PATIELLAR RESURFACING OR RETENTION IN TOTAL KNEE ARTHROPLASTY

A PROSPECTIVE STUDY OF PATIENTS WITH BILATERAL REPLACEMENTS

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Patellofemoral problems are a common cause of morbidity and reoperation after total knee arthroplasty. We made a prospective study of 52 patients who had bilateral arthroplasty (104 knees) and in whom the patella was resurfaced on one side and not on the other. A movable-bearing prosthesis with an anatomical femoral groove was implanted on both sides by the same surgeon using an otherwise identical technique. The mean follow-up was 5.24 years (2 to 10).

In the 30 available patients (60 knees) there was no difference between the two sides in subjective preference, performance on ascending and descending stairs or the incidence of anterior knee pain. Radiographs showed no differences in prosthetic alignment, femoral condylar height, patellar congruency or joint line position.

The use of an appropriate prosthetic design and careful surgical technique can provide equivalent results after knee arthroplasty with or without patellar resurfacing. Given the indications and criteria, which we discuss, retention of the patellar surface is an acceptable option.

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The management of the patella in total knee arthroplasty (TKA) is controversial. The incidence of patellar pain in early designs of tibiofemoral replacement led to recommendations for patellar resurfacing (Freeman, Swanson and Todd 1973; Insall, Scott and Ranawat 1979; Cameron and Fedorkow 1982; Soudry et al 1986; Freeman et al 1989), but these tricompartmental replacements had problems of component wear, loosening, fracture, ligament and tendon ruptures, maltracking and anterior knee pain. Patellofemoral problems, seen in 5% to 30% of contemporary tricompartmental designs, have become a major cause of morbidity and reoperation in TKA with patellar resurfacing. Selective retention of the patella has been recommended more recently (Scott and Reilly 1980; Abraham et al 1988; Shoji, Yoshino and Kajino 1989; Keblish and Greenwald 1990) although there are still potential problems of maltracking and anterior knee pain.

Large, complex forces are transmitted through the normal quadriceps-patellar tendon (QPT) mechanism to the femur and upper tibia, and after a TKA, knee kinematics are altered. Changes may be subtle or extreme, and the addition of patellar resurfacing may be ill-advised. Femoral component design should take into account the patellar articulation whether or not the patella is resurfaced.

The influence of prosthetic design on patellar function must be considered in evaluating the results, since many designs are used, with varying geometry (Ranawat, Insall and Shine 1976; Insall et al 1979; Scott 1979; Scott and Reilly 1980; Kaufer and Matthews 1981; Ranawat, Rose and Bryant 1981; Ranawat 1986; Enis et al 1990; Boyd et al 1993).

We used a prosthesis with an anatomical femoral design and mobile tibial and patellar bearings (LCS, Depuy, Warsaw, Indiana) (Fig. 1). The same surgeon (PAK) performed bilateral TKA, resurfacing the patellar on one side only. This eliminated the variables of demography, disease, technique and design which influence the outcome in retrospective or less controlled comparative studies.

PATIENTS AND METHODS

We reviewed the results of bilateral TKA on 59 patients (118 knees), performed consecutively as a prospective
study with informed consent. Five patients had died before the minimum two-year follow-up, and two had been excluded because different prostheses had been implanted. The remaining 52 patients (104 knees) were reviewed clinically and radiologically.

There were 16 men and 36 women; their mean age was 67.8 years (39 to 87), mean height 164.8 cm (144.8 to 182.9) and mean weight 82.3 kg (50.5 to 113.6). The preoperative diagnosis was osteoarthritis in 44 patients, rheumatoid arthritis (RA) in six, and post-traumatic arthritis in two. Five knees had previously had a high tibial osteotomy, four in the bicompartamental and one in the tricompartmental group.

The mean follow-up was 5.28 years (2.1 to 10.4) for the bicompartamental group and 5.20 years (2.5 to 8.3) for the tricompartmental TKAs. All the operations had been performed by the senior author (PAK), using the LCS knee prosthesis. Twelve knees had bicruciate-retaining meniscal bearings, 65 had posterior-cruciate-retaining meniscal bearings, and 27 had the rotating-platform cruciate-sacrificing tibial design. Size-specific anatomical femoral components were used. The components were uncemented, porous-coated in 88 knees and cemented (textured surface) in 16 (ten tricompartmental and six bicompartamental).

