The burden of wait for knee replacement surgery: effects on pain, function and health-related quality of life at the time of surgery

François Desmeules¹,², Clermont E. Dionne¹,³, Étienne Belzile⁴, Renée Bourbonnais³,⁵ and Pierre Frémont³,⁴

Abstract

Objective. To examine the change in pain and function related to the knee scheduled for surgery, change in health-related quality of life (HRQoL) and change in contralateral knee pain during pre-surgery wait up until time of surgery.

Methods. One hundred and fifty-three patients scheduled for knee replacement were recruited from three hospitals in Québec City, Canada, and followed until surgery. Pre-surgery wait, defined as the time between enrolment on the pre-surgery wait list and surgery, was considered in five categories (≤3, >3–6, >6–9, >9–12 and >12 months). Pain and functional limitations were measured with the Western Ontario and McMaster Osteoarthritis Index (WOMAC) and HRQoL was measured with the medical outcomes study 36-item short form health survey.

Results. Mean pre-surgery wait time was 183 (s.d. 121.9) days. Subjects having waited >9–12 months showed significant deterioration of the WOMAC pain (−9.9; 95% CI −19.2, −0.54) and function (−11.1; 95% CI −18.7, −3.4) scores. On the HRQoL SF-36 physical functioning scale, a significant deterioration was seen in subjects having waited >9–12 months (−11.3; 95% CI −18.4, −4.2) and >12 months (−7.1; 95% CI −12.9, −1.3). On the contralateral knee WOMAC pain score, a significant deterioration was observed in subjects having waited >6–9 months (−10.4; 95% CI −16.9, −3.9) and >12 months (−10.7; 95% CI −19.7, −1.7).

Conclusion. Pre-surgery wait time has a negative significant impact on pain, function and HRQoL at the time of surgery. The magnitude of deterioration seen in this study may be clinically important. The effects of this pre-surgery deterioration on post-surgery outcomes need to be investigated.

Key words: Knee replacement, Waiting lists, Pain, Function, Health-related quality of life, Health services.

Introduction

Knee replacement surgery is a common and successful procedure for patients suffering from OA or other forms of arthritis [1]. Patients endure increasing pain, functional limitations and loss of health-related quality of life (HRQoL) for many years before ultimately undergoing surgery. In many countries, access to this surgery is limited by long waiting lists where mean wait time may range from 85 to 281 days [2]. In Canada, with the development of new government policies, more patients are being operated on but wait time remains a problem and recent data show that across the country, the median pre-surgery wait time ranges from 112 to 291 days [3].
Some authors have suggested that long delays for surgery could result in patient’s deterioration in terms of pain, functional limitations and HRQoL, and may have a negative impact on post-surgery outcomes [4–6]. Few studies have looked at the effects of pre-surgery wait time for knee replacement surgery, and have yielded conflicting evidence [6–13]. Although four studies found a significant (although small to moderate) deterioration of patients while on pre-surgery wait list in terms of pain and functional limitations [6, 8, 10, 12], three other studies found no significant changes [9, 11, 13].

In recent years, a few organizations in Canada and other countries have set benchmarks for maximum acceptable waiting times (MAWTs) for knee and hip replacement surgeries [7, 14, 15]. In Canada, the MAWT has been often set ~6 months from the time of the orthopaedic decision to operate to the time of surgery; elsewhere, these benchmarks range from 3 to 12 months [7]. These benchmarks are based on clinical expertise, patient and government inputs with limited scientific evidence. As mentioned by a few authors, setting up such benchmarks is an ongoing process that needs to be validated and therefore more research is necessary to fully understand the effects of wait time [7, 16].

The available literature on the effects of pre-surgery wait time mainly focused on the knee scheduled for surgery, with little emphasis on the status of the contralateral knee. We have previously shown that, at enrolment on the pre-surgery wait list, contralateral knee pain was significantly associated with worse pain in the knee scheduled for surgery, as well as with worse functional limitations and HRQoL [17]. Therefore, it may be hypothesized that long delays for surgery could result in worse contralateral knee pain, since the contralateral knee needs to compensate for the knee waiting to be replaced. However, to our knowledge, no data exist on this issue.

