Combined anterior cruciate reconstruction and Oxford unicompartmental knee arthroplasty

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The options for treatment of the young active patient with isolated symptomatic osteoarthritis of the medial compartment and pre-existing deficiency of the anterior cruciate ligament are limited. The potential longevity of the implant and levels of activity of the patient may preclude total knee replacement, and tibial osteotomy and unicompartamental knee arthroplasty are unreliable because of the ligamentous instability. Unicompartamental knee arthroplasties tend to fail because of wear or tibial loosening resulting from eccentric loading. Therefore, we combined reconstruction of the anterior cruciate ligament with unicompartamental arthroplasty of the knee in 15 patients (ACLR group), and matched them with 15 patients who had undergone Oxford unicompartamental knee arthroplasty with an intact anterior cruciate ligament (ACLI group). The clinical and radiological data at a minimum of 2.5 years were compared for both groups.

The groups were well matched for age, gender and length of follow-up and had no significant differences in their pre-operative scores. At the last follow-up, the mean outcome scores for both the ACLR and ACLI groups were high (Oxford knee scores of 46 (37 to 48) and 43 (38 to 46), respectively, objective Knee Society scores of 99 (95 to 100) and 94 (82 to 100), and functional Knee Society scores of 96 and 96 (both 85 to 100). One patient in the ACLR group needed revision to a total knee replacement because of infection. No patient in either group had radiological evidence of component loosening. The radiological study showed no difference in the pattern of tibial loading between the groups.

The short-term clinical results of combined anterior cruciate ligament reconstruction and unicompartamental knee arthroplasty are excellent. The previous shortcomings of unicompartamental knee arthroplasty in the presence of deficiency of the anterior cruciate ligament appear to have been addressed with the combined procedure. This operation seems to be a viable treatment option for young active patients with symptomatic arthritis of the medial compartment, in whom the anterior cruciate ligament has been ruptured.

Symptomatic osteoarthritis of the medial compartment in young and active patients with pre-existing deficiency of the anterior cruciate ligament (ACL) is an increasingly common problem. The incidence of osteoarthritis of the medial compartment after ACL injury has been quoted to range from 33% to 70%. Isolated ACL injury seems to increase the risk of developing osteoarthritis tenfold compared to an age-matched uninjured population. Associated meniscectomy further doubles the risk.

There is considerable controversy regarding management of young patients with isolated medial compartment osteoarthritis and concomitant ACL deficiency. Whatever the treatment, the aim should be to offer a procedure that will give lasting relief of symptoms and will not compromise any future surgical requirements. Various options have been described, including arthroscopic debridement, reconstruction of the ACL, high tibial osteotomy with or without ACL reconstruction, unicompartamental knee arthroplasty and total knee replacement (TKR). Arthroscopic procedures alone tend to give only temporary relief of symptoms. Reconstruction of the ACL may be indicated in patients complaining primarily of instability, but does not address the degenerative process. High tibial osteotomy, with or without ACL reconstruction, may improve the patient’s symptoms but does not completely abolish pain, and lateral compartment osteoarthritis is a common sequel. Unicompartamental knee arthroplasty, in isolation (using both fixed and mobile bearings) provides disappointing long-term results when the ACL is deficient. TKR is not an ideal
option because of concerns over implant wear, loss of bone stock and associated reduction in activity.

A procedure which has not been described in detail previously is unicompartmental knee arthroplasty in conjunction with reconstruction of the ACL. If the patients are young and active it is advantageous to use a device with a low rate of wear, such as the Oxford unicompartmental knee arthroplasty. When this device was used in ACL-deficient knees, it had an unacceptably high rate of failure and was therefore considered to be contraindicated in these circumstances. However, the majority of failures were because of tibial loosening, which tended to occur early, with a 21% rate of revision observed by two years. It was proposed that this loosening may have resulted from eccentric or increased loading caused by posterior femoral subluxation or instability. It was reasoned that if the posterior subluxation and instability could be prevented by reconstruction of the ACL, it might reduce the incidence of tibial loosening in this setting.

This paper presents the early results of Oxford unicompartmental knee arthroplasty in patients with isolated medial compartment osteoarthritis and concomitant ACL deficiency, in whom ligament reconstruction was undertaken as either a combined or staged procedure.