Surgical approaches and soft-tissue releases varied according to specific needs, but a medial parapatellar approach was used on knees in varus or neutral alignment, and varus knees were balanced by performing an upper tibial sleeve release. Formal lateral releases were required in less than 10% of cases. The 12 knees with valgus deformity of more than 10° were operated on through a lateral approach (Keblish 1991) and therefore had an extended lateral release as part of the procedure. The balance of the QPT mechanism and patellofemoral tracking were determined at trial reduction with temporary reattachment of the soft-tissue sleeve.

Fifty-one patellae were resurfaced using an LCS metal-backed, anatomical, rotating-bearing patellar component (Buechel and Pappas 1989; Buechel, Rosa and Pappas 1989; Buechel, Pappas and Makris 1991). One patella was resurfaced with a cemented non-metal-backed dome component because the patella was too small to accommodate the rectangular base plate of the LCS patellar replacement.

The 52 patellae which were not resurfaced were treated by a patellaplasty which consisted of:

1) soft-tissue release from the lateral patella to avoid tilting;
2) division of the patellofemoral ligament when it was tight;
3) patellar rim cautery to provide partial denervation;
4) multiple drilling of the articular surface to decompress the subchondral bone; and
5) osteophyte removal to allow better seating of the patella on the trochlea of the femoral component (Keblish and Greenwald 1990).

**Clinical evaluation.** Preoperative and postoperative evaluation was performed by an independent examiner, using a 100-point (modified Hospital for Special Surgery) scoring system with points for pain (30), function (25), range of motion (15), deformity (12), stability (10) and...
strength (8) (Buechel 1982). Postoperative reviews were at 6 weeks, 3 months, 6 months, 1 year, and every year thereafter. In addition to this clinical evaluation, patients were asked to evaluate their subjective preference, their ability to climb stairs, their preferred leading leg while ascending or descending stairs, and the presence of anterior knee pain.

Radiographs were taken at each clinical review, including a standing anteroposterior (AP) view on a 14" x 17" film, flexion and extension lateral views on 10" x 12" films, and a ‘skyline’ view of the patella with 45° knee flexion on a 10" x 14" film. Other special views were taken as necessary. We used the Knee Society’s radiological evaluation system (Ewald 1989) to assess preoperative and postoperative alignment of the knee and the prosthesis, measuring $\alpha$, $\beta$, $\Omega$, $\gamma$, and $\sigma$ angles and radiolucent zones (Fig. 2). The angles $\alpha$ and $\beta$ represent the AP alignment of the femoral and tibial components, respectively. The angle $\Omega$ gives the overall alignment. The angles $\gamma$ and $\sigma$ represent alignment in the lateral plane of the femoral and tibial components, respectively. Midmedullary lines through the femur and the tibia were taken as reference points. Using the method of Figgie et al (1986, 1988) measurements of femoral condylar height and joint line were obtained preoperatively ($Z+W$) and postoperatively ($Z'+W'$) (Fig. 3).

The radiological assessment of patellar tracking after TKA has been difficult to quantify by the techniques of Merchant et al (1974), Laurin et al (1978) and Laurin, Dussault and Lévesque (1979) and one of us (AKV) therefore devised a more objective method. This is briefly explained and illustrated in Figure 4 and has been valuable in assessing individual films and serial or comparative skyline views. It is practical and reproducible and provides a quantitative comparison.

RESULTS

The main results of the comparative study are summarised in Table I. Knee rating scores (Buechel 1982) were 89.9 for the whole series, 89.2 for the bicompartamental TKA group, and 90.1 for the tricompartamental TKA group. We found no significant differences between the two groups in terms of pain, function, or ranges of knee flexion and extension. The mean postoperative range of motion (ROM) was 110.7° for the tricompartamental and 110.1° for the bicompartamental TKAs. There were no apparent differences in clinical function, patellar tracking, quadriceps muscle power or hamstring muscle power between the two groups.