The purpose of the current study was to examine the change in pain and functional limitations related to the knee scheduled for surgery, change in HRQoL and change in contralateral knee pain during pre-surgery wait up until surgery.

Patients and methods

Study design

This study was a longitudinal prospective epidemiological study with repeated measures.

Settings

From February 2006 to September 2007, patients were recruited from the waiting lists of the departments of orthopaedic surgery of three university hospitals in Quebec City, Canada (CHUL, Hôpital Saint-François d’Assise and Hôtel-Dieu de Québec).

Participants

Every week, patients newly enrolled on the waiting lists were contacted by a research nurse. Eligible subjects had to meet the following inclusion criteria: (i) aged ≥ 40 years (ii) newly enrolled on the orthopaedic waiting lists for primary unilateral total knee replacement; (iii) resident of the province of Quebec with provincial universal health insurance coverage (Régie de l’Assurance Maladie du Québec); and (iv) understands and speaks French. Patients were excluded if they were suffering from a severe cardiac condition, any severe degenerative disease or a severe mental disorder. Patients with a previous lower limb replacement (hip or knee) were also excluded. Those who suffered a major trauma to the knee in the previous year or underwent surgery within 30 days of being put on the waiting list were also excluded.

Data collection

Data were collected through the review of the subjects’ medical files and structured telephone interviews lasting ~45 min, conducted by three trained interviewers. The first interview was conducted a few days after enrolment on the pre-surgery wait list (mean ± S.D. 12.6 ± 4.7 days) and a second interview was conducted a few days before surgery (mean ± S.D. −5.7 ± 3.4 days).

The main independent variable was pre-surgery wait time defined as the period (in days) between the date the patient was put on the wait list and the actual date of surgery. These dates were extracted from the surgical wait list database of each hospital. Pre-surgery wait was also considered in five categories (≤ 3, > 3–6, > 6–9, > 9–12 and > 12 months) for analyses, since these categories are often used as thresholds of established MAWTs [7, 14, 15]. Regarding the pre-surgery wait, patients were also asked at the follow-up interview if they had postponed their surgery for personal reasons.

The first dependent variable was the Western Ontario and McMaster Osteoarthritis Index (WOMAC), which measures pain, stiffness and functional limitations related to the knee [18]. The WOMAC scores were transformed in order to obtain a range from 0 to 100, where a score of 100 indicates no pain, no stiffness or any functional limitations. The WOMAC has been found to have very good reliability, convergent construct validity and responsiveness, and has been used extensively with this population [19–21].

The second dependent variable addressed HRQoL, measured with the Medical Outcomes Study 36-Item Short Form Health Survey (SF-36), a generic questionnaire on health status and HRQoL related to eight dimensions of health [22]. It allows for the calculation of a specific scale for each of the eight health dimensions. The score ranges from 0 to 100, where 100 indicates optimal HRQoL. Use of the SF-36 has been extensive in this population [22–28]. The reliability and validity of this questionnaire have been well established [29–31].

The third dependent variable addressed contralateral knee pain and was assessed with the WOMAC pain scale. The WOMAC function scale was not used to measure the functional limitations of the contralateral knee because of time constraint.

Diagnosis, anthropometric data and comorbidities were collected through review of the subjects’ medical files.
The Cumulative Illness Rating Scale was used to assess
the burden of comorbidities [32].
Marital status, household living status and clinical vari-
ables such as duration of symptoms and use of a walking
aid were documented during the first interview. Formal
education, employment status, household income and
social support were also identified at the first interview
with questions drawn from the questionnaire of the
1998 Quebec Health Survey [33]. Psychological distress
was documented with a modified version of the
Psychological Symptom Index that measures depression and
anxiety (range 0–42) [34]. At the second interview,
patients were asked about any therapies used or received
during wait to treat their knee. All drugs, the number of
knee IA corticosteroid injections, use of natural products
and use of physical treatments such as physiotherapy or
other forms of therapies were documented.

