Title: The development and validation of a radiological Decision Aid to determine suitability for medial unicompartmental knee replacement

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Abstract

Aims: An evidence based radiographic Decision Aid for meniscal-bearing unicompartmental knee replacement (UKR) has been developed and this study investigates its performance at an independent centre.

Patients and Methods: Pre-operative radiographs, including stress views, from a consecutive cohort of 550 knees undergoing replacement (UKR or TKR) by a single-surgeon were assessed. Suitability for UKR was determined using the Decision Aid with the assessor blinded to treatment received.

Results: The sensitivity and specificity of the Decision Aid was 92% and 88% respectively. Excluding knees where a clear pre-operative plan was made to perform TKR, i.e. patient request, the sensitivity was 93% and specificity 96%. The false-positive rate was low (2.3%) with all readily identifiable during joint inspection at surgery.

In patients meeting Decision Aid criteria and receiving UKR the 5-year survival was 99% (95%CI 97 to 100%). The false-negatives (3.3%), who received UKR, but did not meet criteria, had significantly worse functional outcomes (flexion ($p<0.001$), AKSS-Functional ($p<0.001$), UCLA ($p=0.04$)), and lower implant survival 93.1% (95%CI 77.6 – 100%).

Conclusion: The radiographic Decision Aid safely and reliably identifies appropriate patients for meniscal-bearing UKR and achieves good results in this population. The widespread use of the Decision Aid should improve the results of UKR.

Level of Evidence: Level III

Keywords: unicompartmental knee replacement; total knee replacement; patient selection; indications; functional outcome; implant survival

Introduction

Unicompartmental knee replacement (UKR) provides significant benefits to patients, healthcare providers and healthcare payers[1-3]. Compared to TKR, patients undergoing UKR recover faster, achieve better functional outcomes, have a lower morbidity and mortality and report higher patient satisfaction[1,2,4,5]. Furthermore, UKR has been reported to be more cost-effective than TKR in both the short and long-term[3,6,7]. One concern with UKR however is the more variable long-term implant survival, with UKR having a higher overall revision rate than TKR[1]. This higher incidence of revision is multi-factorial although is known to be related to patient selection, surgical case load as well as a lower threshold for revision than with TKR[8].

Despite meniscal-bearing UKR being appropriate in up to half of patients, UKR is used in 8% with large variation in usage between surgeons[9]. A key reason for this variation is the lack of recognition of indications for UKR. The primary indication for meniscal-bearing UKR is anteromedial osteoarthritis (AMOA), with spontaneous osteonecrosis of the knee (SONK) representing another important indication[10]. Patient factors including age, weight and level of activity; radiographic factors including chondrocalcinosis and lateral osteophytes; and operative factors including the presence of a chondral ulcer on the medial side of the lateral femoral condyle have been demonstrated not to compromise outcomes and are therefore not considered to be contra-indications[11,12]. Therefore identification of AMOA is critical in determining suitability for meniscal-bearing UKR.

Patients are considered to have AMOA, and are therefore considered to be suitable for meniscal-bearing UKR, if they meet each of the following criteria: a) bone-on-bone osteoarthritis in the medial compartment, b) retained full thickness cartilage in the lateral compartment, c) a functionally normal medial collateral ligament (MCL), and d) a functionally normal anterior cruciate ligament (ACL). In addition they should have e) a patellofemoral joint (PFJ) that does not have severe damage laterally with bone loss, grooving and subluxation[13,14]. These criteria are assessed radiographically and are confirmed at operation. Additionally, practical considerations, such as the ability to flex the knee to 110° under anaesthetic to prepare the femoral condyle, need to be taken into account.

The criteria for AMOA are assessed using standing anteroposterior, valgus stress (in 20º flexion), true lateral and skyline radiographs. In the majority of patients bone-on-bone arthritis in the medial compartment is demonstrated on the standing anteroposterior X-ray, however in a proportion of knees, typically those with smaller anteromedial lesions, additional X-rays, such as a varus stress (in 20º flexion), or a standing flexed (at 20º, otherwise known as a Rosenberg or Schuss view) X-ray is required. A valgus stress X-ray is required to demonstrate both that there is full thickness cartilage in the lateral compartment and that the medial compartment opens fully and thus that the MCL is functionally normal and not shortened. Stress X-rays should be performed with the knee in 20° flexion, to relax the posterior capsule,

with the X-ray aligned parallel to the joint surface (which is best achieved by using a firm 6 inch triangular bolster behind the knee and tilting the X-ray tube 10º)[15]. The functional status of the ACL is best determined from a true lateral radiograph, taken with the knee slightly flexed and the femoral condyles overlapping. Where the ACL is functionally abnormal, or absent, the tibial erosion extends to the back of the tibial plateau and may be accompanied by posterior femoral subluxation. If the tibial erosion cannot be seen or does not extend to the back of the tibia there is a 95% chance that the ACL is functionally normal[16]. The PFJ should be assessed via Skyline X-ray with the knee in 30° flexion with only lateral bone loss with grooving and subluxation representing a contra-indication to meniscal-bearing UKR[17].

