We report the mid-term results of a new patellofemoral arthroplasty for established isolated patellofemoral arthritis. We have reviewed the experience of 109 consecutive patellofemoral resurfacing arthroplasties in 85 patients who were followed up for at least five years.

The five-year survival rate, with revision as the endpoint, was 95.8% (95% confidence interval 91.8% to 99.8%). There were no cases of loosening of the prosthesis. At five years the median Bristol pain score improved from 15 of 40 points (interquartile range 5 to 20) pre-operatively, to 35 (interquartile range 20 to 40), the median Melbourne score from 10 of 30 points (interquartile range 6 to 15) to 25 (interquartile range 20 to 29), and the median Oxford score from 18 of 48 points (interquartile range 13 to 24) to 39 (interquartile range 24 to 45). Successful results, judged on a Bristol pain score of at least 20 at five years, occurred in 80% (66) of knees. The main complication was radiological progression of arthritis, which occurred in 25 patients (28%) and emphasises the importance of the careful selection of patients. These results give increased confidence in the use of patellofemoral arthroplasty.

Isolated patellofemoral arthritis is a well-recognized variant of the osteoarthritic knee.\(^1\) McAlindon et al\(^2\) drew attention to the frequency of this condition in 1992 and recently, Davies et al\(^3\) found that 9.2% of 209 patients attending an orthopaedic outpatient clinic for painful arthritis of the knee had radiological evidence of isolated patellofemoral osteoarthritis. We are increasingly recognising trochlear dysplasia as a cause of patellofemoral disease in younger patients.

Surgical treatment by arthroscopic chondrectomy, chondral grafting and a variety of procedures to correct malalignment has had a varying degree of success in the management of this condition.\(^4,5\) Fulkerson\(^4\) described excellent short-term results from anteriorisation of the tibial tubercle, but there was a tendency for symptoms and function to deteriorate with time, with the results at ten years often showing progression of the arthritic process.\(^5\)

Patellofemoral arthroplasty has been available for approximately 50 years. The earliest designs of implant were crude attempts to resurface either the patella or the trochlea.\(^6\) It was not until the 1970s that several designs gave reasonable short-term results.\(^7,9\) Residual malalignment of the patella and wear of polyethylene were recurring problems, which were found in up to 30% of cases.\(^10-13\) Progression of arthritic disease in either the medial or lateral compartments was also regularly encountered by many authors.\(^8,10-15\) In 2001, Tauro et al\(^13\) described such progression in 8% of patients at eight years and in 2003 Kooijman et al\(^14\) reported progression in 23% of patients at 15 years. Cartier et al\(^15\) noted good results for the Richards model II and III prosthesis (Smith and Nephew, Memphis, Tennessee), but by 11 years the survivorship had decreased to 75% because of progression of tibiofemoral arthritis. These longer term studies have shown excellent and long-lasting functional results in more than 50% of patients.\(^13-15\) Kooijman et al\(^14\) recorded good or excellent functional results in 86% of residual cases at 15 years. Nevertheless, the results do not match those obtained for total knee replacement (TKR), and therefore a new arthroplasty was developed based on a better understanding of patellofemoral kinematics and design. The early results have shown a low rate of complications and good function.\(^16\) We now wish to record the mid-term results of the first three-year prospective series of patients treated with this implant.
Patients and Methods

Prosthesis and technique. The Avon design (Stryker Howmedica Osteonics, Allendale, New Jersey) was developed from the Kinemax Plus patellofemoral articulation (Stryker Howmedica Osteonics) introduced in the late 1980s, which had a rate of patellofemoral complications of 0.3%. The femoral component has a broad symmetrical trochlear flange, which allows relatively unconstrained movement of the patella in extension and attempts to reproduce the normal trochlear anatomy, relying on dynamic muscle balancing rather than a deep constrained groove to maintain patellar stability. The trochlear groove narrows around the arc of flexion so that the patella engages in the groove and becomes more stable as the knee flexes. The patellar component is manufactured from ultra-high-molecular-weight polyethylene with a medially offset dome of 3 mm to facilitate patellar tracking (Fig. 1). The technique of implantation has been published previously and is described in detail on the manufacturer’s website.

