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The Patellofemoral Joint in Total Knee Arthroplasty

Is the Design of the Trochlea the Critical Factor?

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Abstract: The outcome at 10 years is reported of a prospective study of 2 cohorts of total knee arthroplasties treated with (center A) or without (center B) patellar replacement. The same tibiofemoral components were used in all knees. The cohorts were demographically similar. A total of 124 patellae were treated by replacement, and 143 were treated without replacement. The clinical outcome and the patellofemoral revision rates were the same in the 2 cohorts: 1 patient required analgesia for anterior knee pain after replacement, and 1 without replacement required patellar replacement for pain. In the replaced group, patellofemoral survival on a best-case scenario was 100% at 10 years; on a worst-case scenario, 96%. One of the unreplaced patellae had been resurfaced for pain by 10 years. In view of the satisfactory and similar outcomes with and without replacement, we suggest that an appropriate design for the prosthetic trochlea, rather than the replacement or otherwise of the patella, is the main determinant of patellofemoral outcome in total knee arthroplasty. Patella replacement may be optional. Desirable trochlea design features are described.
Key words: total knee arthroplasty, outcome, patella, trochlea.

Ten years ago, total knee arthroplasty suffered from a relatively high incidence of complications associated with the patellofemoral joint [1,2]. This disappointing feature of what was otherwise a successful procedure led to debate as to whether or not the articular surface of the patella should be replaced and, in the event of replacement, exactly how this was to be done. The present study compares the outcome of patellar replacement versus no replacement using the same tibiofemoral prosthesis. Additionally (and not as planned at the outset), the results form a basis for suggestions as to how the trochlear surface might best be designed.

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Material and Methods

Prosthesis

The Freeman-Samuelson prosthesis (Sulzer Orthopaedics AG, Zug, Switzerland) was designed as a modification of the ICLH prosthesis in 1980. The floor of the trochlear surface is circular as viewed from the side and inset into the anterodistal femur. Proximally the anterior flange of the prosthesis and the medial and lateral shoulders are extended sufficiently to engage (even) a patella alta in full extension. The floor is continued posteriorly to roof the intercondylar notch as far as possible, commensurate with permitting access through the remaining notch to extract cement from the posterior femur.

These design considerations have been discussed elsewhere [3,4] and are illustrated in Fig. 1.

The patellar prosthesis is reciprocal in shape to that of the trochlea and is saddle-shaped, providing area contact with the femoral component except in full extension. The prosthesis is designed to be inset and has been fixed either with or without cement [3].

Patients

This study is based on 332 consecutive uninfected Freeman-Samuelson total knee arthroplasties operated on between January 1982 and March 1987. These knees have a potential 10- to 15-year follow-up and have been reviewed, if available, at 10 years.

The patients were operated on in 2 hospitals: The Royal London Hospital, United Kingdom (center A), and Hospital Malalties Reumatiques, Barcelona, Spain (center B).

At center A, the routine clinical policy was to resurface the patella. A total of 148 knees in 132 patients were operated on in this hospital. A total of 124 patellae underwent replacement using a component fixed without cement. The component was cemented in a further 12 knees because the state of the prepared patella (eg, the presence of a cyst in the cavity prepared in the patella) made cementless fixation uncertain. The patella was not resurfaced in 12 knees because the bone was judged to be too thin. In center B, the routine clinical policy was not to resurface the patella. Osteophytes were removed until the bone was a reasonable fit for the trochlea. A total of 143 knees were treated in this fashion. A total of 41 patellae were replaced, 6 with cement and 35 without because the patella was too thin to be shaped to fit the trochlea. There are 2 cohorts for comparison: 124 knees in which the patella underwent cementless replacement in center A and 143 knees in which the patella was not replaced in center B.