Patients and Methods
We prospectively evaluated 15 consecutive patients with primary ACL deficiency and concomitant symptomatic osteoarthritis of the medial compartment who were treated with unicompartmental knee arthroplasty and ACL reconstruction between January 1999 and June 2003 (ACLR group). Patients underwent this procedure and were included in the study only if they had severe symptoms and would otherwise have been considered for TKR or osteotomy. In all cases radiographs of the knees were taken preoperatively (Fig. 1). On the lateral radiograph the defect on the tibia, if visible, extended to the posterior margin, indicating that the ACL was deficient (Fig. 1b). Valgus stress radiographs in 20° of knee flexion demonstrated that the lateral compartment cartilage was of full thickness (Fig. 1c) and that the intra-articular varus deformity was correctable, indicating that the medial collateral ligament was...
functionally normal. In addition, nine patients had MR scans and six had arthroscopies.

Each patient in the ACLR group was matched for age, gender and follow-up with a patient who had undergone Oxford unicompartmental knee arthroplasty for anteromedial arthritis with an intact ACL (ACLI group). This provided a baseline against which clinical scores could be compared, and allowed a detailed radiological assessment of factors such as pathological femoral subluxation, which might lead to failure. All patients were independently assessed and both clinical and radiological data were collected. The instruments for clinical assessment were the Oxford Knee score, the Knee Society score, both objective and functional, and the Tegner activity level score. We used the Oxford Knee score with a minimum of 0 (worst outcome) and a maximum of 48 (best outcome). The mean follow-up was 2.8 years (2.5 to 4.3) for the ACLR group and 2.7 years (2.3 to 4.4) for the ACLI group. Based on previous experience, tibial loosening should have been observed by this time if it were to be a major problem.

**Surgical technique.** The clinical management for each patient with an ACL-deficient knee was selected according to the presenting symptoms. When pain was the main complaint, a simultaneous ACL reconstruction and Oxford unicompartmental knee arthroplasty were performed under the same anaesthetic (four patients). Where instability was the main complaint, the ligament reconstruction was performed as a primary procedure to stabilise the joint. If this procedure alone did not adequately relieve the symptoms a subsequent unicompartmental arthroplasty was undertaken (11 patients). There were two patients who achieved good relief of symptoms from the ACL reconstruction alone and thereby avoided subsequent unicompartmental arthroplasty. They were not included in the cohort of 15 patients.

For the two-stage procedure, the ACL was reconstructed using a standard arthroscopic technique with a four-strand hamstring autograft. The graft was fixed using round headed cannulated interference screws (Smith and Nephew, Huntingdon, United Kingdom). The Oxford unicompartmental knee arthroplasty was subsequently implanted using the standard minimally-invasive technique. The mean time between ACL reconstruction and unicompartmental arthroplasty was nine months (3 to 36).

For the first single-stage procedure, the ligament reconstruction was performed arthroscopically using a four-
stranded hamstring autograft. The Oxford unicompartmental knee arthroplasty was then implanted using the standard technique. For the subsequent three single-stage procedures the ligament reconstruction and unicompartmental arthroplasty were performed through a slightly longer incision, which extended from the upper pole of the patella to the tibial tubercle along the medial border of the patellar ligament. The central third of the patellar ligament was identified and a 10 mm bone-tendon-bone graft was harvested. The tibial tunnel was drilled through the tibial defect of the donor site of the graft aiming to exit centrally in the intercondylar eminence to avoid impinging on the tibial component or the lateral wall of the intercondylar notch. The femoral tunnel was drilled in the standard fashion. The bone-tendon-bone graft was pulled through the tunnel and fixed in the femoral tunnel using an interference screw. The Oxford unicompartmental knee arthroplasty was then implanted using the standard minimally-invasive technique. Finally, the bone-tendon-bone graft was secured to the tibia and the wound was closed (Fig. 2). Post-operative rehabilitation was undertaken as for a primary Oxford unicompartmental knee arthroplasty.

**Radiological assessment.** Post-operative radiographs were taken using an image intensifier. The anteroposterior (AP) film was aligned so that the x-ray beam was parallel to the tibial component. The lateral view was aligned so that both femoral condyles were superimposed. To assess radiolucencies on the AP radiograph, the tibial interface was divided into three sections; medial to the keel, around the keel and lateral to the keel. In each region the radiolucencies were measured for extent and width and the values corrected for magnification (Matlab version 7.0.0, The Math Works Inc., Natick, Massachusetts). The radiolucencies were classified as physiological or pathological, based on the descriptions given by Tibrewal et al. Physiological radiolucencies are not indicative of loosening, whereas pathological radiolucencies and tibial subsidence are. Because the radiographs were taken in a standardised fashion, subsidence could be readily detected by comparing the post-operative and subsequent films. The relative position of the femoral component on the tibial implant was assessed using the lateral radiograph. A perpendicular line was dropped from the centre of the spherical femoral component on to the tibial base plate. The distance between the perpendicular and the back of the keel (x) was measured and was expressed as a percentage of the length of the keel (y) (Fig. 2b). The position of the femoral component with respect to the tibial component was dependent on the angle of knee flexion, which was measured to confirm that the two groups were comparable. The angle of knee flexion was the angle between the tibial axis, defined by a line drawn along the posterior border of the diaphysis of the tibia, and the femoral axis, a line drawn along the posterior border of the diaphysis of the femur. The t-test was used for statistical analysis with a level of significance of \( p = 0.05 \).

