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Return to work and employment retention after uni-compartmental and total knee replacement: findings from the Clinical Outcomes in Arthroplasty study

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ABSTRACT

Background: Little is known about ability to work after unicompartmental knee replacement (UKR) and total knee replacement (TKR), especially in physically-demanding occupations. This study described rates of return-to-work (RTW) and ability to sustain work by job after arthroplasty.

Method: Participants from The Clinical Outcomes in Arthroplasty Study (COASt) aged 18–65 were eligible if they underwent UKR or TKR and had at least 5 years' follow-up post-operation. We posted a survey asking about pre-operative occupation, post-operative occupations and associated physical demands, and whether they had quit a job post-surgery due to difficulties with the operated knee (knee-related job loss (KRJL)). We fitted Cox Proportional Hazard Models to investigate the role of demanding physical activities on KRJL.

Results: 251 people (143 UKR, 108 TKR) returned a questionnaire, of whom 101 UKR and 57 TKR worked post-operatively. Rates of RTW were highest amongst those in managerial and professional or technical roles, whichever operation they received. RTW was poorest amongst those in elementary occupations. In associate professional/technical occupations, RTW rates were better amongst UKR recipients. Amongst participants who returned to work, 17 reported KRJL (8.5% UKR and 16.7% TKR). Respondents were more likely to have KRJL if their job involved carrying/lifting ≥10 kg (HR:4.81, 95%CI 1.55–14.93) or climbing >30 flights of stairs (HR:4.03, 95%CI 1.36–11.98).

Conclusions: Knee arthroplasty recipients working pre-operatively mostly RTW. RTW may be more difficult after TKR than UKR. Jobs which involve lifting and climbing stairs may be particularly challenging. Surgeons offering knee arthroplasty should counsel patients about workability as well as risk of revision.

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1. Introduction

Total knee replacement (TKR) is the most commonly performed operation undertaken to reduce pain and improve functional limitation [1] and quality of life [2] in patients with end-stage knee arthritis. Unicompartmental knee arthroplasty (UKR) is a more recent bone- and ligament-sparing alternative operation that can be offered to patients with end-stage medial-compartment arthritis (present in most of patients with clinical osteoarthritis [3]). Both types of surgery provide good functional outcomes at 10 years post-operation [4], however revision rates are higher amongst UKR recipients [5]. UKR procedures are safer, cheaper [6], and have advantages for faster rehabilitation [7–9]. Consequently, patients and surgeons need to consider these short-term benefits of UKR and weigh them up against the longer-term increased risk of revision. TKRs continue to be offered more commonly than UKRs (88% total vs 12% partial knee procedures in the UK) [10], most likely because of uncertainties about patient selection, optimal bearing surface design, and availability and costs of advanced technology [11].

Another important outcome after knee arthroplasty surgery is return to work (RTW) and ability to work. Indeed, the fastest growth in demand for these operations has been among those aged <65 years [12] and younger patients have been shown to have different requirements and expectations, most importantly around returning to paid employment [13,14]. Ng et al systematically reviewed the literature that compared rate of RTW and length of time to RTW amongst UKR and TKR recipients. The authors found 7 studies published 2009–2020 which provided limited evidence about different rates of RTW after UKRs with TKRs [15]. A subsequent randomised controlled trial including 50 patients with UKRs and 57 patients with TKAs reported no differences in the time taken to RTW post-operatively [16]. Furthermore, with many governments taking legislative measures to encourage people to remain in the workforce to older ages, this will be an outcome of increasing importance.

Previous studies suggest that most people employed at the time of their UKR or TKR return to work [15,17], but that some people fail to do so because of the physical nature of their job [18,19]. In particular, it might be expected that occupations that are associated with demands specific to the knee joint (e.g. kneeling/squatting) might be particularly challenging post-operatively. In one study, Kievit et al compared pre- and post-op activities that loaded the knee joint, such as walking on unequal ground, standing, and lifting or carrying, and found that after TKR/UKR, function was improved when compared with the time at which the knee symptoms began and 3 months pre-operation [20]. However, another study that followed participants post-TKR reported that recipients remained limited in the workplace one-year post-operatively by activities similar to those investigated by Kievit [21].

In light of this, our objectives were to compare amongst recipients of UKR and TKR, the rates of ever returning to work post-arthroplasty and the risk of needing to exit paid work post-arthroplasty because of problems with the operated knee, considering the nature and demands of the employment.

2. Methods

These analyses took place within the Clinical Outcomes in Arthroplasty Study (COASt) [22]. COASt is a prospective cohort study of people undergoing elective knee arthroplasty in England which recruited pre-operative patients March 2010-November 2016 from two large teaching hospitals in the South of England; Southampton General Hospital and Nuffield Orthopaedic Centre, a UK leading orthopaedic hospital performing unicondylar replacement. COASt participants gave their consent to be followed-up annually with postal questionnaires for five years post-operatively. For the current investigation, we contacted COASt participants who underwent unilateral UKR or TKR when they were aged between 18 and 65 years and for whom there was a minimum of 5 years of post-operative follow-up.