Analyses
Descriptive statistics were used to summarize wait time,
subjects’ characteristics as well as WOMAC and SF-36
scores. Paired Student’s t-tests and 95% CI were used
to assess the overall change in the mean WOMAC and
SF-36 scores between the baseline and immediate pre-
surgery interviews. Using wait time in five categories, an
analysis of variance was used to assess differences
between groups of wait at enrolment on the pre-surgery
lists. An analysis of covariance (ANCOVA) was conducted
to assess changes in mean WOMAC and SF-36 scores by
groups of wait time. Crude and adjusted models were
built. Confounding was defined as a change of at least
10% on the wait-time effect (regression coefficient) and
independent variables meeting this definition that were
not believed to be on the causal pathway between wait
time and the dependent variables were included in the
final adjusted models [35]. Data were initially checked
for normal distribution. Residual plots, outliers and multi-
collinearity of final models were also assessed.
Significance level was set at 0.05. In addition to analyses
of covariance, we used adjusted spline curves with two
degrees of freedom to illustrate the evolution of changes
in WOMAC and SF-36 scores by wait time [36]. For these
analyses, wait time was considered as a continuous vari-
able. All statistical analyses were performed with the SAS
software version 9.1 for Windows (SAS Institute, Cary,
NC, USA).

Ethics
All participants signed an informed consent form. The
study was approved annually by the Research Ethics
Boards of all three hospitals.

Results
Participants
Figure 1 presents the flow of patients considered and
recruited for this study. Overall, 588 consecutive new
patients were enrolled on the pre-surgery wait lists for
knee replacement during the recruitment period. Two
hundred and twenty patients were found eligible, of
whom 197 accepted to participate, 45 patients refused
to participate before eligibility was assessed and 32
could not be contacted within 3 weeks. These patients
were included in the calculation of the overall eligibility
proportion (220 + 32)/(588 – 45) = 0.464 and in the cal-
culation of the participation proportion, 197/(220 + (45 × 0.464)) = 81.8%. One hundred and fifty-three
subjects completed the second interview at the time of
surgery (78% of the initial cohort). Six subjects withdrew
from the study at the second interview and six subjects
could not be reached before surgery (follow-up propor-
tion: (197 – 6 – 6)/197 = 93%).

Pre-surgery wait time and subjects’ characteristics
Table 1 presents the pre-surgery wait time and selected
characteristics of the participants of this study. Mean wait
time was 183 (s.d. 121.9) days and median wait time was
148 days (range 32–692). Subjects had a mean age of 66
(s.d. 9.6) years. The majority of patients were women
(65%) and suffered from contralateral knee pain (73%).

Four significant differences were seen between the five
groups of wait time at enrolment on the pre-surgery wait
lists on the WOMAC pain (P = 0.44), function (P = 0.27)
and contralateral knee WOMAC pain (P = 0.34) scores,
the HRQoL SF-36 role physical (P = 0.10) and the SF-36
bodily pain scores (P = 0.22). However, a significant differ-
ence was seen between groups of wait time at enrolment
on the pre-surgery wait list as to SF-36 physical function-
ing score (P = 0.008). In post-hoc analyses, the group
having waited ≤3 months showed a significantly lower
SF-36 physical functioning score at enrolment on the
pre-surgery wait list than the group having waited >3–
6 months (P < 0.01) or the group having waited >9–12
months (P < 0.001). The group having waited >9–12
months showed a significantly higher physical functioning
score at enrolment than the group having waited >6–9
months (P = 0.02).

Overall changes in WOMAC and SF-36 scores during
pre-surgery wait
Table 2 presents the mean WOMAC and SF-36 scores at
enrolment, at surgery and changes in scores during wait
for all 153 subjects. Overall, subjects showed a significant
deterioration in the WOMAC pain (−2.8; 95% CI −5.5,
−0.19) and function (−4.6; 95% CI −6.7, −2.4) scores,
as well as in the contralateral knee WOMAC pain score
(−4.7; 95% CI −7.7, −1.6). Subjects also showed a
significant deterioration in the HRQoL SF-36 physical
functioning scale (−4.8; 95% CI −7.2, −2.4).