An important part is the soft-tissue balancing which is essential to correct any lateral retinacular contracture. This involves release of the lateral patellofemoral synovial folds and a peripatellar release of the retinaculum from the lateral edge of the patella with preservation of the soft-tissue retinacular envelope. In the first year of implantation only a medium-sized component was available, but in the second and third years this was increased to three sizes. More recently, an extra-small size of component has been introduced. The post-operative management has changed over the years and there is now an accelerated regime. The wound is infiltrated with bupivacaine 0.5% with adrenaline 1/200 000, and suction drains are not required. The leg is elevated on two pillows at 30˚ with active rehabilitation commencing on the first post-operative day. Intermittent ice therapy and anti-inflammatory medications are used to reduce discomfort.

Selection criteria. The patients were selected carefully to ensure that there was no co-existent tibiofemoral arthritis. The tibiofemoral joint was assessed by both anteroposterior and lateral weight-bearing radiographs, and a standing tunnel view at 30˚ of flexion is now our preferred choice. The patellofemoral joint was appraised by a tangential view at 30˚ of knee flexion. Initially, treatment was only undertaken in patients with advanced patellofemoral arthritis. As confidence in the procedure grew, we extended the indications to include younger patients with earlier disease and trochlear dysplasia, and those with arthritic changes in whom a previous re-alignment procedure had failed.

The study. A prospective clinical study commenced in September 1996, since when 424 patellofemoral arthroplasties have been performed in 322 patients. Although most of the operations were performed by the senior authors (CEA, JHN), more than 20 consultant surgeons and trainees contributed cases to the study. The prospective nature of the study results in the number of patients available at each review interval changing constantly. We therefore decided to report the first three-year cohort of patients that had been followed for over five years. Between September 1996 and November

Table I. Pre-operative diagnoses in the 109 knees

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of knees (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral facet osteoarthritis</td>
<td>70 (64)</td>
</tr>
<tr>
<td>Symmetrical osteoarthritis</td>
<td>33 (30)</td>
</tr>
<tr>
<td>Medial facet osteoarthritis</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Dislocation and osteoarthritis</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Post-traumatic osteoarthritis</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Total</td>
<td>109 (100)</td>
</tr>
</tbody>
</table>

Table II. Pre-operative radiological changes at the patellofemoral joint in 109 knees

<table>
<thead>
<tr>
<th>Radiological changes</th>
<th>Number of knees (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral subluxation</td>
<td>76 (70)</td>
</tr>
<tr>
<td>Lateral tilt</td>
<td>9 (8)</td>
</tr>
<tr>
<td>Medial subluxation</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Patellar joint narrowing</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Gross cartilage loss</td>
<td></td>
</tr>
<tr>
<td>Lateral facet</td>
<td>47 (43)</td>
</tr>
<tr>
<td>Medial facet</td>
<td>10 (9)</td>
</tr>
<tr>
<td>Both facets</td>
<td>30 (28)</td>
</tr>
</tbody>
</table>

Table III. Previous surgery in the 109 knees

<table>
<thead>
<tr>
<th>Previous surgery</th>
<th>Number of knees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthroscopy</td>
<td>15</td>
</tr>
<tr>
<td>Lateral release</td>
<td>2</td>
</tr>
<tr>
<td>Chondrectomy</td>
<td>3</td>
</tr>
<tr>
<td>Patellar realignment</td>
<td>2</td>
</tr>
<tr>
<td>Fixation of fracture</td>
<td>1</td>
</tr>
<tr>
<td>Nil</td>
<td>86</td>
</tr>
</tbody>
</table>
1999, 109 consecutive patellofemoral arthroplasties were performed in 85 patients, 10 men and 75 women, with a mean age of 68 years (46 to 86). The pre-operative diagnosis and radiological findings are shown in Tables I and II and indicate that nearly 70% of cases had involvement of the lateral facet of the patella. Previous surgical procedures had been performed on 23 knees (Table III). The clinical details and diagnoses were recorded pre-operatively, and an ongoing prospective review was undertaken at eight months, two years, five years and eight years.

Functional scoring was performed using the Bristol pain and knee, the Melbourne patellar and the Oxford knee scores. We used the Oxford score with a minimum of 0 for the worst outcome and a maximum of 48 for the best outcome. A full radiological series of the knee was taken pre-operatively, post-operatively and at each review. The clinical reviews were carried out by the research physiotherapist and nurse, consultant surgeons, knee fellows, and by postal questionnaire in 11 patients who were unable to attend the clinic. The results were entered into the knee database which was administered by a dedicated research secretary. Life-tables and Kaplan-Meier curves were constructed.