Between July 2017 and December 2018, a postal questionnaire was mailed to 401 eligible COASt participants. The questionnaire collected information about demographics (age, sex, height, weight) and the time taken post-operatively to reach their best function (<one year, $\geq$ one year). Everybody was asked to report whether they had ever been in paid employment and whether they were working at the time of their operation and if yes, to report their job title. Participants were asked if they had done any paid work post-operatively and for any job they had held for over a month, they were asked to report the job title/s and whether that job had entailed any of the following physically-demanding occupational activities on an average working day: standing >4 hours; walking >3 km; kneeling/squatting; lifting or carrying >10 kg; lifting and carrying >25 kg; digging or shovelling; climbing >30 flights stairs; or climbing ladders. Space was provided on the questionnaire for respondents to report this information for up to three post-operative jobs held for at least one month. For pre-operative and post-operative jobs held, the job titles were coded using CASCOT software, and then classified into the 2-digit categories provided by the Standard Occupational Classification (SOC) 2010 [23]. Non-respondents to the questionnaire were sent a reminder and another copy of the questionnaire after 4 weeks.

Data from the baseline COASt questionnaire were extracted for each respondent, including sex; body mass index (BMI) at baseline; age and date of UKR/TKR; indication for knee replacement (primary or secondary OA); American Society of Anesthesiologists (ASA) score; and the index of multiple deprivation (IMD) score.

The outcomes for this study were: rates of RTW post-operatively by job sector and rates of reporting having to stop working in a job because of a problem with the operated knee (knee-related job loss (KRJL)). This latter information was captured

by asking participants to report for each of the jobs held post-operatively whether "they left the job at least partly because of a problem with their knee".

2.1. Statistical analysis

Characteristics of the study participants were presented as counts and percentages for categorical variables, means and standard deviations (SD) for continuous normally distributed variables, or medians and interquartile ranges (IQR) for continuous non-normally distributed variables, for the whole sample and separately for UKR and TKR procedures. Differences between respondents and non-respondents, and also between UKR and TKR participants were tested using χ^2 test for categorical but non ordinal variables, Wilcoxon Rank Sum test for continuous not normally distributed variables, Spearman test for trend for ordinal variables and Fisher's exact test for categorical variables where necessary due to sample size.

To explore risk factors for KRJL, a survival dataset was created. Each line of the dataset represented a period of time during which a participant was working and therefore 'at risk' of KRJL. Participants employed pre-operatively were not asked to self-report the precise time taken to RTW after knee replacement (given that this questionnaire was being completed at least 5 years later). Therefore, for people who told us that they were working pre-operatively and that they returned to the same job post-operatively, the date of returning to work was imputed as three months post-operation, based upon findings from the literature about average time taken to RTW [20,24]. Those not working pre-operatively were asked to provide the date of returning to work given that this was a more memorable life event (starting a new job) and could have occurred at any time after rehabilitation. Participants were considered at risk of KRJL from the date they resumed work post-operatively until the earliest of: (a) the date they reported leaving their job because of a problem with the operated knee, (b) the date they stopped working for any other reason than the replaced knee, or (c) end of follow-up if reported that they were in paid work at the time of survey completion. People reporting that they had held more than one job post-operatively were treated as not at risk during any period of being out of work, so that we created multiple records in the survival dataset for each job reported by an individual. The analyses consider time to first event.

Crude Cox proportional hazards (PH) regression models were fitted to examine the risk of KRJL with exposure to any of the physically-demanding occupational activities post-operation. Subsequently regression models were adjusted for: age at UKR/TKR, sex and BMI (measured at baseline); length of follow-up, time taken to reach best function (chosen as a surrogate for fitness after the operation), and type of procedure to account for the difference (UKR or TKR). Finally, the occupational activities significantly associated with KRJL after adjustment for other covariates were further added into a mutually adjusted Cox PH regression model. Statistical analyses were performed using STATA® version 17.0.

2.2. Ethics

Ethical approval was obtained for this investigation [NHS Research Ethics Committee, Oxford REC A (ref. 10/H0604/91) and Oxford REC C (ref. 09/H606/11)]. The permission enabled us to add the questions for the current study to those which formed part of the 5-year follow-up for the participants reaching their fifth year but also for us to send our questionnaire to participants who had already completed their 5-year follow-up.