The concept of an radiographic, atlas based, patient selection tool for UKR was first suggested by Oosthuizen *et al.* and stimulated by this we have developed a radiographic Decision Aid, using the five evidence based criteria, to improve patient selection for medial meniscal-bearing UKR[18]. This study covers the development of the Decision Aid and investigates its sensitivity and specificity in predicting suitability for meniscal-bearing UKR in a consecutive cohort of patients undergoing knee replacement (UKR or TKR) under the care of an independent surgeon who was not involved in the development of the Decision Aid. The mid-term functional outcomes and implant survival in those knees where the Decision Aid advised meniscal-bearing UKR, and who underwent UKR were also investigated.

Materials and Methods

Development of the Decision Aid

An atlas-based radiographic Decision Aid, based on the five criteria that are required to be met to perform medial meniscal-bearing UKR for AMOA has been developed. The Decision Aid is divided into five sections, each assessing one of the five criteria, with radiographic view and exemplar radiographs provided that demonstrate when the criteria are met, as well as exemplar radiographs that demonstrate when the criteria are not met. Example X-rays of knees meeting the criteria to perform UKR were taken from a previously reported series of meniscal-bearing UKR in which the long term functional outcomes and implant survival are known. Examples of knees not meeting criteria are taken from a series of patients undergoing TKR during the same time period. Illustrative X-rays for each criterion were selected by consensus by the Decision Aid development team (initials omitted). Each criteria is assessed by way of a binary, yes-no, polar question with all criteria required to be met to perform meniscal-bearing UKR for an indication of AMOA. Appendix 1.

Validation of the Decision Aid in an independent population

Between 01 January 2008 and 31 December 2008, 550 consecutive primary TKR or primary medial meniscal-bearing UKR were performed by an experienced UKR surgeon (initials omitted) at an independent centre not involved with the development of the Decision Aid. All patients signed an institutional review board approved general research consent allowing for retrospective review. The decision whether to perform meniscal-bearing UKR or TKR was based on history, examination, radiographic assessment including stress X-rays, and intra-operative assessment in line with the recommended indications as described by Goodfellow *et al.*[13].

Suitability for meniscal-bearing UKR was determined by assessing pre-operative radiographs using the radiographic Decision Aid (Appendix 1) with the assessor (initials omitted) blinded to the treatment received. Twelve percent of radiographs (*n* = 227 of 1962 radiographs) were re-assessed at 3 months by the primary assessor and also by an independent assessor (initials omitted).

Patients were followed up independently using a standard protocol. Functional outcomes were assessed using the: American Knee Society Objective Score (AKSS-O), Functional Score (AKSS-F), Lower Extremity Activity Scale (LEAS) and the University of California, Los Angeles (UCLA) Activity Score[19-21]. Where patients had died information about the status of their knee, and the presence of further operation was obtained via primary and secondary care records as well as via patient's relatives where appropriate.

Performance of the Decision Aid was assessed by calculating the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy at identifying suitability for UKR. Performance was calculated based on radiographic assessment alone, and radiographic assessment combined with results of pre-operative findings from patient: history, examination, prior clinical investigations and surgeon assessment. Patient history factors assessed included: patient preference for implant type (i.e. successful contra-lateral replacement) and history of inflammatory arthritis (UKR contra-indicated). Patient examination factors included expected flexion of under 110° which is required to prepare the femur at the time of operation. Prior clinical investigations included the results of a direct assessment of the joint at arthroscopy as well as MRI demonstrating SONK. Other findings from MRI, including the status of the tibiofemoral joint and ACL, were not taken into account as these have not been demonstrated to affect patient outcomes and should not be used for patient selection[22]. Surgeon assessment included cases where the patient may have been suitable for UKR however a pre-operative decision was made by the surgeon to proceed with TKR.