Change in WOMAC and SF-36 scores during pre-surgery
wait by categories of pre-surgery wait time
Figure 2 presents schematically the results of adjusted
models for change in WOMAC scores from enrolment on
the pre-surgery wait list until surgery, by categories of
pre-surgery wait. Only the group having waited between
>9–12 months showed a significant deterioration of the
WOMAC pain score (−9.9; 95% CI −19.2, −0.54). When
comparing change of the WOMAC pain scores, no significant differences were seen between the five groups of pre-surgery wait ($P = 0.53$). On the WOMAC function scale, a significant deterioration was seen in subjects having waited >3–6 months ($-4.1; 95\% \text{ CI } -7.7, -0.55$), >6–9 months ($-6.5; 95\% \text{ CI } -11.1, -1.9$) and >9–12 months ($-11.1; 95\% \text{ CI } -18.7, -3.4$). When comparing changes on the WOMAC function scores, no significant differences were seen between the five groups of pre-surgery wait ($P = 0.27$). On the contralateral knee WOMAC pain scale, a significant deterioration was seen in subjects having waited >6–9 months ($-10.4; 95\% \text{ CI } -16.9, -3.9$) and >12 months ($-10.7; 95\% \text{ CI } -19.7, -1.7$). A marginally significant deterioration was seen in subjects having waited >9–12 months ($-10.7; 95\% \text{ CI } -21.9, 0.54$). When comparing change on the contralateral knee WOMAC pain scores by groups of pre-surgery wait, a significant difference was seen between the five groups ($P = 0.046$). In post-hoc analyses, the group having waited >6–9 months showed a significantly worse deterioration than the group having waited >3–6 months ($P = 0.01$); the group having waited >12 months also showed a significantly worse deterioration than the group having waited >3–6 months ($P = 0.04$).

Figure 3 presents schematically the results of adjusted models for change in HRQoL SF-36 scores by categories of pre-surgery wait. Because a significant difference was observed between groups of wait time at enrolment on the pre-surgery wait list on the HRQoL SF-36 physical functioning scale, results were adjusted for the SF-36 physical functioning score at enrolment. For change in HRQoL SF-36 physical functioning scores, a significant deterioration was seen in subjects having waited >3–6 months ($-4.4; 95\% \text{ CI } -7.6, -1.1$), >9–12 months ($-11.3; 95\% \text{ CI } -18.4, -4.1$) and >12 months ($-7.1; 95\% \text{ CI } -12.9, -1.3$). When comparing change on the HRQoL SF-36 physical functioning scores by groups of pre-surgery wait, no significant differences were seen between groups of wait time ($P = 0.33$).

For the HRQoL SF-36 role physical score, only the group having waited >9–12 months showed a significant deterioration ($-20.6; 95\% \text{ CI } -35.1, -6.1$). There was no significant deterioration on the HRQoL SF-36 bodily pain scale. No significant differences were seen between

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**FIG. 1** Flowchart of patients’ recruitment.