3. Results

In total, 401 COASt participants (222 UKRs and 179 TKRs) who fulfilled our eligibility criteria were sent a postal questionnaire. Of the 401 people contacted 251 completed and returned the survey: 108 were from people with TKR and 143 from people with UKR (response rate 79% for UKR recipients and 60% for TKR recipients). We found differences between respondents and non-respondents. Compared with non-respondents, those participants who returned the questionnaire were on average two years older at the time of survey completion (60 years (IQR:55–64) vs 58 years (IQR:52–62), $p < 0.01$), less likely to be obese (BMI > 30 kg/m^2) (51% vs 65%, $p < 0.01$) and more likely to undergo knee replacement due to primary OA (78% vs 51%, $p < 0.01$). Respondents also lived in less deprived areas than non-respondents (46% vs 32%, $p < 0.01$). The median duration of post-surgical follow-up was 6.4 years IQR (5.4–7.2). Table 1 displays the characteristics of respondents, comparing people who received UKR or TKR. Compared with TKRs, participants who underwent UKR were more likely to have OA as the main indication for the surgery ($p < 0.01$) and were a median of 3 years younger at the time of the operation ($p = 0.03$). In general, similar proportions of TKR and UKR recipients were required to undertake physical occupational activities post-arthroplasty, but workers with a UKR were significantly less likely to report that they needed to climb ladders on an average working day ($p < 0.01$).

3.1. Occupational status pre and post UKR/TKR

Figure 1 shows occupational status before and after arthroplasty for all respondents. Although most (228/251) (91%) UKR and TKR respondents were employed at some point pre-operatively, 28/130 (22%) UKR recipients and 36/98 TKR recipients (37%) were not working at the time of the arthroplasty. In total, 4/28 (14%) people with UKR and 13/36 (36%) with TKR reported that part or the main reason for giving up work preoperatively was because of their knee symptoms.

Table 1
Characteristics of respondents in total and by type of procedure; unicompartmental or total knee replacement.

	All n = 251	TKR n = 108	UKR n = 143	P-value
Sex, n (%)				
Female	142 (57)	62 (57)	80 (56)	0.82[1]
Male	109 (43)	46 (**43**)	63 (44)	
Age at UKR/TKR, median (IQR)	60 (55–64)	62 (56–64)	59 (54–63)	0.03[2]
Body mass index at baseline (kg/m^2), n (%)				
18.5–24.9	32 (13)	12 (11)	20 (14)	0.09[3]
25.0–29.9	89 (35)	33 (31)	56 (39)	
≥ 30.0	128 (51)	62 (57)	66 (46)	
Missing	2 (1)	1 (1)	1 (1)	
Indication for UKR/TKR, n (%)				
Primary OA	195 (78)	75 (69)	120 (84)	<0.01[1]
Secondary OA	22 (9)	19 (18)	3 (2)	
Missing	34 (14)	14 (13)	20 (14)	
American Society of Anaesthesiologists score, n (%)				
ASA I	56 (22)	16 (15)	40 (28)	0.06[3]
ASA II	130 (52)	61 (56)	69 (48)	
ASA III	18 (7)	11 (10)	7 (5)	
Missing	47 (19)	20 (19)	27 (19)	
Index of Multiple deprivation, quintiles				
Least deprived	115 (46)	42 (39)	73 (51)	0.07[3]
2	60 (24)	30 (28)	30 (21)	
3	39 (16)	20 (19)	19 (13)	
4	28 (11)	10 (9)	18 (13)	
Most deprived	7 (3)	6 (6)	1 (1)	
Missing	2 (1)	–	2 (1)	
Respondents with full occupational history post-arthroplasty				
Occupational activities, n yes (%)	**All n = 145**	**TKR n = 51**	**UKR = 94**	**P-value**
Any occupational activity	99 (68)	37 (73)	62 (66)	0.42[1]
Standing > 4 hours/day	76 (52)	24 (47)	52 (55)	0.34[1]
Walking > 3 km/ day	60 (41)	20 (39)	40 (43)	0.69[1]
Carrying/Lifting ≥ 10 kg	58 (40)	25 (49)	33 (35)	0.10[1]
Carrying/Lifting ≥ 25 kg	28 (19)	10 (20)	18 (19)	0.95[1]
Digging/shovelling	18 (12)	10 (20)	8 (9)	0.05[1]
Kneeling/squatting	46 (32)	17 (33)	29(31)	0.76[1]
Climbing up/down > 30 stairs	28 (19)	12 (24)	16 (17)	0.34[1]
Climbing ladders	26 (18)	15 (29)	11 (12)	<0.01[1]

[1] χ^2 test for categorical but non ordinal variables, [2]Wilcoxon Rank Sum test for continuous not normally distributed variables, [3]Spearman test for trend for ordinal variables. †Participants could report more than one occupational activity on an average day, thus the totals do not sum to 100%.

