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Incidence and severity of radiological lateral osteoarthritis 15 years following medial unicompartmental knee arthroplasty

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Aims

To assess the incidence of radiological lateral osteoarthritis (OA) at 15 years after medial unicompartmental knee arthroplasty (UKA) and assess the relationship of lateral OA with symptoms and patient characteristics.

Methods

Cemented Phase 3 medial Oxford UKA implanted by two surgeons since 1998 for the recommended indications were prospectively followed. A 15-year cumulative revision rate for lateral OA of 5% for this series was previously reported. A total of 163 unrevised knees with 15-year (SD 1) anterior-posterior knee radiographs were studied. Lateral joint space width (JSW_L) was measured and severity of lateral OA was classified as: nil/mild, moderate, and severe. Preoperative and 15-year Oxford Knee Scores (OKS) and American Knee Society Scores were determined. The effect of age, sex, BMI, and intraoperative findings was analyzed. Statistical analysis included one-way analysis of variance and Kruskal-Wallis H test, with significance set at 5%.

Results

The mean age was 80.6 years (SD 8.3), with 84 females and 79 males. The mean JSW_L was 5.6 mm (SD 1.4), and was not significantly related to age, sex, or intraoperative findings. Those with BMI > 40 kg/m² had a smaller JSW_L than those with a 'normal' BMI (p = 0.039). The incidence of severe and moderate lateral OA were both 4.9%. Overall, 2/142 (1.4%) of those with nil/mild lateral OA, 1/8 (13%) with moderate, and 2/8 (25%) with severe subsequently had a revision. Those with severe (mean OKS 35.6 (SD 9.3)) and moderate OA (mean OKS 35.8 (SD 10.5)) tended to have worse outcome scores than those with nil/mild (mean OKS 39.5 (SD 9.2)) but the difference was only significant for OKS-Function (p = 0.044).

Conclusion

This study showed that the rate of having severe or moderate radiological lateral OA at 15 years after medial UKA was low (both 4.9%). Although patients with severe or moderate lateral OA had a lower OKS than those with nil/mild OA, their mean scores (OKS 36) would be classified as good.

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Introduction

Knee osteoarthritis (OA) commonly starts in the medial compartment, before progressing to the lateral compartment.[1] Treatments for end-stage medial OA include total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA). UKA offers advantages over TKA with smaller incision,[2] fewer early complications, faster recovery,[3,4] and greater cost-effectiveness,[5] with superior patient-reported outcome measures (PROMs).[4-6] However, revision is more likely with UKA. Raw data from national registries suggest revisions are three times more

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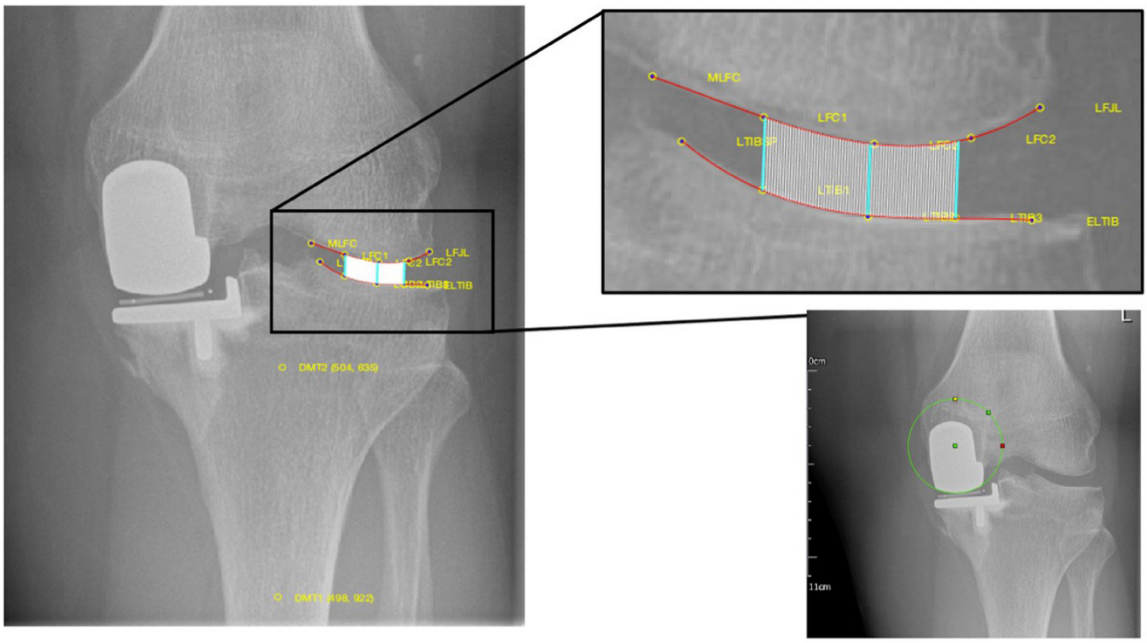