Statistical methods

To assess for differences in functional outcome between subgroups, non-parametric tests (Mann–Whitney U) were performed. Life-table analysis was performed to assess survival using implant-related re-operations, which included any re-operations in which components were changed, in which the bearing was replaced for dislocation, and any re-operations in which new components were inserted as the endpoint. Confidence intervals (CI) were calculated using the method described by Peto *et al*.[23].

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Omitted by authors.

Results

Of the 540 knees (356 patients) in which radiographs were available, 239 (44%) underwent medial meniscal-bearing Oxford Phase 3 UKR (Zimmer Biomet, Warsaw, Indiana) and 301 (56%) underwent TKR. Complete sets of radiographs were not available in 83 knees (29 UKR, 54 TKR) which included two cases of SONK, leaving 457 knees for assessment against Decision Aid criteria. Figure 1. Table 1.

Based on the radiographic Decision Aid 49% (223) of knees were deemed suitable for medial meniscal-bearing UKR and 51% (234) were not suitable. There was excellent intra (Cohen's kappa 0.90) and inter-observer (Cohen's kappa 0.85) agreement.

Of those 234 knees identified as not suitable for UKR 40% (93 knees) did not meet one radiographic criteria, 38% (88 knees) did not meet two criteria, 22% (52 knees) did not meet three criteria and <1% (1 knee) did not meet four criteria. Of those knees that did not meet radiographic criteria, 46% (108 knees) had preserved medial compartment cartilage, 45% (105 knees) had posterior bone loss on their true lateral X-ray indicating ACL insufficiency, 67% (157 knees) had evidence of lateral compartment disease, 11% (25 knees) had evidence of MCL shortening and 16% (37 knees) evidence of bone loss with grooving to the lateral PFJ.

The functional outcomes of knees treated with UKR are outlined in Table 2. In the 194 knees meeting Decision Aid criteria for UKR, who received UKR, there were four implant related reoperations at a mean of 3.8 years (range 0.9 to 6.4 years). There was one case of instability (0.9 years), one case of lateral compartment progression of arthritis (6.1 years), one case of femoral loosening associated with ACL deficiency (6.4 years) and one case due to an unknown cause with the operation performed elsewhere (2.0 years). The five year survival in this cohort was 98.9% (95% CI 96.6 – 100%). Table 3.

In 29 knees the Decision Aid indicated suitability for meniscal-bearing UKR however TKR was performed (18 pre-operative decision, 11 intra-operative decision). Figure 1. No difference in functional outcome was detected between those knees identified as suitable for UKR that underwent TKR and those identified as not suitable for UKR who were treated with TKR. There were no cases of failure in this group at a mean follow up of 3.2 years (range 0 to 7) or in those knees (218 knees) not meeting Decision Aid criteria for UKR who were treated with TKR at a mean follow up was 2.9 years (range 0 to 7).

In 16 knees that did not meet Decision Aid criteria for meniscal-bearing UKR, UKR was performed. Figure 1. At a mean follow up of 4.3 years (range 1 to 6) knees that were identified as not suitable for UKR but underwent UKR had significantly lower flexion, AKSS-Functional Score and UCLA score compared to those knees identified as suitable for UKR and were treated with UKR, Table 2, however they also had lower pre-operative functional scores, and no difference in improvement from baseline was observed. In this group there was one case

of failure, progression of arthritis in the lateral compartment, at 2.3 years. The five year survival (93.1% (95%CI 77.6 – 100%)) in knees not suitable for UKR that underwent UKR was lower than those identified as suitable for UKR treated with UKR, however due to small numbers it was not possible to assess the significance of this difference.

The performance of the Decision Aid is outlined in Table 4. A sensitivity analysis, performed to assess the role of Skyline and Stress X-rays in the work up for meniscal-bearing UKR, demonstrated a decrease in accuracy of 1% and 5% respectively if these X-rays were not performed. Table 5.

Discussion

This study, which was undertaken in a cohort of patients operated on by a surgeon who was not involved with the development of the Decision Aid, found the sensitivity and specificity of the radiographic Decision Aid at predicting suitability for meniscal-bearing UKR to be 92% and 88% respectively. When the radiographic findings were combined with pre-operative factors that influence implant selection (i.e. patient request for TKR or flexion so limited that is was impossible to implant a UKR) the sensitivity and specificity increased to 93% and 96% respectively. In those patients who met Decision Aid criteria for UKR and in whom UKR was performed excellent survival, 99% at five years (95% CI 96.6 – 100%), and functional outcomes were achieved. Taken together this suggests that the Decision Aid is a useful tool for identifying appropriate patients.