Results
Patients were followed for a mean of 5.2 years (5 to 8). Ten patients (12 knees) died during this period, but none of these had had revision. Five patients (seven knees) were lost to follow-up leaving 90 knees (70 patients) in the study. Seven patients (seven knees) were too ill to attend for formal evaluation; thus 83 knees (63 patients) were available for assessment.

The functional outcome scores showed considerable improvement for pain, patellar function and knee function. The median Bristol pain score improved from 15 of 40 (interquartile range (IQR) 5 to 20) points pre-operatively to 35 (IQR 20 to 40) at five years (Fig. 2), the median Melbourne patellar score from 10 of 30 points (IQR 6 to 15) to 25 (IQR 20 to 29) and the median Oxford knee score from 18 of 48 points (IQR 13 to 24) to 39 (IQR 24 to 45) (Fig. 3).

Establishing a measurement of success of any prosthesis is imprecise. If the results are judged using a Bristol score of ≥20 points, then 80% (66) of joints had a successful result at five years. If an Oxford knee score of ≥25 points is used, then 78% (65) of patients were judged to be satisfactory at five years.

There were six early complications (6.5%) including two cases of delayed wound healing, two of post-operative haemarthrosis requiring evacuation by arthroscopy, one manipulation under anaesthesia for stiffness and one case of synovial inflammation. The condition of the articular cartilage and menisci of the knee was recorded at the time of the operation. The medial meniscus was normal in all patients as was the anterior cruciate ligament in all but one. Three lateral menisci were abnormal (frayed or split). There were minor chondral lesions in the tibial plateaux in seven knees. In 48 knees (44%) some chondral abnormalities of Outerbridge grade I or grade II were noted on the femoral condyles. Isolated femoral chondral lesions of less than 1 cm in diameter, were accepted and treated by localised chondrectomy.

Establishing a measurement of success of any prosthesis is imprecise. If the results are judged using a Bristol score of ≥20 points, then 80% (66) of joints had a successful result at five years. If an Oxford knee score of ≥25 points is used, then 78% (65) of patients were judged to be satisfactory at five years.

There were six early complications (6.5%) including two cases of delayed wound healing, two of post-operative haemarthrosis requiring evacuation by arthroscopy, one manipulation under anaesthesia for stiffness and one case of synovial inflammation. All the early complications resolved satisfactorily (Table IV). One patient had patellar
instability, and a distal soft-tissue realignment procedure was performed, with a fair result (pain score > 20). No knees were revised for problems associated with the patellofemoral arthroplasty itself and there have been no cases of deep infection, wear, loosening or fracture. In 25 patients, (28%) radiological progression of osteoarthritic disease of either the medial or lateral compartments of the tibiofemoral joint was noted. Revision was required in four knees (4.2%) within the first five years because of such progression, giving a survivorship of 95.8% (95% confidence interval (CI) 91.8% to 99.8%) with 90 knees at risk at five years (Fig. 6, Table V). There were 11 further revisions after five years. If all patients lost to follow-up were treated as failures, the worst case outcome is 90.3% (95% CI 84.6% to 96%).

If the thresholds for moderate and severe pain (a pain score < 20) were included as outcome criteria in addition to revision for progression of the disease, the five-year survivorship was 88% (95% CI 80.9% to 94.1%).

Discussion
The Avon patellofemoral arthroplasty gave satisfactory results at five years with no evidence of functional deterioration as judged by the outcome criteria. The development of smaller incisions and accelerated rehabilitation are likely to improve the recovery with a reduction in the rate of early complications. Problems of maltracking, and wear of the patellar component noted in previous designs were reduced. In spite of the fact that 70% of cases had pre-operative lateral malalignment with subluxation, post-operative patellar instability which required additional treatment was recorded in only one knee. This is a much lower figure than in our previous series using the Lubinus implant (Waldemar Link, Hamburg, Germany).
Improved patellar tracking was the result of several factors. The broad shallow proximal trochlea of the prosthesis accommodated the various positions of the patella in full extension. The ability to engage the patella with increasing stability in flexion, and the placing of the trochlea so that it is introduced in slight external rotation and lateral translation on the femur, is an important feature which accommodates the lateral malalignment that exists in many of these patients.