Fig. 1

Anterior-posterior radiograph of a 70-year-old male patient showing the method of measuring the lateral joint space width (JSW_L). It involved drawing the mechanical axis of the tibia using midpoints of the proximal and distal tibia (left), identifying lateral femoral and tibial joint lines using five evenly spaced points on the respective surfaces (top right) and scaling the radiograph using the known component size (bottom right). Three lines from the tibial joint line were drawn to meet the femoral joint line parallel to the mechanical axis (top right) – the mean of these measurements determined the mean JSW_L.

common, but matched data suggest two times.[3,7] One large, randomized study concluded revision rates were similar at five years.[8]

Lateral OA progression is the most common cause of UKA revision in the long term.[7] In a series of 682 mobile UKAs, 34% of revisions were for lateral OA, with a 20-year survival of 91%,[9] while in 70 cemented fixed UKAs, 64% of revisions were for lateral OA, with a 20-year survival of 74%.[10] In 1,000 mobile cemented medial UKAs the cumulative revision rate for lateral OA was 4% at 15 years.[11] However, there is limited information about the incidence of radiological lateral OA after medial UKA. In a series of 1,000 cementless mobile UKAs, 9% had radiological evidence of lateral OA at ten years.[12] Beyond ten years, the incidence of radiological lateral OA following medial UKA is unknown, and may be substantially higher.

Severity of tibiofemoral OA is routinely assessed with standing anterior-posterior (AP) radiographs using the Kellgren-Lawrence (KL) classification.[13] This assesses primarily the joint space width (JSW), but also presence of osteophytes, subchondral sclerosis, and bone deformity. Assessing JSW by the appearance of narrowing is not well quantified: Minimum JSW in normal knees (KL 0 to 1) was reported to be 4.8 mm in females and 5.7 mm in males.[14] With medial OA, osteophytes commonly occur in the lateral compartment even if this compartment is otherwise normal.[15] Therefore, after medial UKA, lateral osteophytes should be ignored when assessing the lateral compartment.[15,16] Lateral compartment OA is usually most marked in flexion.[17] Measuring JSW on AP radiograph in full extension may overestimate cartilage thickness in flexion. Conversely, if the radiograph is not aligned exactly on the joint, JSW measurement will underestimate the thickness of retained cartilage.

Our aim was to determine the incidence of radiological lateral OA 15 years after medial UKA. Severity of OA was assessed by JSW measurements using KL excluding osteophytes. We also assessed the relationship between lateral OA and symptoms and patient characteristics.

Methods

A cohort of consecutive cemented Phase 3 medial Oxford UKA for anteromedial OA or osteonecrosis,[18] implanted between December 1998 and November 2005, by two surgeons (CD, DWM) were prospectively followed up. Patients were independently reviewed clinically and with radiographs every fifth year. The 15-year results were published in 2015,[11] but at that stage there were not enough patients with 15-year radiographs to study radiological lateral OA in detail. By 2021 enough patients had 15-year radiographs and these were included in the study.

Radiological analysis. To determine lateral JSW (JSW_L), calculated as the mean of the three measurements as described in Figure 1, 15-year ± 1 year AP knee radiographs were reviewed using in-house software written in MATLAB (v. 9.9, 2020; USA).

Fig. 2

Example of anteroposterior radiograph of an 87-year-old female patient with poor alignment causing a falsely small lateral joint space width.