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*aEligibility status unknown (considered in calculation of participation proportion).*
<table>
<thead>
<tr>
<th>Variables</th>
<th>$n$ (%)</th>
<th>Mean (S.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-surgery wait</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time between enrolment on wait list and surgery, days(^a)</td>
<td>183 (121.9)</td>
<td></td>
</tr>
<tr>
<td>Categories of wait time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\leq 3$ months</td>
<td>35 (23)</td>
<td>68.1 (16.6)</td>
</tr>
<tr>
<td>$&gt;3–6$ months</td>
<td>55 (36)</td>
<td>131.2 (28.5)</td>
</tr>
<tr>
<td>$&gt;6–9$ months</td>
<td>33 (22)</td>
<td>218.2 (26.1)</td>
</tr>
<tr>
<td>$&gt;9–12$ months</td>
<td>12 (8)</td>
<td>312.8 (26.7)</td>
</tr>
<tr>
<td>$&gt;12$ months</td>
<td>17 (11)</td>
<td>443.4 (85.1)</td>
</tr>
<tr>
<td>Surgery postponed for personal reasons</td>
<td>10 (7)</td>
<td></td>
</tr>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, years</td>
<td>66 (9.6)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>99 (65)</td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single, separated, divorced or widowed</td>
<td>56 (37)</td>
<td></td>
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<tr>
<td>Married or common law</td>
<td>97 (63)</td>
<td></td>
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<tr>
<td>Living alone</td>
<td>35 (23)</td>
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<td><strong>Socio-economic characteristics</strong></td>
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<tr>
<td>Educational level (part or complete)</td>
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<tr>
<td>High school or less</td>
<td>89 (57)</td>
<td></td>
</tr>
<tr>
<td>College or university</td>
<td>64 (43)</td>
<td></td>
</tr>
<tr>
<td>Employment status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployed or retired</td>
<td>118 (77)</td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>35 (23)</td>
<td></td>
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<tr>
<td>Household income(^b)</td>
<td></td>
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</tr>
<tr>
<td>$&lt;30,000/year</td>
<td>50 (37)</td>
<td></td>
</tr>
<tr>
<td>$30,000–$59,999/year</td>
<td>48 (35)</td>
<td></td>
</tr>
<tr>
<td>$\geq 60,000/year</td>
<td>35 (26)</td>
<td></td>
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<tr>
<td><strong>Psychosocial characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychological distress (/42)</td>
<td>7.2 (6.9)</td>
<td></td>
</tr>
<tr>
<td>Social support(^c)</td>
<td></td>
<td></td>
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<tr>
<td>Low</td>
<td>72 (47)</td>
<td></td>
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<tr>
<td>High</td>
<td>81 (53)</td>
<td></td>
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<tr>
<td><strong>Clinical characteristics</strong></td>
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<td></td>
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<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OA</td>
<td>146 (96)</td>
<td></td>
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<tr>
<td>RA</td>
<td>7 (4)</td>
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<tr>
<td>BMI, kg/m(^2)</td>
<td>31.4 (6.4)</td>
<td></td>
</tr>
<tr>
<td>Comorbidities(^d) (/56)</td>
<td>6.5 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Duration of symptoms(^e), years</td>
<td>7.9 (8.1)</td>
<td></td>
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<tr>
<td>Contralateral knee pain(^f)</td>
<td>111 (73)</td>
<td></td>
</tr>
<tr>
<td>Use of a walking aid</td>
<td>57 (37)</td>
<td></td>
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<tr>
<td>Knee medication during wait(^g)</td>
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<tr>
<td>Analgesic</td>
<td>88 (58)</td>
<td></td>
</tr>
<tr>
<td>NSAIDs</td>
<td>68 (44)</td>
<td></td>
</tr>
<tr>
<td>Opioid or other pain relievers</td>
<td>19 (10)</td>
<td></td>
</tr>
<tr>
<td>No medication</td>
<td>19 (10)</td>
<td></td>
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<tr>
<td>Use of health products during wait(^h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucosamine</td>
<td>20 (10)</td>
<td></td>
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<tr>
<td>Other product</td>
<td>8 (4)</td>
<td></td>
</tr>
<tr>
<td>Number of IA corticosteroid injections during wait</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>109 (71)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>25 (16)</td>
<td></td>
</tr>
<tr>
<td>2+</td>
<td>19 (13)</td>
<td></td>
</tr>
<tr>
<td>Physical treatments during wait(^i)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>4 (3)</td>
<td></td>
</tr>
<tr>
<td>Other treatment</td>
<td>8 (6)</td>
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</tbody>
</table>

\(^a\)Median (range) 148 days (32–692); \(^b\)\(n = 133; \(^c\)social support was dichotomized around the median score: low (\(\leq 74\)) and high (\(>74\)); \(^d\)\(n = 150; \(^e\)\(n = 140; \(^f\)WOMAC pain score at enrolment on pre-surgery wait list dichotomized into presence or absence of contralateral knee pain; \(^g\)categories presented are not mutually exclusive.
groups of pre-surgery wait on change in HRQoL. SF-36 role physical ($P = 0.10$) or in HRQoL SF-36 bodily pain ($P = 0.22$) scores.