Subjective preference. Many current knee-scoring systems (Ranawat and Shine 1973; Ranawat et al 1976; Buechel 1982; Ewald 1989) do not include some parameters which are necessary to compare bilateral TKAs, such as subjective preference in terms of pain and stair climbing. Thirty of our 52 patients were available for an in-depth interview regarding subjective preference, stair ascent and descent, and the presence of anterior knee pain. When asked to report if one knee ‘felt better’ than the other, 14 expressed no preference, nine preferred the knee with a tricompartamental TKA and seven preferred the knee with a bicompartamental TKA. Of the 14 who had no preference for either knee, ten led with either leg.
The midline of the femoral groove is marked to identify the ideal track on the femoral component; this is point A. The highest points on the lateral and medial condyles are marked as B and C, respectively. Perpendicular lines (AA', BB' and CC') are dropped to a horizontal line. The lowermost point of the patella is marked as point D, and another perpendicular line, DD' is dropped to the horizontal. The ratios shown then provide a percentage measure of congruent contact. Lateral shift of the patella is designated as a positive value and medial shift as a negative value. Ideal tracking, when D is in the same line as A, is 100%.

### Table II. Comparison of ideal prosthesis alignment angles (degrees) with mean alignment angles achieved in the two groups treated with or without patella resurfacing

<table>
<thead>
<tr>
<th>Angle</th>
<th>Ideal</th>
<th>Range</th>
<th>TKA, patella retained</th>
<th>TKA, patella resurfaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>95</td>
<td>93 to 97</td>
<td>96.66</td>
<td>95.87</td>
</tr>
<tr>
<td>Beta</td>
<td>90</td>
<td>87 to 93</td>
<td>88.19</td>
<td>88.43</td>
</tr>
<tr>
<td>Omega</td>
<td>4 to 5 valgus</td>
<td>3 to 7 valgus</td>
<td>5.34</td>
<td>4.83</td>
</tr>
<tr>
<td>Gamma</td>
<td>0</td>
<td>+4 (flexion) to −4 (extension)</td>
<td>+2.87</td>
<td>+3.74</td>
</tr>
<tr>
<td>Sigma</td>
<td>82</td>
<td>85 to 90</td>
<td>82.41</td>
<td>83.22</td>
</tr>
</tbody>
</table>

when ascending or descending stairs, two always led with the bicompartamental side and two with the tricompartmental. Of the nine who preferred the tricompartmental TKA, six led with either leg on stairs, and three preferred to lead with the tricompartmental side. Of those who preferred the bicompartamental TKA, four led with either leg on stairs and three with the bicompartamental side.

**Patellofemoral pain.** No patient reported bilateral anterior knee pain. Six knees had minimal anterior pain which did not limit daily activities; three were tricompartmental and three bicompartamental. Two patients in each group had expressed preference for the contralateral knee when using stairs and one in each group had expressed no preference for either knee.

**Radiology.** The radiological results are summarised in Table II and illustrated in Figure 2. Alignment of the femoral and tibial components was not statistically different between the bicompartamental and the tricompartmental procedures. The mean preoperative mechanical axis (Ω angle) averaged −1.7° (varus). Twelve knees had been in valgus alignment (> 10°), the others had been neutral or in varus.

**Femoral condylar height.** The mean change in femoral condylar height was +3.25 mm, meaning that the femoral component was 3.25 mm larger than the preoperative height of the femoral condyles. There was no significant difference between the bicompartamental group (3.27 mm) and the tricompartmental group (3.23 mm).

**Joint line.** Postoperatively, the mean proximal shift of the joint line was 2.74 mm (−7 to +13). In the tricompartmental group, the joint line had been moved proximally by 3.52 mm (−7 to +12) and in the bicompartamental group by 1.98 mm (−4 to +13; p > 0.05).

**Patellar tracking.** Postoperative patellar tracking was considered to be clinically satisfactory in all cases. Using the radiological method described above, the average congruence was 95.8% for the whole series. In the bicompartamental procedures, this was 97.3% (100 to 80),
and 72% of the patellae had 100% congruent tracking. In the tricompartmental group, the mean tracking was 94.3% (100 to 50), and 62% of patellae showed 100% congruent tracking (p > 0.05; Fig. 4).

None of the patients in our series has required revision for patellofemoral problems, and there were no cases of patellar subluxation or dislocation, rupture of the patellar or quadriceps tendon, or loosening or dissociation of the metal-backed, rotating-bearing patellar component. Two TKAs required revision for other reasons. One tricompartmental TKA was revised at eight days for malposition of the tibial component. This patient needed a tibial-bearing exchange five years later when the rotating patellar component was found to be intact and functioning. Her latest knee score was 90. The second revision was of a bicompartamental TKA for aseptic loosening of the tibial component at seven years. At the revision, the patella was seen to track normally with its remodelled articular surface covered by fibrocartilage. The patient had had no patellofemoral pain. The patella was not resurfaced, and her latest knee scores were 95 on the (revised) bicompart- mental side and 90 on the tricompartmental side.