Amongst the 100 people in work at the time of UKR (22 self-employed, 75 employed, 1 unknown) 5 did not RTW (3 were employed, 1 self-employed and 1 had missing information). However, amongst the 62 TKR recipients (12 self-employed, 48 employed, 2 unknown) 11 participants did not work post-operatively; all of them employed.

Amongst people in work pre-operatively, 95% of UKR recipients RTW and 82% of TKR RTW. Additionally, 14% of UKR and 17% of TKR recipients not working at the time of surgery were able to RTW.

Table 2 (UKR) and Table 3 (TKR) compare the rates of RTW for each of the respondents who ever worked pre-operatively according to the 2-digit SOC 2010 codes generated from their pre-operative job titles (4 were missing and could not be coded). Most people returned to similar jobs to those held pre-operatively. Rates of RTW were highest amongst managers, directors and senior officials (75% TKR vs 75% UKR), those in professional occupations (76% TKR vs 67% UKR), and those in skilled trades (74% UKR vs 75% TKR), whichever operation they experienced. Lowest rates of RTW were seen amongst those in elementary occupations (62% UKR vs 40% TKR). Amongst people in associate professional/technical roles pre-operatively, rates of RTW were significantly lower after TKR than UKR (82% UKR vs 31% TKR, $p < 0.01$) but no other significant differences in rates of RTW were observed by type of job: administrative and secretarial roles (76% UKR vs 50% TKR, $p = 0.219$); caring, leisure and other service professions (82% UKR vs 67% TKR, $p = 0.619$); sales and customer service occupations (71% UKR vs 40% TKR, $p = 0.558$); process, plant and machine operatives (100% UKR vs 57% TKR, $p = 0.475$); and elementary roles (62% UKR vs 40% TKR, $p = 0.637$).

3.2. Occupational activities performed post- UKR/TKR

Amongst the 158 participants (101 UKRs, 57 TKRs) who resumed work post-operatively, 145 (94 with UKRs, 51 with TKRs) provided complete information about their occupational exposure to physically demanding tasks. Participants in work post-arthroplasty received a knee implant at a median age of 58 years (IQR: 53–63 years). Of these, 32% reported a sedentary

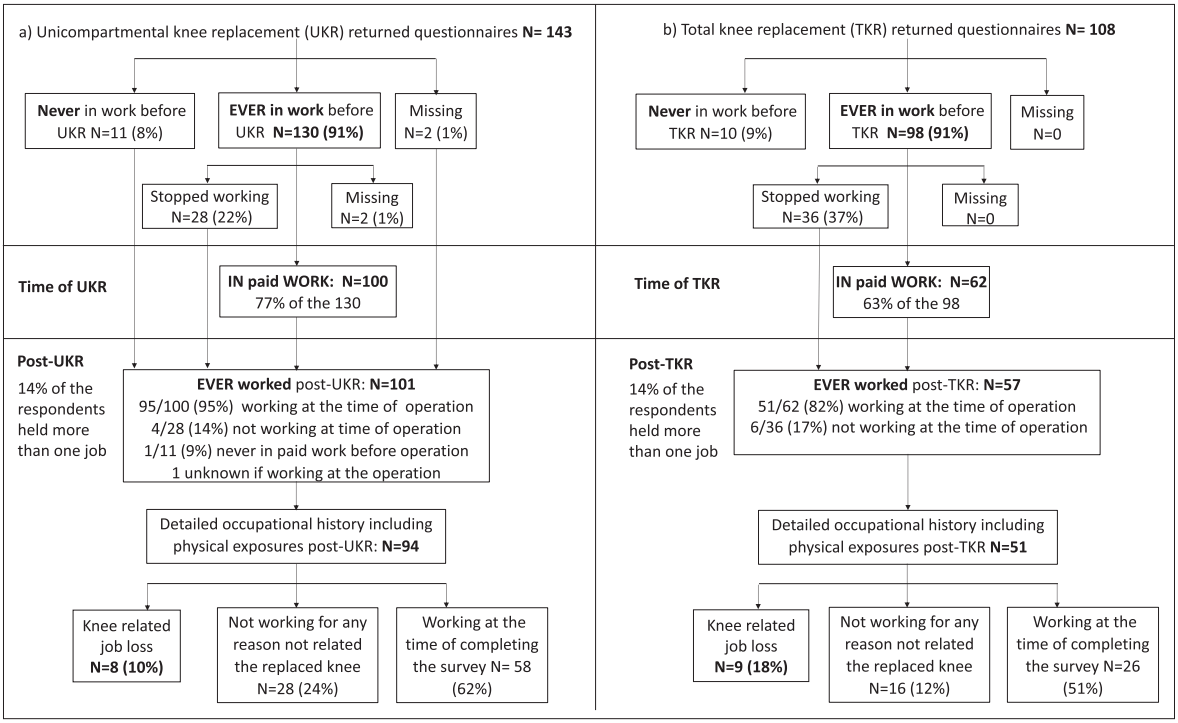

Figure 1. Response rates and pre- and post-operative occupational status among COASt participants aged 18 to 65 who underwent (a) unicompartmental and (b) total knee replacement between March 2010 and December 2013.

job (no physically-demanding activity), whilst amongst those not in sedentary jobs, standing >4 hours/day was the most prevalent activity (52%) (Table 1).