**Discussion**

**Main results**

In this prospective cohort study, 153 subjects scheduled for primary total knee replacement were followed from enrolment on the pre-surgery wait list until surgery. The main objective of this study was to measure the change in pain and functional limitations related to the knee scheduled for surgery and change in HRQoL. We believe it is important to first acknowledge the burden that this delay imposes on many of these patients, even if no or only minimal deterioration occurs before surgery, as they have to wait for several months with significant pain, functional limitations and impaired HRQoL. Subjects’ pre-surgery wait was important in our study, averaging 6 months. HRQoL was also significantly impaired in these subjects and well below the Canadian norms of the SF-36 for age-matched subjects [17]. Overall, subjects suffered a significant deterioration of their condition while waiting, in terms of knee pain, contralateral knee pain, functional limitations and HRQoL. For the involved knee, change in WOMAC pain and function as well as SF-36 HRQoL during wait did not differ between the five groups of pre-surgery wait time. Nonetheless, the group having waited 9–12 months showed a statistically significant deterioration on the WOMAC pain (−9.9%) and function (−11.1%) scales, as well as on the HRQoL SF-36 role-physical scale (−20.6%). On the HRQoL SF-36 physical functioning scale, a statistically significant deterioration was seen in subjects having waited between 9 and 12 months (−11.3%) and also in subjects having waited >12 months (−7.1%). For the WOMAC pain and function scores, and SF-36 physical functioning score, a deterioration of 9.7, 9.3 and 5.3%, respectively, is considered clinically significant; therefore, the magnitude of changes seen in this study may be clinically significant [37–40]. In terms of contralateral knee pain, a statistically and clinically significant deterioration was seen in subjects having waited >6–9 months (−10.4%) and >12 months (−10.7%) and a significant difference was seen between the five groups of wait time.

**Comparison with the literature**

Contrary to our study, another Canadian study that analysed the changes in pain, function and HRQoL, did not find a significant deterioration of patients while they waited for major joint arthroplasty. However, mean wait time was short (4.5 months) and the study included patients waiting for total hip replacement as well as patient with a previous joint replacement (contralateral side or other site) [11]. A Finnish randomized controlled trial showed no deleterious effects of longer wait time on HRQoL in patients waiting for knee replacement, when comparing a long wait-time group (median wait = 266 days, range 28–818) with a short wait-time group (median wait = 73 days, range 8–600) [41]. Because of the design of the study, a third of the subjects of the short wait group had, however, waited for >3 months and this misclassification could have led to underestimate the effects of pre-surgery wait. A study by Kapstad et al. [10] showed a significant deterioration during wait on the WOMAC function scale (3%), but patients in this study waited only a median of 102 days for knee replacement. However, mean wait time was short (4.5 months) and the study included patients waiting for total hip replacement as well as patient with a previous joint replacement (contralateral side or other site) [11]. A Finnish randomized controlled trial showed no deleterious effects of longer wait time on HRQoL in patients waiting for knee replacement, when comparing a long wait-time group (median wait = 266 days, range 28–818) with a short wait-time group (median wait = 73 days, range 8–600) [41]. Because of the design of the study, a third of the subjects of the short wait group had, however, waited for >3 months and this misclassification could have led to underestimate the effects of pre-surgery wait. A study by Kapstad et al. [10] showed a significant deterioration during wait on the WOMAC function scale (3%), but patients in this study waited only a median of 102 days for knee replacement. Our results are similar to those published by McHugh et al. [12]. Although the changes observed were small, these authors found a significant deterioration within 6 months of wait in terms of pain and functional limitation as measured by the WOMAC (6% deterioration on the pain scale and 7% on the function scale), but not on the SF-36 physical functioning scale or on the role-physical scale or the bodily pain scale [12]. In our study, subjects having waited >12 months had a general tendency, although not significant, to deteriorate less than subjects having waited 9–12 months in terms of pain, functional limitations and HRQoL. The smaller deterioration for the >12 months group could have been explained by a higher number of subjects in that category having postponed their surgery because of a better knee condition. However, this was not