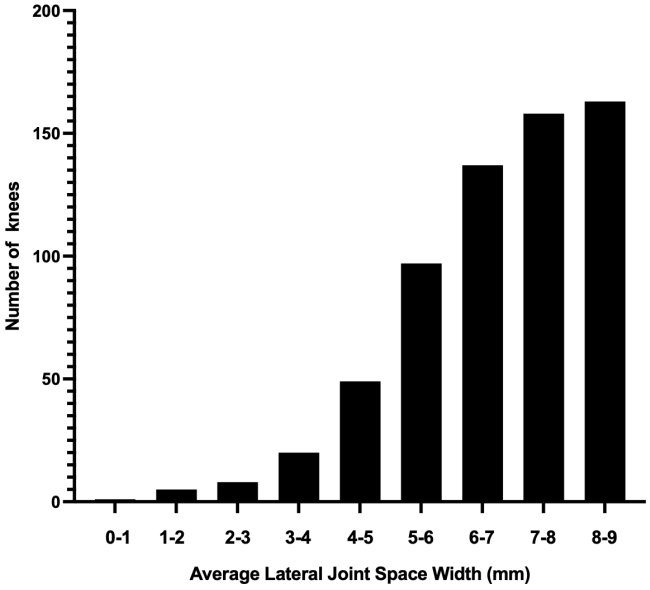

Fig. 3

Cumulative histogram of mean lateral joint space width.

Two independent assessors (HKCS and APD) measured JSW_L. The primary assessor measured all radiographs; a second independent assessor randomly selected 50% of the radiographs. Interuser agreement was calculated for validation.

Where JSW_L was < 5 mm, the severity of radiological OA was graded independently by two experienced orthopaedic surgeons (CD and DWM) using KL excluding osteophytes:[15] nil/mild (grade 0, 1, 2), moderate (grade 3), or severe (grade 4) to ensure narrowing was purely due to OA changes rather than poor radiograph alignment (Figure 2). Grading surgeons were blinded to JSW_L measurements. Any disagreements were discussed prior to grade categorization. JSW_L > 5 mm was considered to be nil/mild OA based on previous studies of normal knees.[19,20]

Classification of OA. Severe OA was defined as JSW_L of < 5 mm and where surgeons rated radiographs as severe OA changes. Moderate OA was defined as JSW_L of < 5 mm and where surgeons rated radiographs as moderate OA changes. All other cases were defined as nil/mild OA.

Objective outcomes. PROMs at 15 years were assessed using the total Oxford Knee Score (OKS), OKS Function (OKS-F), OKS Pain (OKS-P), American Knee Society Score (AKSS), AKSS Objective (AKSS-O), AKSS Functional (AKSS-F), and AKSS without alignment correction (AKSS-MA). For the AKSS-O the varus/valgus alignment was measured using a long arm goniometer placed over the ASIS, the centre of the knee, and the centre of the ankle.[21]

Statistical analysis. Data were reported as mean and standard deviation (SD). Normality was assessed using Shapiro-Wilk's test ($p > 0.05$). The effect of age, sex, BMI, and intraoperative findings on mean JSW_L was analyzed. A one-way analysis of variance (one-way ANOVA) and Kruskal-Wallis H test determined differences between three groups. For group comparisons (severe versus nil/mild/moderate or moderate/severe versus nil/mild), an independent-samples *t*-test or Mann-Whitney U test for parametric and non-parametric data, respectively, was performed. Significance was set at 5%. Data were analyzed using GraphPad Prism (v9.2, USA) and IBM SPSS Statistics, version 27 (IBM, USA).

Results

In total, 662 UKAs had been implanted for more than 15 years. Of these, 163 knees (79 males, 84 females) had a radiograph at a mean follow-up of 15.0 years (SD 0.3) from surgery and were included in this study. Of those excluded, 69 (10%) were revised, 171 (26%) were deceased, 67 (10%) were dropped due to morbidity (dementia, confusion, full-time care, or similar), and the rest did not attend for radiological review, partly because of the risks associated with COVID-19. Mean patient age at radiography was 80.6 years (SD 8.3).

Intra-user agreement. Comparison of JSW_L measurements from both assessors yielded a good ICC of 0.872 (two-way mixed for single measures, 95% confidence interval 0.806 to 0.917). There were disagreements for 5/163 (3.1%) of radiographs; 3/5 (60%) were between nil/mild or moderate, and the rest between moderate or severe.