**Results**

**Clinical assessment.** The two groups were closely matched for age at surgery, gender, and time of follow-up (Table I). All clinical scores for both groups were found to improve post-operatively (Table II). At the last follow-up, the ACLR group had a mean Oxford knee score of 46 (37 to 48), an objective Knee Society score of 99 (95 to 100), and a functional Knee Society score of 96 (85 to 100) and a Tegner score of 3.8 (3 to 6). All the patients in this group had an excellent outcome according to the Knee Society score criteria (\( \geq 85 \)). These results are significantly better than the scores achieved by the ACLI group (Table II). For the ACLR group the mean range of movement improved from 117˚ (90˚ to 120˚) pre-operatively to 130˚ (125˚ to 145˚) at last follow-up, and from 115˚ (85˚ to 125˚) to 130˚ (110˚ to 135˚) for the ACLI group. For the ACLR group the mean fixed flexion deformity improved from 2.4˚ (0˚ to 10˚) pre-operatively to 1.3˚ (0˚ to 5˚) at last follow-up, compared with 2.8˚ (0˚ to 10˚) to 0.9˚ (0˚ to 5˚), respectively, for the ACLI group.

<table>
<thead>
<tr>
<th>Table II. Knee scores</th>
<th>Pre-operative scores (mean (range))</th>
<th>Last follow-up scores (mean (range))</th>
<th>Relative change (mean)</th>
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<tr>
<td></td>
<td>ACLR</td>
<td>ACLI</td>
<td>ACLR</td>
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<td></td>
<td>Difference</td>
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<td>Difference</td>
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<tr>
<td>Oxford Knee score(^{10})</td>
<td>29 (17 to 36)</td>
<td>26 (17 to 35)</td>
<td>NS</td>
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<tr>
<td>Objective Knee Society score(^{11})</td>
<td>55 (25 to 83)</td>
<td>55 (25 to 73)</td>
<td>NS</td>
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<tr>
<td>Functional Knee Society score(^{11})</td>
<td>85 (65 to 90)</td>
<td>80 (55 to 90)</td>
<td>NS</td>
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<td>Tegner(^{12})</td>
<td>1.6 (1 to 3)</td>
<td>1.1 (1 to 2)</td>
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\(^{*}\) ACLR, anterior cruciate ligament reconstruction; ACLI, intact anterior cruciate ligament; NS, not significant
Radiological assessment. There was no significant difference (p = 0.41) in the relative position of the femoral and tibial components between the groups. In the ACLR group the centre of rotation of the femoral component was a mean of 35% (25% to 45%) anterior to the back edge of the keel, whereas in the ACLI group it was a mean of 39% (25% to 54%) anterior to this reference point. There was also no significant difference (p = 0.07) in the mean angle of knee flexion at which the radiographs were taken (ACLR 1° (0˚ to 12˚); ACLI 70 (0˚ to 10˚)).

No patient in either group had evidence of component subsidence or pathological radiolucencies to suggest loosening. There was, however, a significantly lower (p = 0.01) incidence of physiological radiolucencies in the ACLR group (1 of 15) than in the ACLI group (7 of 15). The single radiolucency in the ACLR group was incomplete and was not present medial to the keel. In the ACLI group, four radiolucencies were complete and three were partial.

Complications. There was one patient in the ACLR group who developed a post-operative infection and subsequently underwent a two-stage revision to a TKR. This patient had a combined arthroscopically-assisted ACL reconstruction using hamstring tendons and a unicompartmental knee arthroplasty. No patient in the ACLI group had a significant complication.

Discussion
This study has demonstrated that combined anterior cruciate ligament reconstruction and Oxford unicompartmental knee arthroplasty is technically feasible and provides good short-term results. The mean Oxford Knee score was 46 post-operatively for the ACLR group, which was higher than the mean score of any other unicompartmental or TKR or high tibial osteotomy series of which we are aware. It is likely that this unusually high score partly reflects the youth and level of the activity of the patients, but also suggests that their knees are functioning very well. Surprisingly, the Oxford Knee score was higher than the score of the age-matched patients having a unicompartmental knee arthroplasty in the presence of an intact ACL. This is probably not clinically important as the improvement in the Oxford Knee score was the same for both groups.