One resurfaced patella had a spontaneous undis-
placed fracture of the fracture bed. The patient was a young woman with severe RA, who was dependent on steroids and methotrexate and had poor bone quality. A cemented dome patella with no metallic backing had been used because the metal-backed rotating bearing was too large. She developed a painful knee effusion within six months of operation and the radiographs showed a stellate fracture of the patellar remnant. She was treated conservatively and radiographs five years later showed improvement, with bony consolidation around the patellar prosthesis. This knee, however, remains 'at risk'. Her opposite, bicompartamental knee has remained symptom-free.

DISCUSSION

Patellofemoral problems are the major cause of reopera-
tion after TKA (Scott and Reilly 1980). The complications include patellar subluxation or dislocation, anterior knee pain, and QPT rupture. Complications after resurfacing also include wear of the polyethylene (Wasilewski and Frankl 1989), fracture (Windsor, Scuderi and Insall 1989), cold flow, composite dissociation (metal-backed units), and prosthetic loosening (cemented or cementless). The factors which influence outcome include soft-tissue balance, bone-bed quality, blood supply, joint-line location, patellar position, and prosthetic design.

Biomechanics and patellar function. The patella acts as a dynamic fulcrum for transmission of forces generated by the QPT mechanism. The normal patella tracks in an anatomical trochlea on the anterior distal femur. The mechanism increases the lever arm of the QPT and facilitates knee extension increasing the force of extension by as much as 50% (Zappala, Taffel and Scuderi 1992). The patella also protects the quadriceps and patella
tendons from friction, transmits forces through hyaline cartilage interfaces and protects the distal femoral condyles. It has a proprioceptive role.

The forces acting at the patellofemoral joint are large: Reilly and Martens (1972) estimated compressive forces of over 4000 N, increasing with knee flexion. Kaufer and Matthews (1981) pointed out that patellar height, thickness and length alter the loads and change the contact points substantially from flexion to extension. In the normal knee, a lateral resultant force is produced by the quadriceps mechanism, its magnitude depending upon individual anatomy and soft-tissue balance. Exces-

sive lateral forces may cause patellar subluxation or dislocation and contribute to component failure. Patellar biomechanics may be altered significantly after femoral-tibial resurfacing.

Patellar resurfacing. In the early to mid 1970s, patellar resurfacing was not usual. Most knee prostheses had no anterior flange and the patella was essentially ignored until it became apparent that 20% to 40% of patients were experiencing anterior knee pain (Ranawat et al 1976; Freeman et al 1989). These symptoms were treated by various methods including patellectomy (Bargen et al 1976) and realignment procedures (Ranawat et al 1981).

In 1975, the 'dome' patella was developed at the Hospital for Special Surgery (Aaglietti et al 1975) primarily to treat patellofemoral arthritis and severe chondromalacia patellae. The original design used cobalt-chrome alloy (Insall et al 1979), but a polyethylene version was then used with the Total Condylar knee as an optional procedure. Dome resurfacing decreased patellar-related complications from 25% to 5%, and this led to recommen-
dations that patellar resurfacing should become standard practice (Insall et al 1979; Ranawat et al 1981; Leval, McLeod and Freeman 1983; Ranawat 1986). Patellar resurfacing increased during the 1980s, but the large number of problems reported (Vince and McPherson 1992; Levitsky et al 1993) has rekindled interest in patellar retention.

Design. In the early knee prostheses little attention was paid to the design of the patellar groove. Fixed-bearing hinges, such as the Guepar, had a high rate of patellar dislocation (Mochizuki and Schurman 1979) because of the narrow flange and lack of provision for axial rotation. Second-generation knee replacements provided no groove (ICLH) or an inadequate groove (Stanmore) for patellar tracking. The Total Condylar knee gave a smooth concave groove with a non-anatomical femoral condyle. Newer generations of TKA designs, however, provide a more anatomical femoral condylar geometry. Extreme designs such as the flat non-constrained and the severely con-
strained with deep flanges are becoming less popular. This means that comparative studies in which prostheses such as the duopatellar implant were used, with its non-
anatomical femoral component (Boyd et al 1993) must be considered to be design-specific and to have no general relevance.
Elias, Freeman and Gokcay (1990) studied the geometry and anatomy of the distal femur, and concluded that the radius of the patellar groove of the femur is a single arc with an angle of 90°. The femoral component of the LCS prosthesis which we used (Buechel and Pappas 1989) follows this geometry through the first 108° of knee flexion. The femoral component, therefore, presents the non-resurfaced patella with a near anatomical articular surface, and this may have contributed to the excellent clinical and radiological patellar tracking which we have found.