In total 17/145 participants self-reported KRJL; 8/94 (8.5%) UKRs at 3.8 years (IQR: 2.5–4.8), and 9/51 (17.6%) TKRs at 2.4 years (IQR: 1.1–2.9) post-operation. Participants with full occupational history post-arthroplasty (n = 145) contributed 653 person-years to the survival analysis that assessed occupational activities as risk factors for KRJL. Table 4 shows the crude and adjusted estimates of the risk of KRJL associated with physically-demanding occupational activities performed post- UKR/TKR. There was an increased risk of KRJL for people who reported that, on an average day, they: carried/lifted ≥10 kg (HR: 4.81, 95% CI 1.55–14.93) or climbed up/down >30 flights of stairs (HR: 4.03, 95%CI 1.36–11.98) compared with those who did not perform those activities. Moreover, although not quite attaining statistical significance, standing >4 hours/day (2.6-fold increased risk) and kneeling/squatting (2.5—fold increased risk) were both associated with an elevated HR of KRJL.

When the regression models were repeated, adding both statistically significant occupational factors, carrying/lifting ≥10 kg was the occupational activity found most strongly associated with the risk of KRJL (HR: 3.47 95%CI 1.02–11.76) whereas the effect of climbing >30 flights of stairs became attenuated (HR: 2.40 95%CI 0.73–7.90).

4. Discussion

This study described pre- and post-operative occupational status among people aged ≤65 years at the time of UKR or TKR and evaluated their capacity to sustain employment post-arthroplasty, considering occupational activities that load the knee joint. In total, 78% of UKR and 58% of TKR respondents returned to work post-operatively. Regardless of the type of surgical procedure undertaken, most people who were in paid jobs pre-operatively returned to work (95% UKR and 82% TKR), and a further 14% of UKR and 17% of TKR recipients unable to work pre-operatively also RTW. In total, 12% of those who RTW (8.5% of UKR and 17.6% of TKR recipients) reported that they had to leave a job post-operatively because of problems with their operated knee (KRJL). The occupational exposures associated with an increased risk of KRJL were jobs that entailed, on a daily basis, lifting or carrying ≥10 kg and/or climbing >30 flights stairs.

In general, knee arthroplasty (TKR and UKR) facilitates an excellent chance of RTW amongst people employed pre-operatively who want to RTW. Our RTW rate of 82% amongst employed TKR recipients is very consistent with the mean 40–98% reported across 14 TKR studies [24]. Our rate of RTW after UKR of 95% is even better than the average 81.7% amongst UKR recipients reported in a systematic review [15]. Such is the effectiveness that even amongst a sample of military service members, 33/39 (85%) who received a UKR implant resumed work by 2-years post-operatively [25] despite the physical

Table 2
Changes in self-reported occupation pre- and post-UKR according to SOC 2010 major groups in 130 people ever in work pre-UKR.

SOC 2010 codes	People in work ever before UKR (N)	Did not return to work post-UKR					Returned to work post-UKR							
		Total N (%)	M[2] (%)	F[3] (%)	Age (yrs) Median (IQR)	Duration of FU (yrs), Median (IQR)	Total N (%)	M[2](%)	F[3] (%)	Age (yrs) Median (IQR)	Duration of FU (yrs), Median (IQR)	Same job as pre-op, N (%)	Different job post-op N (%)	Missing N (%)
1 Managers, Directors and Senior Officials	16	4 (25)	50	50	63 (63–64)	6.5 (5.6–7.2)	12 (75)	58	42	59 (56.5–62)	5.9 (5.1–6.3)	9	2	1
2 Professional Occupations	29	7 (24)	43	57	63 (56–64)	6.1 (5.1–7.1)	22 (76)	41	59	58 (53 – 60)	6.7 (5.6–7.4)	21	1	-
3 Associate Professional and Technical Occupations	17	3 (18)	67	33	61 (58–65)	5.9 (5.5–7.3)	14 (82)	36	64	57.5 (51–59)	6.6 (5.0–7.2)	10	3	1
4 Administrative and Secretarial Occupations	17	4 (24)	25	75	56 (47–63)	6.8 (5.8–7.4)	13 (76)	8	92	55 (51–63)	6.7 (5.5–7.1)	11	2	-
5 Skilled Trades Occupations	19	5 (26)	80	20	64 (63–64)	6.4 (5.6–6.4)	14 (74)	86	14	61.5 (57–65)	6.4 (5.1–7.6)	12	1	1
6 Caring, Leisure and Other Service Occupations	11	2 (18)	50	50	64.5 (64–65)	6.2 (5.6–6.8)	9 (82)	22	79	59 (52–62)	7.1 (7.1–7.4)	7	2	-
7 Sales and Customer Service Occupations	7	2 (29)		100	61.5 (58–65)	5.5 (5.2–5.8)	5 (71)	60	40	52 (48–53)	7.3 (6.4–7.3)	5	-	-
8 Process, Plant and Machine Operatives	3	-	-	-	-	-	3 (100)	-	100	54 (49–63)	7.5 (5.6–7.8)	-	-	-
9 Elementary Occupations[1]	8	3 (38)	33	67	63 (59–65)	6.8 (6.2–7.5)	5 (62)	60	40	56 (52–59)	6.8 (5.3–7.6)	3	1	1
Missing job title	3						4							