**Table 2** Overall changes in WOMAC and SF-36 scores of the study participants from enrolment on the pre-surgery wait list until primary unilateral total knee replacement surgery ($n = 153$)

<table>
<thead>
<tr>
<th></th>
<th>Mean score at enrolment$^{a}$ (s.d.)</th>
<th>Mean score at surgery$^{a}$ (s.d.)</th>
<th>Change in score$^{a}$ (s.d.)</th>
<th>95% CI</th>
<th>Comparison between time $P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOMAC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>46.1 (18.2)</td>
<td>43.3 (17.2)</td>
<td>−2.8 (16.5)</td>
<td>−5.5, −0.19</td>
<td>0.04$^*$</td>
</tr>
<tr>
<td>Function</td>
<td>46.0 (14.3)</td>
<td>41.4 (15.2)</td>
<td>−4.6 (13.5)</td>
<td>−6.7, −2.4</td>
<td>&lt;0.001$^*$</td>
</tr>
<tr>
<td>Contralateral knee pain</td>
<td>74.9 (21.9)</td>
<td>70.2 (23.9)</td>
<td>−4.7 (18.9)</td>
<td>−7.7, −1.6</td>
<td>0.002$^*$</td>
</tr>
<tr>
<td>SF-36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical functioning</td>
<td>23.0 (17.4)</td>
<td>18.2 (15.0)</td>
<td>−4.8 (14.9)</td>
<td>−7.2, −2.4</td>
<td>&lt;0.001$^*$</td>
</tr>
<tr>
<td>Role-physical</td>
<td>38.0 (25.6)</td>
<td>35.6 (21.8)</td>
<td>−2.4 (25.4)</td>
<td>−6.5, 1.7</td>
<td>0.25</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>26.6 (11.7)</td>
<td>27.2 (10.9)</td>
<td>0.61 (13.0)</td>
<td>−2.7, 1.5</td>
<td>0.56</td>
</tr>
</tbody>
</table>

$^{a}$Scores presented as percentages. A higher score signifies a better condition; $^{a}$a negative change in score signifies a deterioration of the condition; $^* P < 0.05$. 

Contrary to our study, another Canadian study that analysed the changes in pain, function and HRQoL, did not find a significant deterioration of patients while they waited for major joint arthroplasty. However, mean wait time was short (4.5 months) and the study included patients waiting for total hip replacement as well as patient with a previous joint replacement (contralateral side or other site) [11]. A Finnish randomized controlled trial showed no deleterious effects of longer wait time on HRQoL in patients waiting for knee replacement, when comparing a long wait-time group (median wait = 266 days, range 28–818) with a short wait-time group (median wait = 73 days, range 8–600) [41]. Because of the design of the study, a third of the subjects of the short wait group had, however, waited for >3 months and this misclassification could have led to underestimate the effects of pre-surgery wait. A study by Kapstad et al. [10] showed a significant deterioration during wait on the WOMAC function scale (3%), but patients in this study waited only a median of 102 days for knee replacement. Our results are similar to those published by McHugh et al. [12]. Although the changes observed were small, these authors found a significant deterioration within 6 months of wait in terms of pain and functional limitation as measured by the WOMAC (6% deterioration on the pain scale and 7% on the function scale), but not on the SF-36 physical functioning scale or on the role-physical scale or the bodily pain scale [12]. In our study, subjects having waited >12 months had a general tendency, although not significant, to deteriorate less than subjects having waited 9–12 months in terms of pain, functional limitations and HRQoL. The smaller deterioration for the >12 months group could have been explained by a higher number of subjects in that category having postponed their surgery because of a better knee condition. However, this was not
the case here; the 11 subjects who willingly postponed their surgery were equally distributed in the five categories of wait (data not shown). The smaller deterioration for the >12 months group could possibly be explained by a response shift in subjects having to endure very long wait. This situation was also reported in a similar study on the effects of pre-surgery wait time and hip replacement between subjects having waited 6–12 months and subjects having waited >12 months [42].