The main concern about the Decision Aid is that there were a few false-positives (2.3%) where the Decision Aid suggested a UKR should be done yet the surgeon did not do a UKR. As a UKR was not done we cannot know what the outcome would have been had one been implanted and therefore have to assume that it might not have been good. Importantly in all of these false-positives the contra-indication to UKR, such as a ruptured ACL, was readily identifiable during routine examination of the joint at the time of surgery. As inspection of the knee at the time of surgery is part of the surgical routine, with this stated to be necessary on the Decision Aid, we believe that it is safe to recommend the Decision Aid as the primary assessment for patient suitability for UKR. The only proviso being that the patient must be consented for the possibility of a TKR, with TKR instrumentation being available should this be required.

In 3.3% of cases the Decision Aid did not support the use of a UKR yet one was implanted. In these false-negatives, although the clinical outcomes were satisfactory, the patients had significantly worse functional outcomes (flexion ($p<0.001$), AKSS-Functional ($p<0.001$), UCLA ($p=0.04$)), and a lower implant survival 93.1% (95%CI 77.6 – 100%) compared with those that had a UKR that was supported by the Decision Aid. This would suggest that the Decision Aid does identify the optimal patients for UKR and that surgeons should be cautions extending the indications beyond those recommended by the Decision Aid. The most common reason why the Decision Aid did not support a UKR, that was implanted, was that there was only partial thickness cartilage loss in the medial compartment and not bone-on-bone, as this subgroup of patients has previously been shown to have unpredictable results in independent studies[24,25].

Sensitivity analysis, investigating the role of Skyline and Stress X-rays, highlighted the importance of performing Stress X-rays when identifying suitability for meniscal–bearing UKR. In this series if Stress X-rays were not performed the accuracy of the Decision Aid would be reduced by 5%: Table 5. In the absence of Stress X-rays 10% of knees would be

inappropriately identified as suitable for meniscal-bearing UKR (PPV) as lateral compartment disease, demonstrated on valgus stress, would be missed. In addition 11% of knees would be inappropriately identified as not suitable for meniscal-bearing UKR (NPV) due to medial bone-on-bone arthritis, demonstrated on varus stress, not being seen on standing antero-posterior X-rays. This highlights the importance of performing stress X-ray in the work-up for UKR, particularly as during visual intra-operative examination it is often impossible to assess the cartilage thickness in the lateral compartment.

The sensitivity analysis demonstrated that not performing Skyline X-rays only resulted in a 1% reduction in the accuracy of the Decision Aid. This finding, combined with the fact that bone loss and grooving in the lateral part of the PFJ is readily identified at the time of operation, suggests that Skyline X-rays could be omitted as they do not significantly influence patient selection. Furthermore in the past Skyline X-rays were not recommended. The reason why Skyline X-rays, and to certain extent Stress X-rays, have been included in the Decision Aid is different. The majority of surgeons currently restrict usage of UKR to cases where the lateral compartment and PJF are virtually pristine, so as to avoid disease progression. This is incorrect, as providing the valgus stress radiograph shows full thickness cartilage laterally, and there is not severe arthritis in the lateral part of the PFJ seen on Skyline X-ray, this study demonstrates that excellent outcomes can be achieved. Indeed full thickness ulceration is commonly seem on the medial side of the lateral femoral condyle, as well as in the PFJ, and these factors have previously been demonstrated not to compromise the outcomes[12,14,17]. If surgeons uses the Decision Aid then they can complete an evidence-based document to determine whether a UKR is indicated. Furthermore they can keep the document in the patient's record so if their decision to do a UKR is ever questioned they will have evidence to show that it was correct.

The recommended indications for meniscal-bearing UKR are satisfied in about half of knees needing knee replacement. In this study, which excluded lateral UKR, it was used and its use was supported by the Decision Aid in 44% of cases and very good results were achieved. There are also multiple published or presented series from surgeons who use UKR for about half of their knee replacements in which the Oxford Phase 3 UKR has achieved a 10 year survival of around 95% [26-29]. Analysis of data from the national registry of England and Wales demonstrates that surgeons doing the Oxford Knee in less than 20% of knee replacements, and in particular less than 10%, have a high revision rate, partly because they are doing small numbers and partly because they are using the wrong indications[1]. At 20% and above the revision rate is acceptable but best results are achieved when surgeons do the Oxford in about half of knee replacements. Under these optimal circumstances the re-operation rate of UKR is similar to that of TKR out to eight years[1]. The use of the Decision Aid would ensure that surgeons use the recommended indications and therefore achieve optimal results. Under

these circumstances the patients will have all the advantages of UKR, including a faster recovery, lower morbidity and mortality compared to TKR, without the higher re-operation rate.

