

Candidacy for Medial Unicompartmental Knee Replacement Declines with Age

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Abstract

Background: The effect of age on the percentage of primary knee replacements appropriate for unicompartmental replacement (UKR), defined as candidacy, is unknown. The aim was to determine the candidacy and outcome of UKR in different age groups.

Hypothesis: Age is associated with candidacy for medial UKR

Patients and Methods: This cross-sectional study determined UKR candidacy from preoperative radiographs, including stress views, from 457 consecutive knee replacements (TKR or UKR) in a specialist joint replacement centre. Candidacy, estimated from radiographs and from usage, was determined for all knees and then stratified by age group <50, 50-60, 60-70, 70-80, and 80+. The outcome of UKR implanted in these groups was also assessed. To avoid overestimating, candidacy estimated by usage was used for the primary analysis.

Results: Candidacy decreased with age (OR 0.98, $p=0.008$) and was 61% (CI42-78), 52% (CI43-61), 43% (CI35-51), 41% (CI31-52), and 36% (CI22-52) respectively. Candidacy estimated by radiographs was slightly higher overall (49% compared to 46%) and in all age groups than candidacy estimated from usage. Neither functional outcome ($p=0.47$) nor implant survival ($p=0.54$) was affected by age. Overall 80% achieved good/excellent Knee Society objective scores, and the five-year implant survival was 99%.

Discussion: There is a strong association of candidacy for UKR with age in that younger patients are more likely to be candidates (61% in those <50 and 36% in those 80+). Good outcomes can be expected in patients of all ages who are appropriate for UKR.

Level of evidence: IV (Prognostic cross-sectional study)

Keywords: Unicompartmental knee replacement; candidacy; age; outcomes

Manuscript
Introduction

Provision of knee replacement is increasing [1], and is most rapid in those historically considered too young (<60 years of age) [2-3]. In the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man (NJR), young patients are more likely to receive unicompartmental knee replacement (UKR) than their elderly peers [4]. However, registries don't contain information on patient selection and therefore don't reflect true candidacy: it is likely that some of patients receiving UKR weren't indicated for UKR, whilst others undergoing total knee replacement (TKR) could have had UKR. It thus remains unknown how age affects candidacy for UKR.

Goals of surgery in young patients differ to those in older patients; generally speaking, younger patients require a higher functioning knee, and will wish to avoid major revisions given their longer life expectancy, contrarily older patients will ideally undergo a procedure with a rapid recovery and minimal risk of medical complications that restores appropriate function. Both UKR and TKR can be used for anteromedial osteoarthritis of the knee. UKR provides shorter hospital stays, better function, fewer deep infections, lower mortality, and fewer perioperative complications such as venous thromboembolic and major cardiac events [5-8]. The main criticism of UKR is its higher revision rate, with registries showing a higher revision rate for UKR than TKR [9-10]. Diagnosis of knees appropriate for UKR, which we have defined as candidacy, often requires specialist imaging, such as stress radiographs, which are not routinely available in non-specialist centres. It will be of interest to patients, surgeons and health providers to have an idea about how candidacy for medial UKR might change with age. No previous studies have looked at the proportion of patients in different age groups who are eligible for medial UKR.

The questions of this study are: 1) what is the association of age and candidacy for medial UKR, 2) what is the outcome of UKR in different age groups, and 3) how does the candidacy determined by actual usage, radiographs including stress views, and radiographs excluding stress views compare? We hypothesised that UKR candidacy would be higher in younger age groups.

Material and Methods

2.1 Study design and patients:

A retrospective cross-sectional study of a consecutive series of knee replacement patients (UKR and TKR) was studied to determine the effect of age candidacy for Oxford medial UKR. Outcome was determined using prospectively collected data.

Between 01 January 2008 and 31 December 2008, 457 consecutive knees with complete preoperative imaging underwent primary TKR or primary medial Oxford mobile-bearing UKR (Oxford Phase 3

UKR, Zimmer Biomet, Warsaw, Indiana). All procedures were performed by an experienced joint replacement surgeon (KRB). All patients signed an institutional review board approved general research consent allowing for retrospective review. Details of this cohort has been reported[11], this study is a secondary analysis focussing on age.

Patients were followed up using a standard protocol. Functional outcomes were assessed using the American Knee Society Objective Score (AKSS-O), Functional Score (AKSS-F)[12], Lower Extremity Activity Scale (LEAS)[13] and the University of California, Los Angeles (UCLA) activity score[14]. Where patients had died, information about the status of their knee, and the presence of any further operation was obtained via primary and secondary care records as well as via patient's relatives where appropriate.