Remodelling of the patella. The normal patella does not articulate uniformly with the femoral trochlea (Insall, Tria and Scott 1979); different areas of the articular surface come into contact with the femoral condyles at different phases of knee motion. After knee arthroplasty, the articular surface of the patella must adapt to the geometry of the femoral component. This gradual process requires minimal biological remodelling if the patella is exposed to an anatomical design with a constant curve and uniform femoral geometry. Non-anatomical designs require excessive remodelling.

Remodelling has been referred to as stress contouring (Smith, Stuart and Pinder 1989) and is a biological response producing gradual adaptation of the articular surface to the trochlea and the condyles of the femoral component (Fig. 5). The changes are gradual and become apparent radiologically at two or more years after TKA. Excessive patellar stresses may lead to abnormal remodelling with less good results, and these are more likely to occur with non-anatomical femoral flanges.

Patellaplasty. Several options are available when a non-resurfaced patella is retained. The patellaplasty which we describe has been used routinely by the senior author (PAK) for the past 12 years. Various aspects of this technique have been described for conditions such as chondromalacia patellae, osteonecrosis, and patellar subluxation (Sisk 1992) and we believe that this enhances biological remodelling. Merkow, Soudry and Insall (1985) have reported a high incidence of patellar subluxation or dislocation in valgus knees. For such knees we used a lateral approach with an extended lateral release, and this appears to have eliminated patellar maltracking (Keblish 1991).

Figgie et al (1986, 1988) using the Total Condylar design correlated proximal displacement of the joint line with an increased incidence of patellofemoral problems. We found small proximal movement of the joint line in our cases with no statistical difference between the two groups. In two knees, one in each group, proximal movement of the joint line by more than 10 mm was associated with excellent scores.

The nerve supply to the patella has been investigated extensively (Halata et al 1984; Halata, Rettig and Schulze 1985; Kanatani, Hirohata and Umetani 1986; Badalamente and Cherney 1989; Wojtys et al 1990). The presence of substance-P fibres and Ruffini and Pacinian corpuscles is documented, and although their exact role is uncertain, it may include pain/pressure reception, and possibly proprioception. This provides another argument for patellar retention.

Previously published reports suggest that patients experience better pain relief and functional performance with resurfaced patellae (Enis et al 1990; Boyd et al 1993; Levitsky et al 1993), but we found no subjective preference.

Reuben et al (1991) reported that patellar strain is increased and tensile strength is decreased by 30% to 40% after coronal plane osteotomy for resurfacing. The decreased thickness increases the risk of fracture, especially if there is pre-existing osteopenia. The problem becomes worse when extensive lateral releases are required which further devascularise the QPT mechanism. In rheumatoid arthritis the patella is often small and osteopenic, and therefore at risk. Patellar resurfacing has been recommended in these patients because of the fear that antigen in the retained articular cartilage might perpetuate the inflammatory disease (Sledge and Ewald 1979). In our series the six rheumatoid patients had good results, apart from the one fracture of a resurfaced patella. Indications and contraindications. A near-normal appearance and contour of the patella favour its retention,

Fig. 5
Comparative skyline radiographs of an 84-year-old man with clinical scores of 97 points for each knee. The patient continues to be an active ice dancer. Patellar function and tracking are comparable 7 and 10 years after replacement.
and are commonly cited by those who advocate selection (Scott and Reilly 1980), although no published study has related these criteria to a better functional outcome. There are no absolute criteria for patellar resurfacing but we give some guidelines in Table III. At operation, the decision on patellar management should be deferred until trial tibial and femoral components are in place. Movement through the full arc of extension/flexion then allows an accurate evaluation of the patellofemoral articulation, and helps to influence the decision.

Conclusions. If the prosthesis is suitable, and if technical and radiological criteria are met, the non-resurfaced patella performs as well as the resurfaced patella.

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REFERENCES