To our knowledge, this is the first study to report on the effects of pre-surgery wait on contralateral knee pain and to demonstrate a significant and clinically important deterioration in subjects waiting 6–9 months and >12 months (subjects’ deterioration for those having waited >9–12 months was marginally significant). Those changes were near the established threshold for clinically significant differences of 9.7% on the WOMAC pain scale [39]. We believe these results are important, since this deterioration could potentially worsen in the acute post-surgery rehabilitation phase where there is a greater load on the contralateral uninvolved knee. We did not specifically measure function or HRQoL of the contralateral knee because of time constraint, and clearly further research is needed to fully evaluate the effects of pre-surgery wait on contralateral knee status. However, these results have important clinical implications regarding the prioritization of patient on wait lists or for optimization of conservative treatment while patients wait for surgery (often called ‘prehabilitation programmes’), since such therapeutic interventions could realistically target both knees to maximize the patient’s status.
Strengths of the study
This prospective cohort study included a high participation proportion (81.7%) and few patients were lost to follow-up (8%), although several patients ultimately did not undergo knee replacement for various reasons (16%). There is no indication of selection bias, as there were no significant differences between participants and eligible non-participants on age and gender, and no significant differences in terms of pain, functional limitations and HRQoL at the enrolment on the pre-surgery wait list. SF-36 HRQoL role-physical and bodily pain models are adjusted for age, employment status, comorbidities, living situation, BMI and social support. A negative change in score signifies a deterioration of the condition.

Study limitations
The precision of some estimates was low, as shown by the large CIs found in the analyses by categories of wait time. The use of these categories was based on thresholds often cited for MAWTs, even though it resulted in small count categories in our study [7]. Other categorizations of wait time, in particular combining the last two categories (>9–12 and >12 months), yielded similar results and did not change our conclusions (data not shown). It is important to point out that this study only reported effects of pre-surgery wait time for subjects...
having waited at least 30 days and that a small proportion of subjects with very short wait were excluded from the study. Also, we did not take into account the wait between the physician’s reference and the initial orthopaedic consultation because of methodological difficulties in recruiting patients at that point in time. We did retrospectively find that the mean wait time between the physician’s reference and the initial orthopaedic consultation was 89 days (data not shown). Therefore, we believe the total combined wait time could result in a worse deterioration of patients. Another limitation of our study was that the main outcome measures were self-reported and we did not include performance-based measures. The WOMAC and the SF-36 have been found to be valid instruments; still, it has been reported that performance-based measures complement self-reported measures [44]. Therefore, the pre-surgery wait time effect or the strength of this effect on performance-based measures could be different from the findings of our study.

Participants of our study waited for several months with important pain, functional limitations and impaired HRQoL before undergoing knee replacement. Pre-surgery wait had a negative impact on pain and function related to the knee scheduled for surgery, on contralateral knee pain and HRQoL. Although the magnitude of these changes was small to moderate, they were most likely clinically important. Since patient’s health status is the strongest predictor of knee replacement post-surgery outcomes, actions should be taken to alleviate patient’s burden and to minimize potential deterioration of patients waiting for knee replacement surgery. We believe such actions should include a reduction in wait time and prioritization of patients. Better conservative management and implementation of prehabilitation should also be considered. Finally, more research is needed to evaluate the full impact of contralateral knee pain in patients waiting for knee replacement. Above all, the effects of the pre-surgery deterioration on the post-surgery outcomes need to be investigated.

Rheumatology key messages

- Subjects waited extensively with considerable pain, functional limitations and impaired HRQoL before undergoing knee replacement.
- Pre-surgery wait has a negative impact on pain, function and HRQoL.

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