Assessment of osteoarthritis after reconstruction of the anterior cruciate ligament

A STUDY USING SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY AT TEN YEARS

We used single-photon emission computed tomography (SPECT) to determine the long-term risk of degenerative change after reconstruction of the anterior cruciate ligament (ACL). Our study population was a prospective series of 31 patients with a mean age at injury of 27.8 years (18 to 47) and a mean follow-up of ten years (9 to 13) after bone-patellar tendon-bone reconstruction of the ACL. The contralateral normal knee was used as a control. All knees were clinically stable with high clinical scores (mean Lysholm score, 93; mean Tegner activity score, 6). Fifteen patients had undergone a partial meniscectomy and ACL reconstruction at or before reconstruction of their ACL.

In the group with an intact meniscus, clinical symptoms of osteoarthritis (OA) were found in only one patient (7%), who was also the only patient with marked isotope uptake on the SPECT scan compatible with OA. In the group which underwent a partial meniscectomy, clinical symptoms of OA were found in two patients (13%), who were among five (31%) with isotope uptake compatible with OA. Only one patient (7%) in this group had evidence of advanced OA on plain radiographs.

The risk of developing OA after ACL reconstruction in this series is very low and lower than published figures for untreated ACL-deficient knees. There is a significant increase (p < 0.05) in degenerative change in patients who had a reconstruction of their ACL and a partial meniscectomy compared with those who had a reconstruction of their ACL alone.

Patients and surgeons are concerned about the risk of degenerative change after reconstruction of the anterior cruciate ligament (ACL). Unfortunately, current evidence does not clearly define the role of reconstruction of the ACL in the prevention of degenerative change, although an increased risk is seen in untreated ACL-deficient knees, a risk which has been quoted to be as high as 44% at 11 years. Further studies of the natural history of unstable knees would now be difficult to repeat.

It is known that early stabilisation after rupture of an ACL reduces the risk of future meniscal injury. Symptomatic ACL-deficient knees are more likely to have chondral lesions if associated with a meniscal tear, further increasing the risk of osteoarthritis (OA). ACL reconstruction may, therefore, have a protective effect upon articular cartilage, but this has yet to be shown. The quoted prevalence of degenerative change after reconstruction of the ACL, measured by plain radiographs, ranges between 10% and 87%. Unfortunately, many of these studies are weakened by variables such as the type of operation, whether notchplasty was also undertaken and the severity of the knee injury. Studies have shown that early reconstruction of the ACL reduces the development of OA when compared with late reconstruction. However, there is one study by Daniel et al which compared the risk of OA after reconstruction of the ACL with unreconstructed ACL-deficient knees. They concluded that reconstruction actually increased the risk of degenerative change, a finding disputed by many surgeons.

The work by Daniel et al is weakened because the reconstructed patients had a more severely-injured knee than those who were unreconstructed and the method of reconstruction varied, incorporating procedures which are no longer used.

Accurate measurement of articular cartilage degeneration depends on the sensitivity and specificity of the investigation used. Plain radiographs cannot identify early degenerative change. MRI is very sensitive and specific for meniscal and ligamentous lesions but poor for articular cartilage pathology. Arthroscopy is sensitive and specific for the articular surface.
but is unable to recognise early subsurface pathology; it also requires a general anaesthetic and is an invasive procedure. A radioisotope bone scan is very sensitive to degenerative change, measuring increased subchondral metabolic osseous activity before clinical symptoms and changes on plain radiographs or at arthroscopy appear.\textsuperscript{15}

In order to help clarify the relationship between reconstruction of the ACL and the risk of degenerative change, we studied the subchondral metabolic osseous activity of knees at a mean of ten years after a successful reconstruction of the ACL, undertaken by a single surgeon, with the same operation and rehabilitation.

**Patients and Methods**

**Patients.** We included 31 patients with an unstable ACL injury (clinical symptoms of instability and a positive pivot shift test),\textsuperscript{16} reconstructed by the senior author (GSED). There were 21 men and ten women; all patients (mean age 27.8 years) were followed up for a mean of ten years (9 to 13) after reconstruction of the ACL. All had arthroscopic bone-patellar tendon-bone reconstruction without notchplasty.\textsuperscript{17}

We excluded patients with a chondral lesion at operation and multiple ligamentous injuries as they had a higher risk of developing later OA. The contralateral uninjured knee was used as a control. Patients with a contralateral knee injury or operation were also excluded.

Our original database of consecutive patients who underwent a reconstruction of their ACL by the senior author began in 1990 as part of a prospective follow-up. We selected the first 60 patients from this database in order to provide the longest follow-up. We excluded 29 patients for the reasons detailed in Table I. All patients were clinically scored with the Lysholm and Tegner activity scoring systems.\textsuperscript{18} The Tegner activity scale contains 11 levels of work- and sports-related activities: 0 to 3 (daily activities), 4 to 6 (physical fitness, sports and heavy work-related activities), 7 to 10 (competitive sports).\textsuperscript{18} The Lysholm score evaluates both knee symptoms (disability) and physical finding (impairment) to a maximum of 100 for a normal knee. Their meniscal status at the time of reconstruction of the ACL was recorded.