Overall. At 15 years after surgery, 4.9% (n = 8) knees had severe lateral OA, 4.9% (n = 8) had moderate lateral

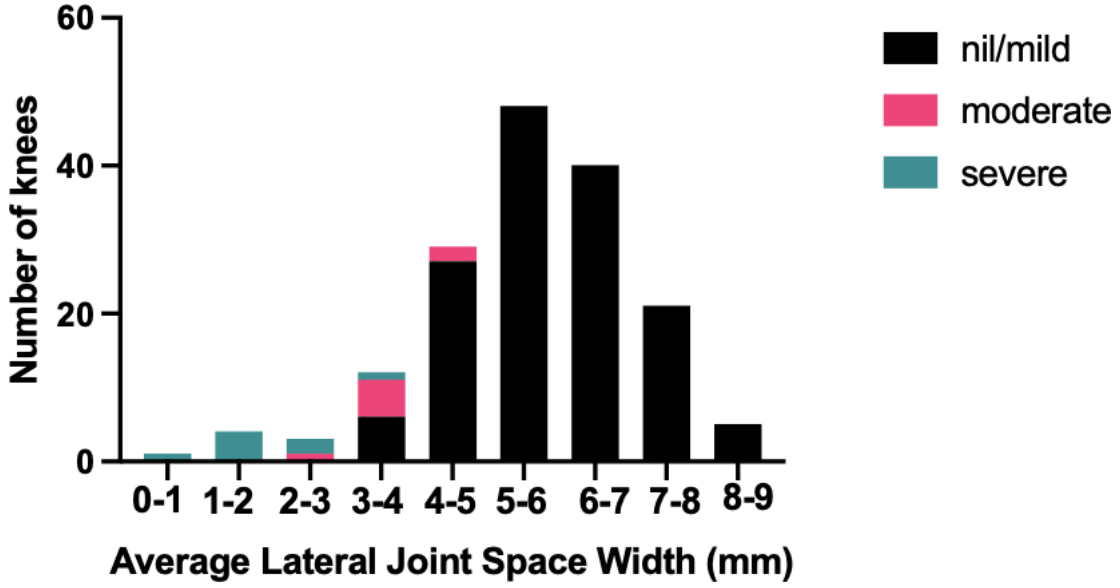

Fig. 4

Frequency histogram for mean lateral joint space width broken down by category.

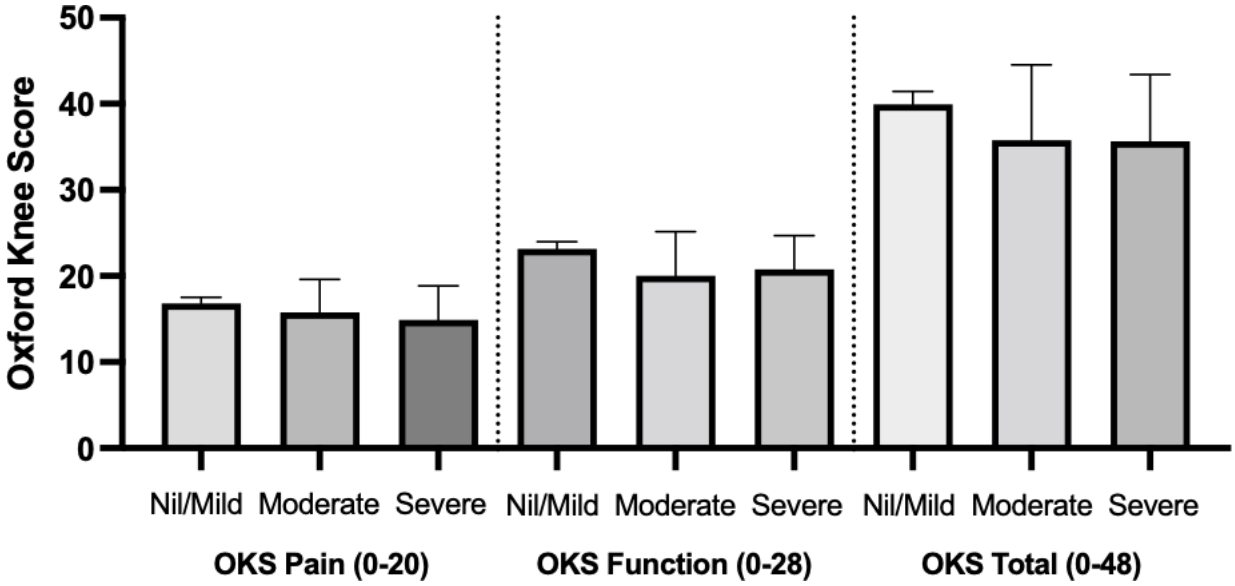

Fig. 5

15-year Oxford Knee Scores (OKS), with mean and 95% confidence intervals

OA, and 90.2% (n = 147) had nil/mild lateral OA. Overall mean JSW_L was 5.6 mm (SD 1.4) (Figure 3).