Importantly this radiological Decision Aid is implementable at all hospitals as it does not require specialist equipment or imaging modalities and enables surgeons to develop a patient management plan during a single clinic appointment. As it is simple it could not only be used by surgeons but also referring physicians. Alternative techniques such as MRI have been proposed to assess suitability for UKR however they add additional time and cost, and the clinical relevance of these findings with respect to patient selection has yet to be characterised. Furthermore, Hurst *et al*. have demonstrated no difference in clinical outcomes following UKR in knees with MRI contra-indications to UKR compared to those without questioning the clinical relevance of MRI findings[22].

There are certain limitations to this study. This study retrospectively analyses the mid-term outcome of patients treated by a single experienced UKR surgeon with longer term data awaited. A single experience UKR surgeon series was chosen such that UKR utilisation was high and that UKR was being utilised in all appropriate cases, none the less it is acknowledged that there may be variation amongst experienced UKR surgeons in terms of their patient selection. In addition although the five year results in the series were good we do not know what the long term results will be, however these are likely to be good because the surgeon has adhered to the recommended indications.

Conclusion:

The radiological Decision Aid has a high sensitivity and specificity for predicting suitability for meniscal-bearing UKR and demonstrates that meniscal-bearing UKR can be used in around half of knees with excellent implant survival and functional outcomes. The Decision Aid is safe as, providing surgeons examine the knee at surgery, no patient should have an inappropriate UKR. The use of the radiological Decision Aid should optimise patient selection, which will minimise the revision rate of UKR and will allow more patients to benefit from UKR.

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Table 1: Preoperative Patient Demographic

	UKR Mean (SD) (*n* = 239)	TKR Mean (SD) (*n* = 301)	*p*
Time from surgery (year)	6.7 (0.4)	6.7 (0.5)	0.23
Follow Up (years)	3.9 (1.8)	2.8 (2.4)	**<0.001**
Age (years)	63.2 (10.3)	65.8 (10.2)	**0.01**
% male (%)	41.0	40.2	0.85
BMI	31.9 (7.3)	33.3 (7.6)	**0.02**

Table 2: Functional outcomes in those undergoing UKR

	Decision Aid appropriate for UKR Mean (SD)	Decision Aid not appropriate for UKR Mean (SD)	*p*
Flexion			
Preoperative	115.8 (8.8)	109.2 (11.9)	**<0.001**
Postoperative	117.8 (7.8)	112.0 (11.4)	**<0.001**
Change	2.1 (10.6)	2.7 (12.7)	0.65
Knee Society Objective Score			
Preoperative	38.6 (13.9)	40.4 (18.9)	0.69
Postoperative (most recent)	87.7 (16.2)	90.2 (13.6)	0.63
Change	49.1 (21.4)	49.1 (22.7)	0.98
Knee Society Functional Score			
Preoperative	57.5 (15.5)	51.7 (18.9)	**0.001**
Postoperative (most recent)	72.9 (22.7)	64.2 (25.1)	**<0.001**
Change	15.3 (22.9)	12.2 (24.9)	0.12
Lower Extremity Activity Score			
Preoperative	9.5 (2.8)	9.1 (2.9)	0.09
Postoperative (most recent)	9.9 (2.9)	9.7 (3.0)	0.44
Change	-8.1 (3.8)	-7.7 (3.7)	0.32
UCLA Score			
Postoperative (most recent)	6.2 (2.5)	5.3 (1.9)	**0.04**

Table 3: Decision Aid appropriate for UKR that underwent UKR

FU (Y)	Number at start	Revised	Withdrawn	At Risk	Annual Failure	Survival	95% CI	95% CI
0 to 1	194	0	7	190.5	0.000	100	100	100
1 to 2	187	1	7	183.5	0.005	99.5	98.4	100
2 to 3	179	1	25	166.5	0.006	98.9	97.2	100
3 to 4	153	0	57	124.5	0.000	98.9	97.0	100
4 to 5	96	0	19	86.5	0.000	98.9	96.6	100