The broad shallow trochlear means that careful balancing of the soft tissues is essential, and this avoids the problems with trochlear designs which have a deep groove that allow larger articular surface contact. These designs require accurate placement of the prosthetic trochlear groove depending on the position of the patella in the particular patient, and will allow no accommodation of the dynamic characteristics of tracking in the conscious active patient.14,15

The development of more refined soft-tissue releases preserved the integrity of the knee capsule while lengthening the tight retinacular structures that contributed to lateral malalignment. In our opinion, the subperiosteal peripatellar release of the lateral retinacular contracture at the lateral border of the patella was particularly important. This avoided the need for a destructive mid-lateral release in most cases.

There appeared to be no need to restrict function after the arthroplasty and the outcome scores showed successful restoration of function which was maintained at least to five years. Comparison with other series of patellofemoral arthroplasties and with TKR was difficult because of the use of different scoring systems, and the fact that the widely used American Knee Society score23 is insensitive to patellofemoral function, open to bias and has poor repeatability.21 We used a separate pain score which seemed to show satisfactory results. We have also used the Oxford Knee score which is well validated and shows results at five and eight years which were similar to those of unicompartmental replacement.26

Our first 109 cases were for well-established and often quite advanced patellofemoral osteoarthritis which had been present for many years. There were a few cases with persistent or recurrent pain, the main cause of which is arthritic disease progression in the tibiofemoral joint. Previous series have recorded this complication occurring in up to 10% of patients.13-15 Tauro et al13 in 2001 recorded an 8% progression rate in patients undergoing the Lubinus prosthesis at eight years, while Kooijman et al14 recorded 23% progression with the Richards Model II prosthesis at 15 years. The present series recorded radiological disease progression in 25 patients (29%). Although there have been only four revisions for this cause at five years, and the survivorship curve for disease progression (Fig. 6) shows only a slow deterioration, there were 11 more revisions by eight years.

A detailed radiological study of our cases with progression of disease by Nicol et al27 showed that progression in the tibiofemoral joint was more common than expected in contrast to the findings after unicompartmental arthroplasty. The changes documented in the articular cartilage at operation showed that over 40% of the femoral condyles had some surface damage, which may account for the high rate of arthritic progression. In retrospect, our original indications for patellofemoral arthroplasty were too general. Further investigation is required to identify factors which predispose to progression of the disease. Pre-operative bone scanning or MRI may define those patients with isolated patellofemoral degeneration.

It has become apparent that many younger patients with significant patellofemoral arthritis have some trochlear dysplasia. Therefore, our indications have expanded to include younger patients with earlier disease and also as a salvage procedure in patients who have failed to benefit from other surgical procedures. Patients with persistent dislocation,
early arthritic damage with malalignment and post patellofemoral syndrome have also been treated successfully.28

Some authors have suggested that patellofemoral arthritis should be treated by TKR. The series of Mont et al29 and Laskin and van Steijn30 have shown satisfactory results, and present persuasive arguments for this approach. However, they compare their outcomes with those of older published series with different functional scoring systems, which do not give an adequate comparison. Component arthroplasty has many advantages, especially in younger patients who have failed to respond to more conservative surgery, since limited bone resection is undertaken. If necessary, revision surgery to a TKR is straightforward.

The results of our series give increased confidence in isolated patellofemoral arthroplasty. We are continuing to review this series and intend to report longer term results in the future. The precise indications for the procedure need to be refined, but our experience suggests that it can probably be extended to younger patients with trochlear dysplasia and considerable lateral malalignment with arthritic damage. However, a larger series with longer follow-up of younger patients is required before this can be generally recommended. Progression of arthritic disease in the tibiofemoral joint remains a potential hazard. Careful selection of patients is required to avoid this complication, particularly since patients over 70 years of age are likely to have a satisfactory long-term result with TKR.

We would like to thank colleagues for referring patients for treatment to the Bristol Knee Group. We would like to thank Ms Susan Miller, the Knee Research Secretary, who has made a major contribution to the study in managing the database and co-ordinating patient follow-up.

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

References