**Plain radiographs.** Weight-bearing anteroposterior, lateral and skyline views were performed and graded using the Ahlback\textsuperscript{19} system by a blinded consultant radiologist. Each of the three compartments was scored between 0 (no osteoarthritis) and 3 (more than 50% joint-space narrowing).

**Radioisotope scan.** Single-photon emission computed tomography (SPECT) of the injured and control knees was performed three hours after injection of 740 MBq of Tc-99m MDP. Imaging was performed using a 128 x 128 matrix, 62 stops, 30 seconds per stop on a triple-headed gamma camera (Philips Irix; Philips Medical Systems, Surrey, UK). This

<table>
<thead>
<tr>
<th>Exclusion criteria</th>
<th>Number of patients excluded (n = 29)</th>
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<tbody>
<tr>
<td>Chondral injury</td>
<td>10</td>
</tr>
<tr>
<td>Pregnant or attempting to conceive</td>
<td>3</td>
</tr>
<tr>
<td>Contralateral knee injury</td>
<td>3</td>
</tr>
<tr>
<td>Ipsilateral knee surgery</td>
<td>2</td>
</tr>
<tr>
<td>Ipsilateral other knee injury</td>
<td>1</td>
</tr>
<tr>
<td>Unwilling to take part</td>
<td>2</td>
</tr>
<tr>
<td>Unable to attend (living abroad)</td>
<td>3</td>
</tr>
<tr>
<td>Serious post-operative knee injury</td>
<td>1</td>
</tr>
<tr>
<td>Lost to follow-up</td>
<td>4</td>
</tr>
</tbody>
</table>

**Table II.** Results for the anterior cruciate ligament (ACL) reconstructed group with an intact meniscus (n = 15)

<table>
<thead>
<tr>
<th></th>
<th>ACL-reconstructed knee</th>
<th>Control knee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Lysholm score\textsuperscript{18}</td>
<td>96 Limit by other knee</td>
<td>Limited by other knee</td>
</tr>
<tr>
<td>Mean Tegner score\textsuperscript{18}</td>
<td>6 Limit by other knee</td>
<td>Limited by other knee</td>
</tr>
<tr>
<td>Clinical OA* – number (%)</td>
<td>1 (7)</td>
<td>0</td>
</tr>
<tr>
<td>Severe radiographic OA – number</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
| OA on SPECT\textsuperscript{1} scan – number (%) | 1 (7)   | 0 | * OA, osteoarthritis \[
|                                               | f SPECT, single-photon emission computed tomography |

**Table III.** Results for the anterior cruciate ligament (ACL) reconstructed group which underwent a meniscectomy (n = 16)

<table>
<thead>
<tr>
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<th>ACL-reconstructed knee</th>
<th>Control knee</th>
</tr>
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<tbody>
<tr>
<td>Mean Lysholm score\textsuperscript{18}</td>
<td>95 Limit by other knee</td>
<td>Limited by other knee</td>
</tr>
<tr>
<td>Mean Tegner score\textsuperscript{18}</td>
<td>7 Limit by other knee</td>
<td>Limited by other knee</td>
</tr>
<tr>
<td>Clinical OA* – number (%)</td>
<td>2 (13)</td>
<td>0</td>
</tr>
<tr>
<td>Severe radiographic OA – number</td>
<td>1 (7)</td>
<td>0</td>
</tr>
<tr>
<td>OA on SPECT\textsuperscript{1} scan – number (%)</td>
<td>5 (31)</td>
<td>0</td>
</tr>
</tbody>
</table>
was reconstructed using ordered subset iterative reconstruction and displayed for reporting as transverse, coronal and sagittal slices. The images were reported by a blinded consultant in nuclear medicine (JB) with ten years of experience in reporting radioisotope images of knees. Uptake was graded 0 to 3 in each compartment: 0, normal; 1, mild, almost normal; 2, moderate, but not compatible with OA; 3, marked, compatible with OA.

**Statistical analysis.** Statistical advice recommended that the results were analysed with a non-parametric test, the Mann-Whitney U test, on 30 consecutive patients. The study was approved by the local ethics committee which included assessment according to the regulations of the National Radiation Guideline Committee. It was funded through central government. Values for p < 0.05 were used to indicate statistical significance.

**Results**
All knees were clinically stable with a mean Lysholm score of 93 (79 to 100; maximum 100) and a mean Tegner activity score of 6 (6 to 8).

We separated patients according to their meniscal status at the time of ACL reconstruction into two similarly-sized groups, 15 with intact menisci and 16 who underwent a meniscectomy and ACL reconstruction. The control knees in both groups had neither clinical symptoms, nor radiographic signs of OA, nor increased uptake on SPECT scan (Tables II and III).

In the group with an intact meniscus (Table II), clinical symptoms of OA were found in one patient (7%), who was one of two (13%) with plain radiographic evidence of OA (Fig. 1) and was the only patient (7%) with evidence of OA on the SPECT scan (Fig. 2).