The mean JSW_L in the severe, moderate, and nil/mild groups was 1.9 mm (SD 0.7), 3.5 mm (SD 0.6), and 5.9 mm (SD 1.1) respectively (Figure 4). No radiographs with JSW_L > 4.5 mm were graded worse than nil/mild lateral OA.

Overall, 25% (n = 2, at 16.9 and 17.4 years) of knees with severe lateral OA and 13% (n = 1, at 17.1 years) with moderate lateral OA subsequently underwent revision for lateral OA, compared to 1.4% (n = 2, at 15.4 and 18.3 years) in the nil/mild lateral OA group.

Functional scores. Figure 5 shows 15-year OKS. Table I shows preoperative and 15-year OKS. At 15 years, the OKS were slightly lower in severe (35.6 (SD 9.3)) and moderate (35.8 (SD 10.5)) lateral OA groups than nil/mild lateral OA group (39.9 (SD 9.2)); these differences were not significant (p = 0.099, Kruskal-Wallis test) (Figure 5). A similar pattern was seen in the OKS-P and OKS-F subscales with the only significant difference being a lower

Table I. Oxford Knee Scores by lateral osteoarthritis severity.

Mean score (SD)	Total (n = 163)	Nil/Mild (n = 147)	Moderate (n = 8)	Severe (n = 8)
Preop OKS-P	7.4 (3.6)	7.3 (3.6)	8.1 (4.1)	8.3 (3.7)
15-year OKS-P	16.7 (4.4)*	16.8 (4.4)*	15.8 (4.6)	14.9 (4.8)
Preop OKS-F	14.9 (5.7)	14.8 (5.6)	13.9 (6.7)	17.7 (6.0)
15-year OKS-F	22.9 (5.2)*	23.1 (5.1)*	20.0 (6.1)	20.8 (4.7)
Preop OKS	22.4 (8.6)	22.1 (8.7)	23.9 (6.5)	26.0 (9.6)
15-year OKS	39.5 (9.2)*	39.9 (9.2)*	35.8 (10.5)	35.6 (9.3)

*Non-parametric data.
OKS, Oxford Knee Score; OKS-F, OKS Function; OKS-P, OKS Pain; SD, standard deviation.

Table II. American Knee Society Scores by lateral osteoarthritis severity.

Mean score (SD)	Total (n = 163)	Nil/Mild (n = 147)	Moderate (n = 8)	Severe (n = 8)
Preop AKSS-O	49.6 (22.7)	49.7 (22.4)	59.7 (16.8)	42.4 (30.4)
15-year AKSS-O	78.0 (17.6)*	78.4 (17.4)*	70.8 (24.4)	78.5 (13.8)
Preop AKSS-F	68.1 (19.2)*	68.2 (20.2)*	65.0 (13.2)	69.0 (8.9)
15-year AKSS-F	75.3 (19.0)	76.0 (19.4)*	67.5 (13.6)	70.6 (15.2)*
Preop AKSS	117.7 (35.8)	117.9 (37.1)	124.7 (29.0)	111.4 (26.2)
15-year AKSS	153.4 (29.7)*	154.4 (30.0)*	138.3 (32.7)	149.1 (16.2)
Preop AKSS-MA	124.5 (33.8)*	125.2 (35.0)*	124.7 (29.0)	115.4 (24.1)
15-year AKSS-MA	163.2 (29.7)*	165.0 (29.9)*	143.3 (26.9)	150.4 (17.6)

*Non-parametric data.
AKSS, American Knee Society Score; AKSS-F, AKSS Functional; AKSS-MA, AKSS without alignment correction; AKSS-O, AKSS Objective; SD, standard deviation.