Table 4: Performance of the Decision Aid in predicting suitability for UKR

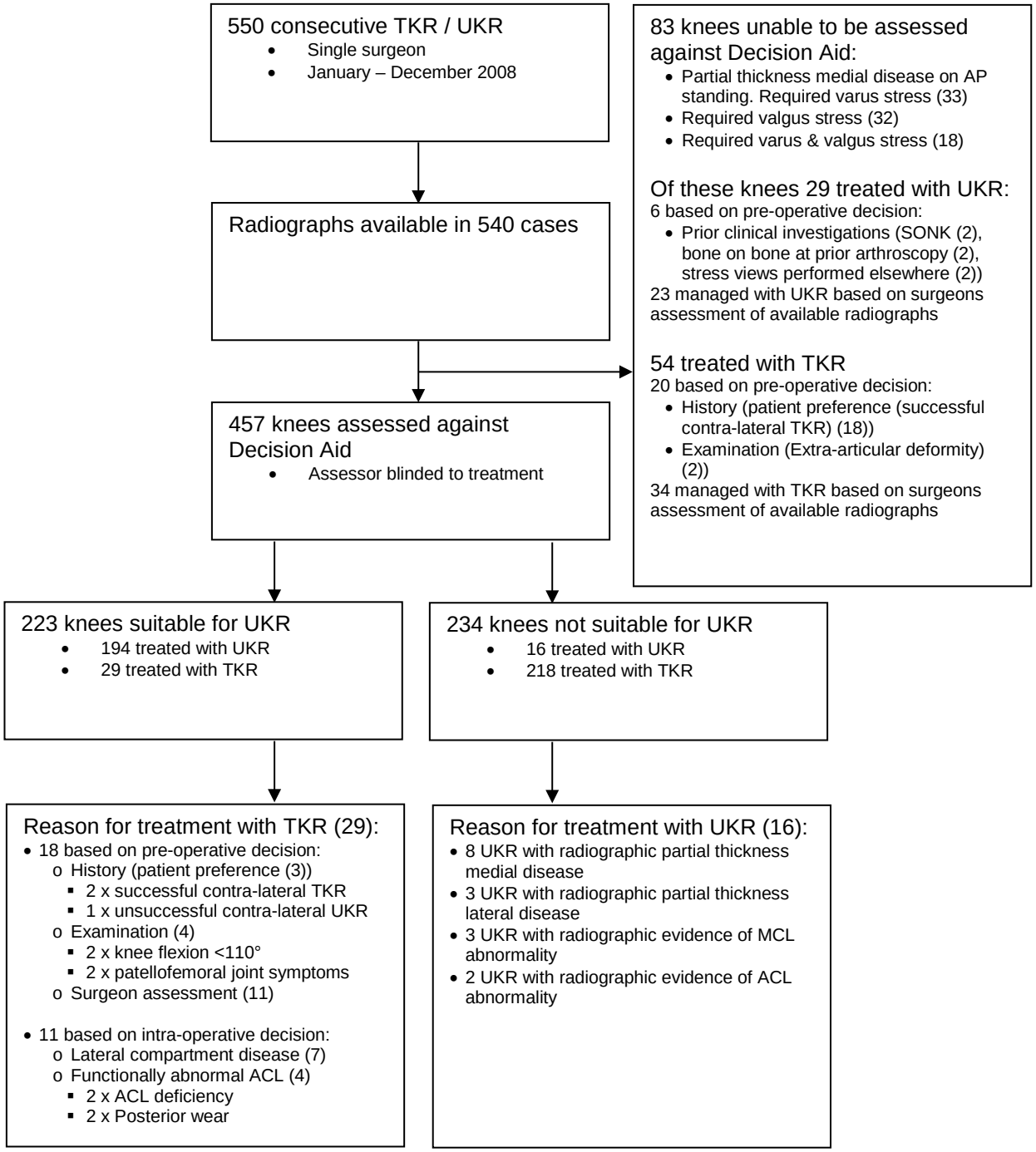
	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Radiology alone	92	88	87	93	90
Radiology plus history	92	90	88	94	91
Radiology plus examination	92	90	89	93	91
Radiology plus surgeon assessment	92	93	92	94	93
Radiology plus results of prior investigations	93	88	87	93	90
Radiology plus all of above	93	96	95	94	94

History: Patient preference for implant type (i.e. successful contra-lateral replacement).
Examination: Clinical finding influencing implant selection (i.e. predicted flexion <110° under anaesthetic, required to perform UKR)).
Surgeon assessment: Pre-operative decision made by the surgeon to proceed with TKR based on patient assessment.
Prior investigations: Prior arthroscopy demonstrating indication or MRI demonstrating SONK.