The main concern about this combined procedure is long-term survival of the implant. With an intact ACL the Oxford medial unicompartmental knee arthroplasty has achieved survival rates in excess of 90% at ten and 15 years in many series.17,18 Even in patients under 60 years of age the survival was greater than 90% at ten years.15 However, in the ACL-deficient knee the results have been less satisfactory. In the only published series of medial Oxford unicompartmental arthroplasty there were 28 cases, of which six failed before two years. The most common cause of failure was tibial component loosening.6 It seems that reconstruction of the ACL has prevented the failures associated with ACL deficiency.8 In our current series, no adverse radio-

logical signs were observed in relation to tibial component fixation. In addition, the radiological measurements suggest that, at least in the unloaded knee, there is no pathological posterior femoral subluxation to cause eccentric loading and therefore loosening of the tibial component. If failure due to ligament instability can be avoided the most important failure mechanism in this young and active patient group will be wear. A retrieval analysis and an in vivo study using the Oxford unicompartmental knee arthroplasty have demonstrated that, provided the components are implanted correctly, the wear rate is one or two hundredths of a millimetre per year.7,19

The decision whether to combine ACL reconstruction with unicompartmental knee arthroplasty depends partly on whether the primary disorder is ACL deficiency or arthritis of the medial compartment. In primary medial arthritis in the presence of an intact ligament, the erosion is located anteriorly and centrally on the tibial plateau, giving rise to the term anteromedial osteoarthritis.20 This is the ideal situation for unicompartmental knee arthroplasty as the rest of the knee tends to be in good condition. As the degenerative process progresses, the ACL may rupture secondarily and the tibial erosion extends posteriorly. This tends to be associated with other changes in the knee such as shortening of the medial collateral ligament and progression of the arthritis to the lateral compartment. Therefore, in primary medial compartment arthritis with secondary rupture of the ACL, we believe that combined ligament reconstruction and unicompartmental knee arthroplasty is not usually appropriate because of the other associated changes. These patients, who are usually elderly, are best treated with a TKR.

In contrast, in cases of primary traumatic ACL rupture with secondary arthritis of the medial compartment, the cartilage defect and bony erosion tend to be central and posterior on the tibia, (posteromedial osteoarthritis). This is likely to be due to recurrent episodes of giving way, in which posterior femoral subluxation in the medial compartment places a heavy load on the posterior meniscus and posterior articular cartilage of the tibia, producing meniscal tears and the development of arthritis. In some cases the rest of the knee joint remains essentially intact, with no shortening of the medial collateral ligament. This is probably because, in extension, the intact distal femoral cartilage is in contact with intact anterior tibial cartilage, so the varus deformity is corrected and the medial collateral ligament is of normal length. It is in these patients, who are often young, that we would perform a combined anterior cruciate reconstruction followed by unicompartmental knee arthroplasty.

Depending on the presenting symptoms, the combined procedure can be done in one or two stages. We now perform the one-stage procedure ‘open’ as we feel an arthroscopically-assisted ACLR increases the risk of infection. For the one-stage procedure we now favour using a bone-tendon-bone graft rather than a hamstring graft for two
reasons: first, it provides stronger initial fixation, and so may help correct any femoral subluxation, and secondly the tibial tunnel can be drilled through the donor site in the tibial tubercle, which being slightly lateralised is less likely to cause a fracture of the medial tibial plateau.\footnote{21}

Our most surprising observation was the lower incidence of physiological radiolucencies in the ACLR group than in the ACL group. With well-aligned x-rays, this type of radiolucency is commonly seen and is of no clinical significance as it is not related to symptoms or loosening. We are unable to explain the different incidence in the two groups. A detailed comparison of the stresses beneath the tibial component in cases with intact and reconstructed ACL may provide the explanation.

Although the combined procedure is ideally suited to the young and recreationally active, there is a concern that the excellent function may result in high physical demands on the knee, even when the patient is advised to restrict their activities.\footnote{22} It is therefore necessary to inform the patient of the risk of failure, even though revision to a TKR is relatively easy.\footnote{23}

The short-term results of ACL reconstruction combined with an Oxford unicompartmental knee arthroplasty are good. All patients have an excellent clinical outcome. Although there is a concern about long-term failure, the radiological results suggest that the failure rate will be similar to that achieved in ACLI knees. We therefore believe that our combined approach is a viable option for young active patients with symptomatic medial compartment arthritis in whom the ACL has been disrupted.

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References