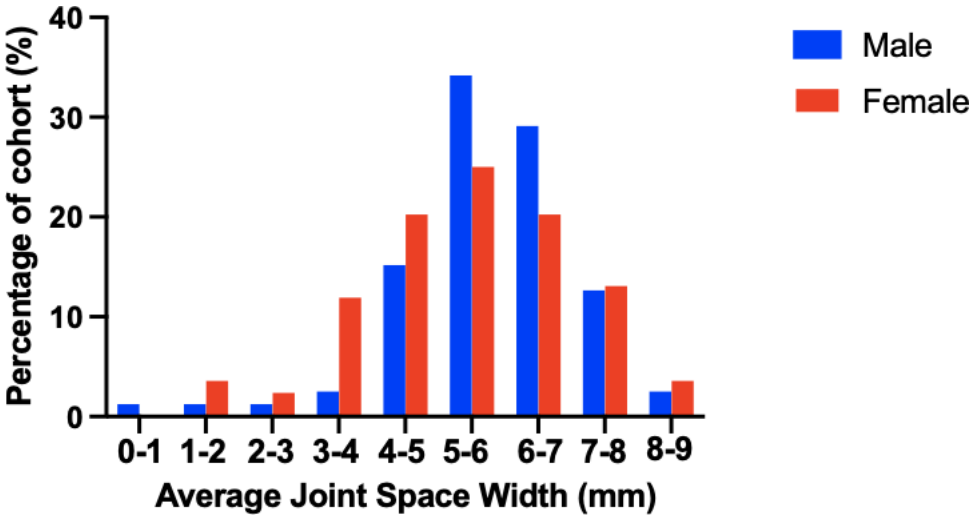

Fig. 6
A frequency histogram of mean lateral joint space width.

OKS-F in the moderate/severe group compared to the nil/mild group (20.4 vs 23.1; p = 0.044, independent-samples *t*-test).

Table II shows pre- and 15-year AKSS, with no significant differences seen. However, at 15 years after surgery, severe knees were 5.2° (p = 0.001, Mann-Whitney U test) and moderate 4.3° (p = 0.001, Mann-Whitney U test) more valgus compared to nil/mild knees.

Sex. The mean JSW_L for males was 5.7 mm (SD 1.3) and 5.4 mm (SD 1.5) for females, and not statistically significantly different (p = 0.110, Mann-Whitney U test). Figure 6 shows a frequency histogram.

There was a greater proportion of females than males graded with severe and moderate lateral OA (7.1% vs 2.5% severe, 6.0% vs 3.8% moderate, 86.9% vs 93.7%

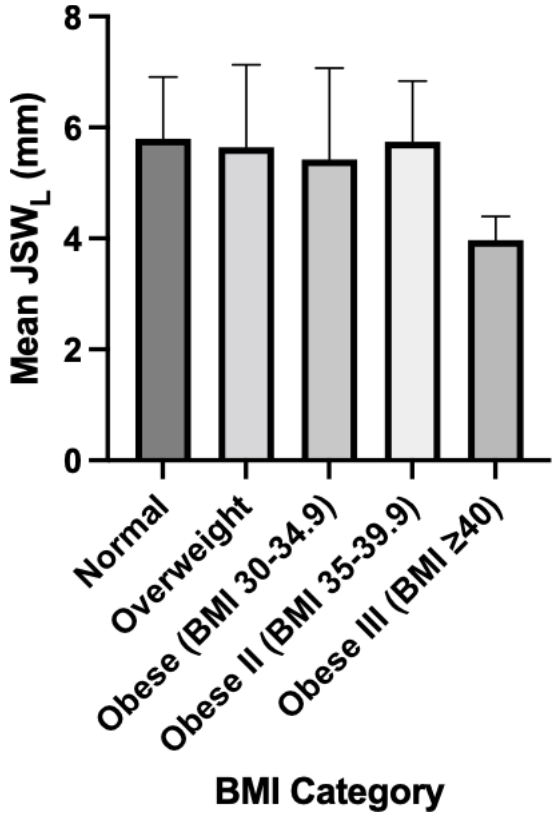

Fig. 7
BMI category against mean lateral joint space width (JSW$_L$).

nil/mild), but these differences were not statistically significant (p = 0.229, chi-squared test).

Age. Mean age was 80.6 years (SD 8.3). The mean ages for the nil/mild, moderate, and severe groups were 80.5 years (SD 8.3), 82.3 years (SD 8.4), and 81.7 years (SD 8.0), respectively. There were no significant difference in age between the nil/mild, moderate, and severe lateral OA groups (p = 0.973, Kruskal-Wallis test).

BMI. Mean BMI was 29.5 kg/m^2 (SD 5.0). In total, 27 patients had a normal BMI, 61 were overweight, 51 had a BMI between 30 to 34.9, 19 had a BMI of 35 to 39.9, and five had a BMI ≥ 40. The relationship between BMI category and mean JSW$_L$ was analyzed (Figure 7); the only significant difference was between those with normal BMI and those with BMI 40 (5.8 vs 4.0; p = 0.039, Kruskal-Wallis test).