Table 5: Sensitivity analysis: Skyline and Stress-X-ray

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
All radiographic and clinical findings	93	96	95	94	94
Radiographic and clinical findings - No Skyline X-ray	93	94	93	94	93
Radiographic and clinical findings - No Stress X-ray	88	90	90	89	89

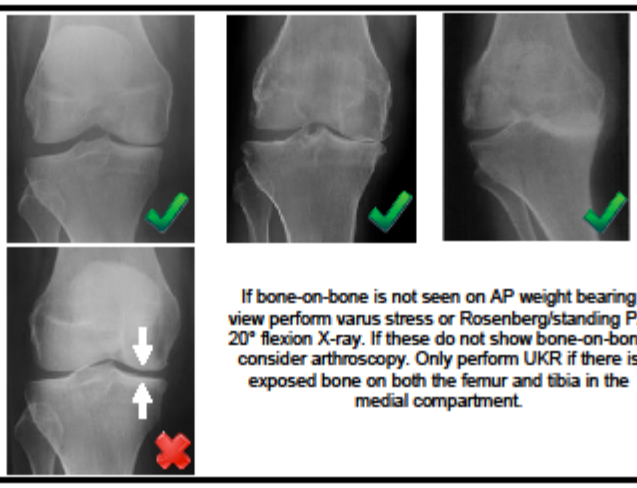
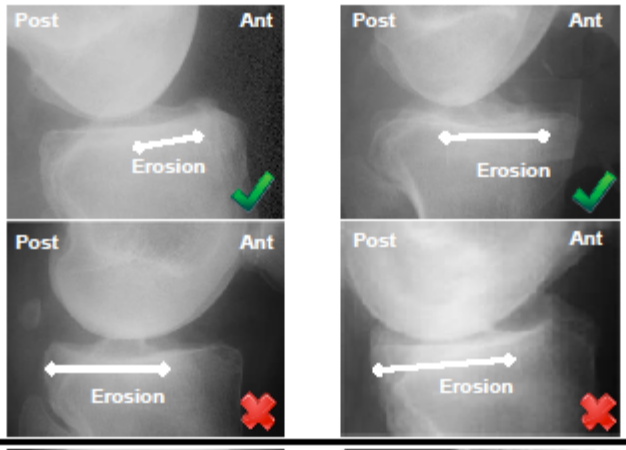
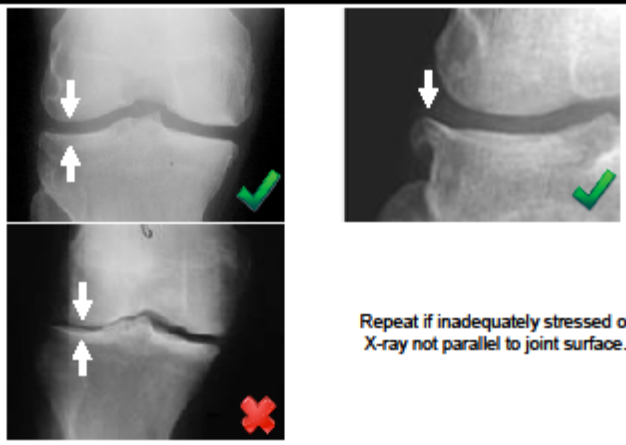
Figure 1: Flow of Study Patients



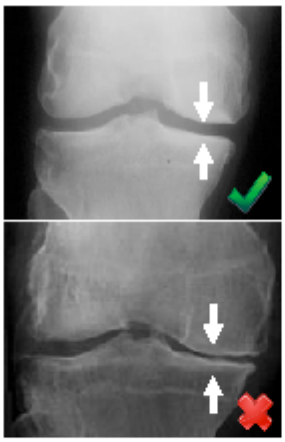
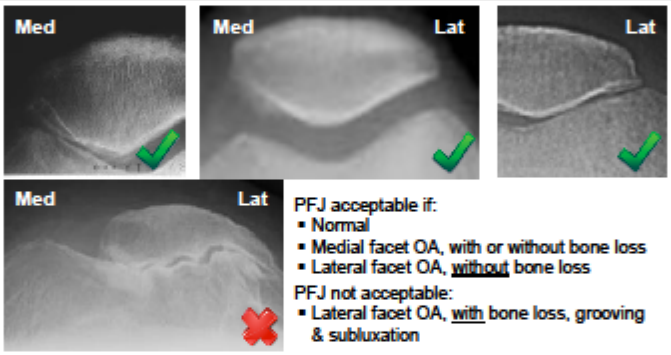
Appendix 1

Radiographic assessment for medial Oxford UKR

- Recommended X-rays: AP weight bearing, true lateral, valgus stress & skyline. (Varus stress or Rosenberg/standing PA 20° flexion if bone-on-bone not seen on AP X-ray)
- Only proceed if all criteria are satisfied.

