)	42/218 (19.3)	1.27 [0.65-1.13]	0.24
Patient living alone, n/N (%)	147/526 (27.9)	77/220 (35.0)	0.72 [0.52-1.01]	0.06
Patient being responsible for another person, n/N (%)	111/521 (21.3)	49/218 (22.5)	0.93 [0.64-1.37]	0.72
Pain, WOMAC subscale (0-100), [N] mean (SD)	[520] 60.4 (19.0)	[221] 47.5 (24.5)	1.16 [1.11-1.21]	<0.0001
Function, WOMAC subscale (0-100), [N] mean (SD)	[475] 63.7 (18.1)	[202] 49.8 (23.4)	1.05 [1.04-1.06]	<0.0001
Stiffness, WOMAC subscale (0-100), [N] mean (SD)	[517] 63.4 (22.6)	[214] 48.8 (25.6)	1.36 [1.25-1.49]	<0.0001
WOMAC total score (0-100), [N] mean (SD)	[461] 62.6 (17.7)	[189] 48.5 (22.3)	1.04 [1.03-1.05]	<0.0001
HOOS Quality of life subscale (0-100), [N] mean (SD)*	[500] 22.7 (16.3)	[215] 38.1 (22.0)	0.96 [0.95-0.97]	<0.0001
OARSI JSN radiographic grade (3-4), n/N (%)	232/246 (94.3)	79/169 (61.2)	10.49 [5.64-20.67]	<0.0001
Surgeon's gender, male, n/N (%)**	287/307 (93.5)	142/163 (87.1)	2.12 [1.11-4.07]	0.02
Surgeon's experience, years, [N] mean (SD)	[299] 18.3 (9.7)	[161] 17.1 (8.8)	1.01 [0.99-1.03]	0.21

% are % of available data. N=number of patients with available data.

\*Lower scales indicate worse status

\*\*This line indicates that 93.5% of patients being recommended for surgery had seen a male surgeon

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**Table 4. Factors associated with indication for TKR : multivariate analysis adjusted on country**

Variable	Complete model	Second model
	OR [95% CI]	OR [95% CI]
OARSI JSN radiographic grade (3-4), for 1-point increase	<b>2.90 [1.69-4.97]</b>	Not analysed
WOMAC total score (0-100), for 10-point increase	<b>1.65 [1.32-2.06]</b>	<b>1.25 [1.14-1.37]</b>
Age, years	1.01 [0.97-1.06]	<b>1.03 [1.01-1.04]</b>
Gender, female	1.01 [0.47-2.12]	0.90 [0.95-0.99]
Patient being responsible for another person	1.21 [0.44-3.24]	0.93 [0.61-1.43]
Surgeon's experience, years	1.06 [0.99-1.13]	Not analysed

The complete model included all variables but due to missing data only 243 patients contributed to the model

The second model was performed after excluding the variables with most missing data, radiographic OARSI grade and surgeon's experience. In this model 754 patients were analysed. Significant results are presented in bold type.

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**Table 5. Factors associated with indication for THR: multivariate analysis adjusted on country**

Variable	Complete model	Second model
	OR [95% CI]	OR [95% CI]
OARSI JSN radiographic grade (3-4), for 1-point increase	<b>3.30 [2.17-5.03]</b>	Not analysed
WOMAC total score (0-100), for 10-point increase	<b>1.38 [1.15-1.66]</b>	<b>1.49 [1.33-1.68]</b>
Age, years	1.02 [0.98-1.04]	1.02 [1.00-1.04]
BMI >35kg/m <sup>2</sup>	1.32 [0.41-4.97]	0.72 [0.37-1.48]
Patient living alone	1.18 [0.55-2.62]	0.60 [0.37-0.96]
Surgeon's gender, male	1.04 [0.27-3.61]	Not analysed

The complete model included all variables but due to missing data only 273 patients contributed to the model

The second model was performed after excluding the variables with most missing data, radiographic OARSI grade and surgeon's gender. In this model 511 patients were analysed. Significant results are presented in bold type.

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**Table 6. Surgeons' announced reasons for « non-indication for TJ R »**

Reasons	Knee, N=491	Hip, N=219
	N (%)	N (%)
Symptoms were not severe enough	224 (45.6)	102 (46.5)
Another treatment should be tried first	147 (29.9)	50 (22.8)
Because of comorbidity	36 (7.3)	13 (5.9)
Patient declined surgery	26 (5.3)	17 (7.8)
Further investigations are required	22 (4.5)	20 (9.1)
Main problem was not hip/knee OA	12 (2.4)	9 (4.1)
Other causes	24 (4.9)	8 (3.7)

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