2.2 Methods: Identification as medial UKR candidate

Candidacy for medial UKR was determined in three ways. The first was based on the senior surgeon's actual implantation of UKR. This decision was based on a full history (including patient preference), examination findings, review of radiographs and intraoperative confirmation. The criteria used by the surgeon are medial compartment bone-on-bone osteoarthritis, no cartilage defects in the weight-bearing portion of the lateral compartment, and functionally intact anterior cruciate and medial collateral ligaments. Cartilage defects in the patellofemoral joint were accepted as long as there was no bone loss on the lateral facet. The second method used two blinded reviewers to identify candidacy on radiographs. To satisfy the decision for medial UKR, a weight-bearing anteroposterior radiograph, a valgus stress radiographs, a lateral radiograph and a patella skyline radiograph were required to demonstrate the above patho-anatomy. In addition, if medial bone-on-bone was not seen, a Rosenberg and/or a varus stress view was required. The final method also used radiographs, but did not include stress radiographs.

2.3 Methods of assessment: Outcome variables

The primary outcome was the percentage of patients candidate for medial UKR in different age groups. Secondary outcomes included: 1. Effect of age on radiographic reason why a knee was not appropriate for UKR; and 2. Effect of age on functional outcomes and survival in those who were radiographic candidates for and who went on to receive UKR. Functional outcomes were assessed with AKSS-O, AKSS-F, LEAS, and UCLA score, and the percentage of patients achieving an AKSS-O of 70 or greater (considered to be a good or excellent outcome) was calculated. Kaplan-Meier survival estimates were calculated, with implant revision considered as removal, insertion or exchange of any implant component.

2.4 Statistical analysis:

Intra and interobserver agreement was calculated with Cohen's kappa. To estimate the effect of age on candidacy we calculated the percentage of knees receiving UKR against age using pre-defined age groups of <50, 50 to <60, 60 to <70, 70 to <80, and 80 years or older at surgery, and calculated 95% confidence intervals with Clopper-Pearson confidence intervals. Significance was tested with univariate logistic regression with age as a continuous variable. Standardised likelihood by age group was determined by dividing age-stratified candidacy estimates by the total candidacy estimate of UKR performed in this study and those reported in the registry. To assess test accuracy we calculated sensitivity, specificity, and accuracy. For continuous secondary outcomes (functional scores) we determined mean score, and tested significance with univariate and multivariate linear regression models. Covariates were body mass index (BMI), sex, and pre-operative score if applicable. To analyse implant survival we used Kaplan-Meier survival estimates and a log rank test for a trend. Given the rarity of revision, we used three age groups to improve power and reliability (<60, 60 to <75, and 75+). STATA version 14 (STATA corp, Texas, USA) and R (R Core Team, Vienna, Austria) were used for statistical analyses. A p-value of <0.05 was considered significant.

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Results

There were significant differences in baseline characteristics with regards to age, with younger patients having higher BMI, pre-operative AKSS-F and pre-operative LEAS (Appendix Table A). Younger patients had worse AKSS-O, but there were no significant differences in the percentage of females, or pre-operative flexion. For radiograph review, there was excellent intra- (Cohen's kappa 0.90) and inter-observer (Cohen's kappa 0.85) agreement.

Overall candidacy, estimated from patients receiving UKR was 46% (CI 41 to 51, n=210/457). Candidacy estimated using recommended radiographs was 49% (CI 44 to 53, n=223/457). There was a negative association between candidacy in those receiving UKR and age (Odds Ratio 0.98, 95% CI 0.96 to 0.99, p=0.008). The percentage of knees receiving UKR progressively increased with younger age grouping; from oldest to youngest estimates were 36% (CI 22 to 52, n=15/42), 41% (CI 31 to 52, n=40/97), 43% (CI 35 to 51, n=68/157), 52% (CI 43 to 61, n=68/130), and 61% (95% CI 42 to 78, n=19/31). Candidacy from radiographs revealed similar trends (Figure 1). Lateral compartment wear was the most common reason for not being appropriate for medial UKR (Table 1).

In those knees appropriate for UKR, there was improvement in all functional scores that was not significantly associated with age (Figure 2 and Table 2). The percentage achieving a good or excellent AKSS-O from youngest to eldest group was 95%, 77%, 77%, 83%, and 80% (p=0.47). There were four revisions giving a five-year survival of 98.9% (95% CI 96 to 100, number at risk 190; Table 3). These

were not related to age at surgery ($p=0.36$). Five-year survival for those less than 60 was 98.8% (CI 91 to 100), for those between 60 and 75 it was 98.9% (CI 92 to 100), and there were no revisions in those older than 75 at operation.