[1]Comprise jobs which mainly involve routine tasks. These occupations often entail using hand-held tools and in some cases, they require physical effort (e.g. agricultural, nursery and factory workers, security guards, warehouse operators, refuse collectors or postal workers) [23]; [2]M: male; [3]F: female.

Table 3
Changes in self-reported occupation pre- and post-TKR according to SOC 2010 major groups in 98 people ever in work pre-TKR.

SOC 2010 codes	People in work ever before TKR (N)	Did not return to work post-TKR					Returned to work post-TKR							
		Total N (%)	M[2] (%)	F[3] (%)	Age (yrs) Median (IQR)	Duration of FU (yrs), Median (IQR)	Total N (%)	M[2] (%)	F[3] (%)	Age (yrs) Median (IQR)	Duration of FU (yrs), Median (IQR)	Same job as pre-op, N (%)	Different job post-op N (%)	Missing N (%)
1 Managers, Directors and Senior Officials	4	1 (25)	100	-	64 (64–64)	7.3 (7.3–7.3)	3(75)	67	33	62 (45–65)	5.5 (5.0–6.8)	3	-	-
2 Professional Occupations	21	7 (33)	29	71	63 (60–64)	6.5 (5.0–6.7)	14 (67)	21	79	55.5 (50–64)	5.3 (5.0–7.3)	11	3	-
3 Associate Professional and Technical Occupations	13	9 (69)	22	78	63 (59–64)	6.5 (5.0–7.3)	4(31)	75	25	56.5 (52.5–61.5)	6.5 (5.6–7.2)	3	1	-
4 Administrative and Secretarial Occupations	10	5 (50)		100	64 (60–64)	5.7 (5.0–6.1)	5(50)	40	60	60 (41–64)	7.1 (6.9–7.4)	5	-	-
5 Skilled Trades Occupations	16	4 (25)	75	25	58.5 (55–63)	5.7 (5.0–6.5)	12 (75)	83	17	62.5 (60–64.5)	5.6 (5.5–6.2)	11	-	1
6 Caring, Leisure and Other Service Occupations	9	3 (33)	33	67	62 (55–65)	6.2 (5.1–6.4)	6(67)	16	83	58 (56–64)	6.6 (5.0–7.2)	4	2	-
7 Sales and Customer Service Occupations	5	3 (60)	33	67	63 (54–63)	6.9 (5.0–7.8)	2(40)	-	100	59 (57–61)	6.2 (5.9–6.5)	2	-	-
8 Process, Plant and Machine Operatives	7	3 (43)		100	58 (54–65)	5.8 (5.3–7.9)	4(57)	100		59.5 (56–63)	6.3 (5.7–6.5)	4	-	-
9 Elementary Occupations[1]	10	6 (60)	67	33	62 (62–63)	7.0 (6.7–7.2)	4(40)	25	75	60.5 (55.5–64)	7.1 (6.2–7.8)	4	-	-
Missing job title	3						3					-	-	-

[1]Comprise jobs which mainly involve routine tasks. These occupations often entail using hand-held tools and in some cases, they require physical effort (e.g. agricultural, nursery and factory workers, security guards, warehouse operators, refuse collectors or postal workers) [23]; [2]M: male; [3]F: female.

Table 4
Hazard ratios (HR) of knee related job loss (KRJL) and physically-demanding occupational physical activities amongst 145 people in work post-UKR/TKR.