Intraoperative findings at the primary operation. There was no significant relationship between mean JSW$_L$ and intraoperative findings: the severity of cartilage damage in the lateral compartment (central: p = 0.747, one-way ANOVA; medial: p = 0.889, Kruskal-Wallis test); the severity of medial OA (femur: p = 0.852, one-way ANOVA; tibia: p = 0.290, Kruskal-Wallis test); the severity of cartilage damage in the patella-femoral joint (lateral facet patella: p = 0.385; medial facet patella: p = 0.906; trochlea: p = 0.199, one-way ANOVA); or the anterior cruciate ligament status (p = 0.298, one-way ANOVA).

Discussion

This was the first detailed study of radiological lateral OA 15 years after medial UKA. The incidence of both severe and moderate lateral OA was 4.9%. The remainder had nil/mild OA. Those with moderate or severe OA had slightly more symptoms than those with nil/mild OA, but differences tended not to be significant. However, the proportion of patients subsequently being revised was higher for those with severe (25%) or moderate OA (13%) than those with nil/mild OA (1%). While morbid obesity (BMI > 40 kg/m^2) was associated with a decrease in JSW$_L$, lower levels of BMI, age, sex, and intraoperative findings at primary surgery were not.

Generally speaking, OA is primarily considered a disease of cartilage.[22] If this were true, then the lateral cartilage would be expected to fail in the long term after a medial UKA implanted for failed medial cartilage. This is why many surgeons prefer TKA to UKA. However, this study showed that at 15 years, 4.9% had severe and 4.9% had moderate lateral OA. Previous analysis of this series reported a cumulative revision rate for lateral OA at 15 years of 4%.[11] Therefore, overall at 15 years the chance of developing lateral OA after medial UKA is small. This would suggest that medial OA is not a manifestation of a generalized cartilage problem in the knee.[23] Rather, it would suggest that medial compartment OA is at least in part a consequence of an abnormality related to the medial compartment, which is probably mechanical.[17] Once medial OA is established, knee kinematics will become disordered which may cause OA to progress to the rest of the knee. However, if a UKA was implanted and the kinematics were restored to normal, lateral progression would be arrested in most cases.

Most previous radiological studies, albeit with less than 15-year follow-up, also concluded that significant OA laterally is rare after medial UKA.[23,24] Conversely, Misir et al[25] reported that 35% of cases had radiological evidence of lateral OA progression at a mean of seven years postoperatively. However, all cases had grade 0 or 1 KL lateral OA preoperatively and the majority of cases that progressed did so by only one grade. Therefore, very few in that study would have reached grade 3 (moderate) or 4 (severe) OA, which agrees with our study. Furthermore, with marked varus on the preoperative weight-bearing radiographs due to medial OA, there may have been some apparent widening of JSW$_L$ which would disappear postoperatively, and might cause a change of grade even though there was no OA progression.

For every outcome score we assessed, patients with moderate and severe lateral OA tended to have a worse score than those with no or mild lateral OA. However, the difference was only statistically significant for one

score (OKS-F 20.4 vs 23.1; p = 0.044, independent-samples *t*-test). It would be surprising if the scores of those with significant moderate or severe OA were not worse than those without OA. It is, therefore, likely that the difference is real, but is not consistently significant as the numbers with OA are small (severe 8, moderate 8). Overall the difference between the groups was small. The 15-year OKS for nil/mild OA was 40, and for moderate and severe OA 36. Although a difference of four in OKS is considered clinically important, the moderate and severe groups would still be considered to have a good outcome. Furthermore, a mean OKS of 36 is the expected long-term outcome following TKA.[26] Therefore, although these patients with moderate or severe lateral OA do have some symptoms, they are not severe enough to warrant further surgery.

Patients with moderate/severe lateral OA at 15 years were more likely to have a subsequent revision than those with nil/mild lateral OA (severe 25%, moderate 13%, nil/mild 1%). These revisions tended to occur within four years from when the radiograph was obtained, presumably when symptoms worsened. The majority of patients did not subsequently require revision, suggesting that for the majority the symptoms did not deteriorate after this period.