Candidacy estimated with an AP, lateral and skyline radiograph was 48% (CI, $n=220/457$). The accuracy of this method compared to usage was 87% (95% CI 84-90). Test sensitivity was 89% and specificity was 86%. When assessed against the decision made using all available radiographs (including stress views), accuracy was 94% (95% CI 91-96), with sensitivity of 93% and specificity of 94%. There was no difference between candidacy estimated by usage, and by all radiographs ($p=0.74$), or using AP, lateral and patella skyline radiographs alone ($p=0.89$).

Discussion

This study shows that UKR candidacy is strongly associated with age, with decreasing candidacy in older age groups identified from usage and from radiographic evaluation. Patients who were candidates for UKR had five-year implant survival of 99% and good functional outcomes following UKR, and there was no relationship between patient outcome and age. This therefore suggests that, whatever the patients age, if they satisfy the recommended indications for UKR and receive UKR they will get good results.

We found candidacy decreased with age and was 61% for those <50, 52% for those 50-60, 43% for those 60-70, 41% for those 70-80 and 36% for those 80+. The NJR[4] suggests that overall 8% of primary knee replacements are UKR and that usage of UKR decreases with increasing age being 18% in those <60 years, 9% in those 60-70, 5% in those 70-80, and 3% in those 80+. Overall candidacy of this cohort of knee replacement patients from the United States of America (USA) was about 50%. This is identical to radiographic candidacy assessed in an independent centre in the United Kingdom [15], and is similar to usage of surgeons from centres around the world who achieve good results with UKR [16-23].

Arguably, elderly patients benefit most from UKR due to lower morbidity and mortality associated with the procedure [24]. Due to limited life expectancy revision is unlikely, and was not seen in this study. A simple analysis suggests that a cohort of elderly patients undergoing UKR by an experienced surgeon might have 1-2% more revisions over their lifetime relative to TKR [4], however there would be half the number of strokes and myocardial infarctions [24]. Furthermore, a health-economic study based on NJR data[25] showed in this group of patients, over their life time, that UKR provides better quality of life and is less costly than TKR.

It would seem many surgeons preferentially use UKR for young patients (Figure 3). This may be because UKR provides better function[26-27]; or it may be surgeons feel that in the elderly TKR is better as it is definitive surgery, whereas in the young UKR is a pre-knee replacement and an easier

revision[28]. If surgeons reserve UKR for younger patients they will only perform a limited number of procedures[29]. Recent evidence suggests that surgeon usage of UKR (number of UKR as a percentage of their knee replacement practice) is more important than caseload in determining revision rate, and to achieve low revision rates surgeons should use UKR for at least 20% of their knee replacements [16]. Therefore, to achieve acceptable usage and optimise patient outcomes, surgeons should use UKR for all age groups, not just the young [29].

Many centres do not undertake stress radiographs for knee replacement, and undertake weight-bearing anteroposterior, lateral and patella skyline radiographs only. Using these alone, which were well aligned in this series, accuracy was high, with about nine out of ten patients being correctly identified as a candidate or not. Furthermore, they overestimated actual implantation by only 2%. Therefore these X-rays are satisfactory for estimating candidacy in a series, but due to false positives and false negatives is not ideal for determining if an individual patient is appropriate for UKR. We found, in each age group, the most common reason why patients were not appropriate for UKR was the presence of radiographic evidence of lateral compartment osteoarthritis. It is thus important to assess the lateral compartment with radiographs in the preoperative work up, and intra-operatively. In all groups, valgus stress radiographs identified narrowing in about 10% of cases that were not identified on standard radiographs. It is therefore sensible, at least for inexperienced surgeons, to use the full set of radiographs.

The main limitation of the study was that the population was selected from a high volume joint replacement surgeon with an interest in UKR. This may increase candidacy owing to the possibility of local referral patterns, whereby patients who were UKR candidates may have been referred. For this reason we compared the likelihood between age groups, as this reflects willingness to perform UKR in different age groups and is independent of the actual number candidate (Figure 3). A strength of this study is that, as a high volume joint replacement centre, complete imaging and work up for UKR allowed estimation for the utility of weight bearing AP, lateral and skyline radiographs to help inform future studies. This work is important as there are no previous estimates looking at the effect of age on candidacy, nor is there validated accuracy for estimation using radiographs without stress views. In addition to assessing candidacy we also assessed outcome so as to ensure that, with the recommended candidacy in each age group, the results were acceptable. A limitation with this aspect of the study was that as there were only four revisions and the estimates of survival in the subgroups are not reliable.