Occupational activities	Knee related job loss (KRJL)		Median time at risk (years)		Crude HR (95% CIs)	Adjusted HR[1] (95% CIs)
	No n (%)	Yes n (%)	No KRJL	Yes KRJL		
Standing >4 hours/day						
No	64 (93)	5 (7)	5.2	2.4	1	1
Yes	64 (84)	12 (16)	4.8	3.5	2.31 (0.81–6.56)	2.67 (0.88–8.10)
Walking >3 km/day						
No	76 (89)	9 (11)	5.2	2.4	1	1
Yes	52 (87)	8 (13)	4.8	3.5	1.40 (0.54–3.62)	1.56 (0.56–4.31)
Carrying/Lifting ≥10 kg						
No	82 (94)	5 (6)	5.1	2.4	1	1
Yes	46 (79)	12 (21)	4.8	3.5	3.99 (1.41–11.34)	4.81 (1.55–14.93)
Carrying/Lifting ≥25 kg						
No	102 (87)	15 (13)	5.1	2.4	1	1
Yes	26 (93)	2 (7)	4.9	4.1	0.50 (0.12–2.20)	0.48 (0.10–2.35)
Digging/shovelling						
No	112 (88)	15 (12)	5.1	2.9	1	1
Yes	16 (89)	2 (11)	4.6	3.1	1.02 (0.23–4.49)	1.23 (0.26,5.79)
Kneeling/squatting						
No	91 (92)	8 (8)	4.9	1.4	1	1
Yes	37 (80)	9 (20)	5.2	3.8	2.28 (0.88–5.91)	2.57 (0.95–6.93)
Climbing up/down >30 flights stairs/day						
No	107 (91)	10 (9)	5.0	2.1	1	1
Yes	21 (75)	7 (25)	4.9	3.9	3.07 (1.17–8.08)	4.03 (1.36–11.98)
Climbing ladders						
No	105 (88)	14 (12)	5.2	2.7	1	1
Yes	23 (88)	3 (12)	4.8	3.9	1.03 (0.30–3.60)	0.86 (0.20–3.63)

[1] Adjusted for: age at operation, sex, BMI at baseline, time to reach best function post-UKR/TKR, age at follow-up and surgical procedure.

requirements of these jobs. Importantly however, not all arthroplasty recipients will manage to RTW and the physical demands of work [24] and older age [18,26] can be barriers to RTW. In our study, we found that participants who RTW for at least one-month post-arthroplasty were younger than those who did not. Exploring the within-group differences in RTW rates amongst those in different occupational groups receiving TKR or UKR, we found that rates of RTW were generally lowest amongst those needing to RTW in elementary occupations (typically jobs which are more physically demanding). When comparing TKR and UKR recipients, rates of RTW were generally similar no matter which occupational sector the individual needed to work in. However, UKR recipients were found significantly more likely than TKR recipients to RTW in associate professional and technical occupations (e.g. technical workers in fields related to trade, finance, administration, social work, physical sciences, social sciences or humanities). It is possible that it is easier to return to these types of jobs after UKR than after TKR but we cannot rule out that surgeons selectively offered UKR to individuals expressing a desire to return to their work which involved some physical demands.

Most respondents remained in their pre-operative occupation but 11% of TKR recipients moved to a different job sector post-operation, a finding consistent with the 9% (42/482) reported by Lombardi et al [27]. Interestingly, another study reported that a much higher proportion (57%) changed jobs post-operatively [26]. However, everyone in this study by Scott et al received a TKR when they were aged <60 years and it is possible that, whilst they might have needed to work for economic reasons, they may have found their former job more difficult after the TKR. Interestingly, our rate of 88% return to the same job sector amongst UKR recipients is also superior to the 75% reported by Kievit et al [20]. When asked about their pre-operative expectations, besides pain relief and improvement of physical function, younger patients expect to be able to perform better in a wide variety of occupational activities [13]. Despite this, as many as 65/236 (28%) participants in a multi-centre study did not expect to be able to carry out occupational activities that involved weight bearing through the knee joint within 6 months post-operatively [28]. Until now, there have been few studies that have considered the ability of knee arthroplasty recipients to perform occupational knee demanding activities, and more specifically about whether employees can sustain these types of occupations. Sankar et al [21] found that post-operative patients reported that they were coping better with work-related activities 12-months post- TKR, but our findings suggest that some limitations may persist after surgery. In particular, lifting/carrying ≥10 kg and climbing >30 flights stairs/day were associated with an increased risk of exiting paid work at an average of 2.9 years post- UKR/TKR because of the difficulties that these occupational activities posed on the replaced knee. Our study also enquired about exposure to carrying/lifting ≥25 kg and this was not found associated with KRJL. Whilst seemingly contradictory, this might reflect either that only a small number of older workers post-arthroplasty are exposed to this activity, hence making the study under-powered to detect an effect or another plausible explanation might be that only the fittest workers are doing very heavy lifting (≥25 kg) post-arthroplasty. We hypothesised that occupational kneeling/squatting would be a risk factor for KRJL, since many people find it difficult or even impossible to kneel post- UKR/TKR [29,30]. Indeed, two studies [20,26] found that kneeling was the

activity with the least improvement out of the 13 activities assessed at 2 and 3-years post-operation. In the current study, we found no significant association between occupational kneeling /squatting and KRJL. It may be that our study was underpowered, perhaps because relatively few arthroplasty recipients were required to undertake such activities post-surgery.