Compared with knees with nil/mild OA, knees with moderate or severe OA were in 4° and 5°, respectively, more valgus. Most of this is likely due to the loss of JSW_L associated with lateral OA. The JSW_L of knees with moderate or severe OA was 2 mm or 4 mm, respectively, smaller than those with no/mild OA. As 1 mm loss of JSW would account for about 1° of valgus, the loss of JSW may not account for all the valgus. Those knees developing lateral OA may also have had less constitutional varus or were possibly overcorrected at operation.

The mean JSW_L of 5.6 mm in our study at 15 years was similar to Yue et al's[27] measurements of 5.36 mm (SD 1.10) in weightbearing AP radiographs immediately postoperatively. Although a small proportion of cases in our study developed lateral OA, the majority had a normal JSW_L, and therefore no significant OA. The only factor we identified associated with a decrease in JSW_L was BMI > 40 kg/m^2. High BMI is associated with knee OA and those with BMI > 40 kg/m^2 after medial UKA should be advised to lose weight.[28] There was no significant difference in the mean patient age with nil/mild (80.5 years), moderate (82.3 years), or severe OA (81.7 years), suggesting that age does not influence the development of lateral OA after medial UKA. Females are known to be at increased risk from knee OA compared to males,[29] with a ratio as high as 4:1.[30] In normal knees (KL 0 to 1), Beattie et al[14] reported females having a narrower mean JSW (4.8 mm) than males (5.7 mm). While females also had a narrower JSW_L than males (5.4 mm versus 5.7 mm) in our study, the difference was not statistically significant; this may be attributed to the smaller size of our study. We also found more females than males were graded as having severe and moderate lateral OA (7.1% vs 2.5% severe, 6.0% vs 3.8% moderate), but these differences were not statistically significant. Our study cannot draw any firm conclusions on whether females are or are not more likely to develop lateral OA after medial UKA than males.

There was no relationship between the findings at the primary operation and the JSW_L. Surprisingly, the severity of cartilage damage laterally was not related to subsequently developing lateral OA. A frequent intraoperative finding is that there is full-thickness loss of cartilage on the medial side of the lateral condyle, caused by impingement on the lateral tibial spine as a result of the varus deformity. This has previously been shown not to compromise the outcome, and the current study supports this. Of the cases included here, 40/149 (27%) had partial-thickness cartilage loss on the central weightbearing area of the lateral femoral condyle. This did not increase the rate of lateral OA, probably because at the preoperative assessment the JSW_L was considered normal. Additionally, there is debate whether patellofemoral joint damage should be considered to be a contraindication to UKA. This study found no statistically significant relationship between intraoperative of patellofemoral joint findings and severity of JSW_L, and therefore agrees with other papers that conclude that the state of the patellofemoral joint should not be considered a contraindication in UKA.[31-33]

The main limitation of the study was that some of the unrevised UKAs implanted 15 years ago or more did not have radiographs at 15 years. Therefore, the sample may not be representative of the whole cohort and may underestimate the incidence of lateral OA. However, this seems unlikely as those with knee symptoms associated with OA would be more likely to attend a clinical assessment than asymptomatic patients. Therefore, our study is perhaps more likely to overestimate the incidence of OA. Another limitation is that weightbearing AP radiographs were taken with the knee fully extended, possibly underestimating the OA severity. However, the JSW_L after medial UKA has been shown to be similar on weightbearing AP, supine AP, or valgus stress taken with at least 20° of flexion.[27] The radiographs with possible OA were reviewed by experienced surgeons, ensuring none with OA were missed or misinterpreted due to technical problems, such as malalignment. Furthermore, we did not compare the 15-year radiographs with immediate postoperative radiographs, so were unable to determine the JSW_L change over 15 years. However, none of the patients had moderate or severe lateral OA at the time of surgery, so all those showing moderate or severe lateral OA at 15 years would have progressed.

In conclusion, at 15 years following medial UKA the incidence both of severe and moderate radiological

lateral OA was 4.9% in those that had not been revised. Patients with severe or moderate lateral OA had slightly more symptoms than those with nil or mild OA, but their symptoms were similar to those expected following a TKA. Given our previous study of these patients reported a 4% rate of revision for lateral OA at 15 years, these findings should reassure surgeons and patients that the proportion of UKA being revised or having a poor result due to progression of lateral OA in the long term is small.

Take home message

- The incidence of both moderate and severe radiological lateral osteoarthritis (OA) is low (5%) 15 years after medial unicompartmental knee arthroplasty.
- Of those with radiological lateral OA, patient-reported outcome scores are similar to those after total knee arthroplasty.

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