In conclusion, UKR candidacy is strongly associated with age, with candidacy decreasing with increasing age and about two thirds of very young patients (<50) and one third of very old patients (>80) being appropriate. Patients who are candidates had good five year functional outcomes and implant survival following UKR, and there was no relationship between patient outcome and age.

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Conflict of interest: The author or one or more of the authors have received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article. In addition, benefits have been or will be directed to a research fund, foundation, educational institution, or other non- profit organisation with which one or more of the authors are associated.

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Tables

Table 1: Radiographic contraindications to UKR by age group (%). Each knee can have more than one contraindication. Findings from varus and valgus stress radiographs included.

Age group	N	Contraindication prevalence				
		Lateral wear	Medial PTCL	ACL deficiency	MCL deficiency	Bone-on-bone lateral facet patella arthritis
<50	31	22.6	9.7	3.2	4.0	6.5
50 to <60	130	27.7	28.5	17.2	9.5	9.4
60 to <70	157	34.4	20.4	25.6	7.8	9.6
70 to <80	97	41.2	28.9	26.8	13.5	7.2
80+	42	47.6	19.1	34.2	9.5	7.1
P value	N/A	<0.01	0.97	<0.01	0.44	0.50

ACL Anterior Cruciate Ligament; MCL Medial Collateral Ligament; N Number; N/A Not Applicable; PTCL Partial Thickness Cartilage Loss (not bone-on-bone); UKR Unicompartamental Knee Replacement

Table 2: Linear regression coefficients between age and change in function for the subset of knees that received UKR who were candidates for UKR

	Unadjusted	P value	Adjusted	P value
ROM (n=448)	-0.003 (0.06)	0.96	-0.047 (0.05)	0.39
KSC (n=446)	-0.040 (0.10)	0.69	-0.055 (0.12)	0.65
KSF (n=448)	-0.067 (0.11)	0.54	-0.160 (0.16)	0.33
LEAS (n=332)	-0.012 (0.02)	0.58	-0.012 (0.03)	0.67
UCLA* (n=158)	-0.027 (0.02)	0.12	0.036 (0.03)	0.21

*Post-operative score.
UKR Unicompartamental Knee Replacement; KSC Knee Society Score Clinical Component; KSF Knee Society Score Functional Component; LEAS Lower Extremity Activity Score; UCLA University of California Los Angeles Activity Score; ROM Range of Movement

Table 3: Details of revision operations

<u>Time from primary (years)</u>	<u>Age at primary (years)</u>	<u>Indication</u>
0.9	65	Instability
2.0	52	Unknown (revised elsewhere)
6.1	53	Progression of lateral compartment OA
6.4	46	ACL deficiency and femoral loosening

Figure legends:

Fig. 1 Estimated candidacy for medial Oxford UKR by method and age group

Fig. 2 Functional outcomes for UKR candidates receiving UKR by age group

Fig. 3 Standardised slope comparison of UKR usage in different age groups between this study and National Joint Registry 2013 reported usage. A comparison of the relative likelihood of UKR implantation in different age groups. The slope suggests that surgeons within the registry are not performing UKR on elderly patients and are selectively choosing younger patients, when compared to the trends of candidacy seen in this study. However, candidacy estimates from this paper also show that many more patients in each age group could receive UKR than currently receive it.

Appendix Table A: Preoperative demographics of cohort by age groups						
Age group	<50	50-60	60-70	70-80	80+	P value
Number	31	130	157	97	42	N/A
Mean age in years (range)	45.6 (39-50)	56.0 (50-60)	65.1 (60-70)	74.2 (70-80)	83.8 (80-93)	N/A
Mean body mass index (SD)	37.0 (8)	34.2 (7)	33.6 (7)	29.3 (6)	26.9 (5)	<0.001
Number females (%)	16 (52%)	72 (55%)	105 (67%)	59 (61%)	24 (57%)	0.25
Preop range of movement in degrees (SD)	112 (10)	112 (11)	112 (12)	114 (10)	111 (10)	0.31
Preop Knee Society Score Objective (SD)	35.1 (13)	39.6 (17)	39.4 (15)	42.7 (18)	34.4 (17)	0.04
Preop Knee Society Score Functional (SD)	59.8 (16)	57.0 (15)	55.6 (18)	54.6 (17)	41.2 (21)	<0.001
Preop Lower Extremity Activity Scale Score (SD)	9.3 (3)	10.0 (3)	9.3 (3)	8.7 (3)	8.2 (3)	0.02
N/A not applicable, SD standard deviation						