Criterion	Example X-rays	Conclusion ☑
(1) Medial bone-on-bone X-ray: ▪ AP weight bearing ▪ Varus stress (20° flexion) or Rosenberg/standing PA 20° flexion		Bone-on-bone (or bone loss) Meets criteria ☐ No bone-on-bone Does not meet criteria ☐
(2) Functionally intact ACL X-ray: ▪ True lateral (femoral condyles overlapping)		Functional ACL (preserved posterior tibia) Meets criteria ☐ Absent ACL (posterior erosion/subluxation) Does not meet criteria ☐
(3) Full thickness lateral cartilage X-ray: ▪ Valgus stress (20° flexion)		Full thickness (Ignore osteophytes) Meets criteria ☐ Lateral narrowing Does not meet criteria ☐

Radiographic assessment for medial Oxford UKR

Criterion	Example X-rays	Conclusion ☑
(4) Functionally normal MCL (correctable intra-articular deformity) X-ray: ▪ Valgus stress (20° flexion)		Correctable deformity (Normal medial opening) Meets criteria ☐ Not correctable (Incomplete medial opening) Does not meet criteria ☐
	Repeat if inadequately stressed or X-ray not parallel to joint surface	
(5) Acceptable patello-femoral joint X-ray: ▪ Skyline		Meets criteria ☐ Does not meet criteria ☐
	PFJ acceptable if: ▪ Normal ▪ Medial facet OA, with or without bone loss ▪ Lateral facet OA, without bone loss PFJ not acceptable: ▪ Lateral facet OA, with bone loss, grooving & subluxation	

The primary indication for the Oxford UKR is anteromedial OA. The diagnosis of anteromedial OA is based on the radiographic criteria shown above [1]. Medial avascular necrosis is also an indication.

The following factors do not preclude Oxford UKR if all other criteria are met:

- Isolated medial pain is not a requirement. Pre-operative anterior knee pain has been reported to not compromise the outcome [2,3].
- Patient's age, weight and activity level [4-6].
- Chondrocalcinosis (cartilage calcification on X-ray), lateral marginal osteophytes or medial tibial subluxation (which should correct when the UKR is implanted if the ACL is intact) [6-8].

The final decision on whether to perform UKR is made when the knee has been opened and directly inspected. The following factors do not preclude Oxford UKR if all other criteria are met:

- Full thickness cartilage loss on the non-weight bearing medial side of the lateral femoral [9].
- Full thickness cartilage loss in the patellofemoral joint

[1] Hamilton TW et al. Validation of a Radiological Decision Aid to Determine Suitability for Medial Mobile-bearing Unicompartmental Knee Replacement. NIHR Doctoral Research Training Camp Poster. July 2015.
[2] Berend K et al. Does Preoperative Patellofemoral Joint State Affect Medial Unicompartmental Knee Arthroplasty Survival? AAOS Poster No. P204. February 2011.
[3] Liddle AD et al. Preoperative pain location is a poor predictor of outcome after Oxford unicompartmental knee arthroplasty at 1 and 5 years. KSSTA 21:2421-6, 2013.
[4] Berend K. et al. Obesity, Young Age, Patellofemoral Disease and Anterior Knee Pain: Identifying the Unicondylar Arthroplasty Patient in the United States. Orthopedics. 30:19–23, 2007.
[5] Kang, S. et al. Pre-operative Patellofemoral Degenerative Changes Do Not Affect the Outcome After Medial Oxford Unicompartmental Knee Replacement. JBJS Br. 93-B:476–8, 2010.
[6] Pandit H. et al. Unnecessary Contraindications for Mobile-bearing Unicompartmental Knee Replacement. JBJS Br. 93-B:622–8, 2011.
[7] Goodfellow JW, O'Connor J, Pandit H, Dodd C, Murray D. Unicompartmental Arthroplasty with the Oxford Knee (2nd Edition), Goodfellow Publishers, Oxford, UK, 2015. [8] Kumar V et al. Comparison of Outcomes after UKA in Patients With and Without Chondrocalcinosis: A Matched Cohort Study. KSSTA 2015 *online* 19 March 2015.
[9] Kendrick BJ et al. The implications of damage to the lateral femoral condyle on medial unicompartmental knee replacement. JBJS Br 92(3)374-9, 2010.