In the group which underwent a meniscectomy (Table III) clinical symptoms of OA were found in two patients (13%), who were among seven (44%) with plain radiographic evidence of OA and five (31%) with evidence of OA on the SPECT scan (Fig. 2). Only one patient (7%),
who was part of the meniscectomy group, had evidence of advanced OA (Ahlback score of 3) on plain radiographs. This patient's SPECT was severely affected (Fig. 3).

The distribution of the SPECT scores is shown in Figure 2, with a statistically significant difference when an isolated reconstruction of the ACL was compared with ACL reconstruction and partial meniscectomy (p < 0.05).

Discussion
The relationship between reconstruction of the ACL and the risk of osteoarthritis is controversial for several reasons. First, the development of OA and ACL reconstruction may be the result of the initial injury to the subchondral bone, and hyaline and meniscal cartilages. Secondly, the measurement of the severity of OA is difficult, particularly in the early stages. Lastly, clinical symptoms do not always correlate with imaging or the arthroscopic assessment of OA. This results in many areas of disagreement in the management of ACL injuries.

There are many studies which have added to the knowledge of the relationship between reconstruction of the ACL and OA. However, most include too many variables and make interpretation of the results difficult. There is strong evidence that meniscal injury and initial chondral injury can lead to OA in unstable knees. Recent evidence suggests that women older than 30 years of age are more likely to develop OA after reconstruction of the ACL.

There is also some evidence that acute bone bruises and a delay in reconstructing the ACL increase the risk of OA. Other important variables, albeit unconfirmed, may include: the type of reconstruction, presence of a notchplasty with damage to the articular surface, the expertise of the surgeon performing the reconstruction and activity levels of the patient after reconstruction. If these variables are controlled, the final measurement of degenerative change will depend upon the sensitivity of the investigation used to measure OA and the time which has elapsed since the reconstruction.

In our study, most of these variables were controlled, except for meniscal injury which we analysed separately. All patients had high Tegner activity scores. None had chondral injuries at arthroscopy and none had undergone a notchplasty. However, pre-operative MRI scans were not routinely performed and we could not exclude bone bruising. The reconstruction was performed by one surgeon using one technique and post-operative rehabilitation involved accelerated mobilisation.

Radionuclide scanning is a highly sensitive method of identifying early degenerative changes. The validity of SPECT for OA of the knee was first confirmed in 1985 and subsequently by others. Compared with planar scintigraphy, SPECT increases image contrast and improves the detection and localisation of lesions. The assessment of early OA by plain radiography is difficult, the presence of osteophytes being regarded as the most reliable indicator. However, the bone dust and debris which is produced during an intra-articular reconstruction of the ACL may be responsible for generating osteophytes and result in a falsely high diagnosis rate of early OA on plain radiographs. We, therefore, categorised the presence of OA on plain radiographs as an Ahlback score of greater than 1 in the worst affected compartment.

The increased uptake on SPECT scan was low for the majority of patients in our study. The scans were reported by a consultant in nuclear medicine with ten years' experience of using one of the highest resolution scanners in the United Kingdom. Such low-intensity uptake on SPECT indicates increased metabolic activity of indeterminate cause. It is clear that major surgery on the knee is unlikely to return the knee to normality and, therefore, some increased metabolic activity is to be expected.

OA on SPECT scan is present when there is markedly increased isotope uptake (grade 3 in our method) in any of the three compartments of the knee (Fig. 4). Using SPECT, our prevalence of OA at ten years after reconstruction of the ACL was 7% if the menisci were intact and 31% if a partial meniscectomy was performed. This is considerably lower than the published prevalence of radiographic OA in unreconstructed ACL-deficient knees. Most studies quote rates for advanced OA. For example, Noyes et al referred to “joint space narrowing and significant subchondral sclerosis” as evidence of advanced OA in 44% of their patients. If the same criteria to describe OA had been used in our study, then only one patient (7%) would have demonstrated the plain radiographic changes of advanced OA.
One limitation of our study is the absence of acute MRI scans of the injured knees. MRI is a sensitive investigation for bone bruises, which may later result in an increased risk of OA. This may explain the one patient in the group with an intact meniscus who developed clinical OA. However, the natural history of bone bruises is not yet known and they may actually be benign.

Radionuclide scanning has only been used for the assessment of OA after reconstruction of the ACL in one other study. This concluded that reconstruction increased the risk of OA. However, the knees in this study had multiple pathologies, different stabilisation techniques and chondral injury. Our more tightly standardised study reveals a very low risk of OA ten years after ACL reconstruction suggesting that reconstruction protects against later OA. We thus encourage other workers to use the highly sensitive SPECT scan as a valuable tool in order to further resolve this controversial issue.

Supplementary Material

A further opinion by Mr Derek Bickerstaff is available with the electronic version of this article on our website at www.jbjs.org.uk

We wish to thank Dr Robert Wilkins, Consultant Radiologist, and Richard Morris, Statistician, for their invaluable help with this study.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References