The findings of this study need to be considered alongside some limitations. The COASt study recruited people as they were wait-listed for knee arthroplasty. Allocation to UKR or TKR was not random, and the decision would have been made pre-operatively by the patient and surgeon based upon a range of factors including distribution of the pre-operative X-ray changes, age, fitness, BMI and patient choice. Consequently, any differences found in post-operative outcomes comparing UKR and TKR could be attributable to these pre-operative factors. Secondly, we found lower rates of response from younger arthroplasty recipients, those in more deprived locations and more obese participants. Response rates are often poorer from younger populations [31] and return to work is more likely to be economically necessary amongst younger recipients so that we may have under-estimated rates of RTW by losing younger respondents. Employment, obesity, and deprivation status are inter-linked. People from deprived backgrounds are more likely to be obese, to need to work for economic reasons but to have jobs requiring physically-demanding activities and with lower levels of autonomy. Non-respondents could have reduced our capability to show differences for KRJL by workplace demands, suggesting that the effects may, in fact, be even stronger than those demonstrated. Thirdly, information about pre-operative job title, post-operative occupational history, including duration of the work and exposure to occupational activities were collected by postal questionnaire at a mean follow-up of 6.4 years' post-arthroplasty. For this reason, recall bias cannot be excluded, particularly by the group of people reporting KRJL, who may have been more prone to remember physically demanding activities if they caused the individual difficulty. Our response rate of 63% was reasonable but we cannot rule out a participation bias such that people who had returned to work post-arthroplasty were more likely to respond and thus, the high RTW rates reported here may be over-estimated. Our study design did not aim to capture post-operative exit from paid work for any reasons other than the replaced joint and we cannot rule out that some individuals will have exited work for another health reason (e.g. cardiovascular disease) before they had the chance to experience KRJL. There is not necessarily any reason to believe that this would have differentially affected people after TKR more or less than people after UKR, not least because ASA scores pre-operatively were similar in both groups, but as stated above, surgeons may offer the choice of operations based on a range of factors, including for example fitness or comorbidity. We sampled COASt participants who were aged $\leq$65 years at the time of their primary surgery aiming to collect information from those most likely to RTW. However, as many as 1 in 10 people in the UK remain in paid work at $\geq$65 years and over [32], and it is plausible that a high proportion of people working at older ages are in less physically-demanding occupations. Therefore, had we obtained a full sample of everyone of any age doing any work post-operatively, the rates of KRJL may have been lower. Finally, the participants in COASt do not represent the full range of socio-economic deprivation. In total, 46% of respondents in this study had Index of Multiple Deprivation (IMD) scores suggesting that they lived in the least deprived areas. Socio-economic deprivation is associated with lower educational attainment and hence a higher chance of working in more manual, physically-demanding jobs. This study may have consequently been under-represented for such individuals and failed to show real differences that might have been shown with a larger group of workers in manual jobs. Despite the limitations, to our knowledge this is the first study to examine feasibility of working in the range of different type of jobs after total or partial knee replacement, exploring the workplace demands, and collecting this information when 55% of participants were still working >6 years post-operatively.

4.1. Conclusion and implications for clinical practice

As the demand for total and partial knee replacement increases over time [10,12,33] and people are encouraged to work to older ages, more people will need to RTW after knee arthroplasty. General advice offered to arthroplasty recipients mainly relates to the operational procedure and post-operative care, leaving younger patients with limited or even inconsistent information on RTW [34,35]. Our study suggests that the majority can RTW successfully, although it may be hardest in elementary jobs. Our findings suggest that job retention may be more difficult in occupations that entail lifting/carrying weights and climbing stairs, which may imply that rehabilitation could play an important role in those who need to return to physically demanding jobs. A systematic review [36] which sought to evaluate evidence about the effect of rehabilitation on work participation published prior to March 2017, unfortunately found a paucity of evidence. Return to work may be easier after UKR than TKR in some types of work and pre-operative counselling about TKR as compared with UKR should consider this alongside the risk of revision.

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Authors contributions

KWB, ECH, GN contributed to the design of the study. EZ, ECH, KWB, NKA designed the questionnaire. Data collection was performed by EZ and statistical analysis by GN and EZ. EZ wrote a first draft of the manuscript which was critically reviewed and approved by all the co-authors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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