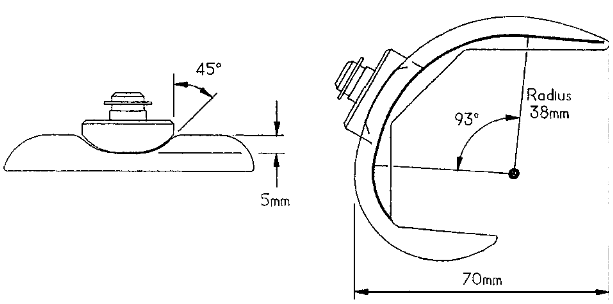

Fig. 1. In sagittal section, the anterior-distal trochlear floor is circular (radius, 38 mm; arc, 93°) and inset to replicate the location of the floor of the natural trochlea. Proximally the floor is extended to articulate with even the highest patella. Distally the floor covers the anterior half of the natural intercondylar notch. In profile, the lateral wall of the trochlea is 5 mm high and inclined 45° to the vertical. The patella is saddle-shaped to mate with the circular part of the trochlea.

Table 1. Demographic Data in the Patients Reviewed

	Patella Replaced, Center A	Patella Unreplaced, Center B
RA:OA	34:62	36:79
Male:Female	31:65	25:90
Age 30–59:>60	20:76	34:81

RA, rheumatoid arthritis; OA, osteoarthritis.

In the early 1980s, a technique of cementless press-fit tibiofemoral fixation was under evaluation at both hospitals. This technique failed [5–7] and was abandoned. Sixteen of the knees in center A and 15 in center B in which the tibiofemoral components had been fixed in this way failed as a consequence of aseptic loosening and required revision. None of these revisions was carried out as a direct consequence of patellofemoral failure, but the presence of tibiofemoral loosening made a precise evaluation of patellofemoral function impossible. One knee in center B was revised for anterior knee pain (see later).

In center A, 2 knees were lost to follow-up, and 10 patients died within 10 years. In center B, 4 knees were lost to follow-up, and 8 died. A total of 96 knees in center A and 115 knees in center B in which patellofemoral function could be assessed remained for review at 10 years. The demographic data for the patients in the 2 centers who were available for review are presented in Table 1. The 2 groups are similar with respect to diagnosis, gender, and age.

All knees were followed prospectively, clinically and radiologically at (in principle) 1, 2, 3, 4, 5, 7, and 10 years after surgery using standard protocols. Clinical and radiologic examinations were conducted and reviewed by surgeons independent of the operating surgeons. Patellofemoral function was assessed clinically by reference to anterior knee pain and the range of flexion. Radiologic assessment was made on lateral and skyline views, noting the presence of fractures, tracking and osteolysis or migration of the component (in the case of replaced patellae), or sclerosis and bone changes (in unreplaced patellae). Anterior migration of the component within the patella was determined by measur-

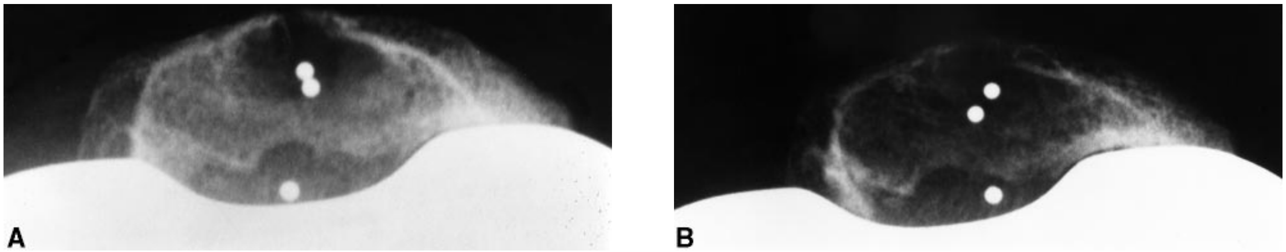

Fig. 2. Osteolysis in a patella in the replaced group. (A) 5 years after operation. (B) 7 years after operation.

ing the distance between the anterior patellar cortex and the radiopaque sphere in the patellar component (Fig. 2).

Survival analysis for the patellar prosthesis in knees treated without cement in center A was performed using the life-tables method as described by Armitage [8] and later established by Dobbs [9] and Tew and Waugh [10,11]. In the absence of a prosthesis, survival was not calculated for center B.

Results

Clinical Results

Anterior pain present at rest and unrelieved by analgesia was noted in 1 knee in the replaced group. Radiographs of this knee showed no abnormality, and no explanation was found for the pain. No treatment was given. One patient in the unresurfaced group had similar severe pain and 18 months after operation underwent a patellar resurfacing but experienced no pain relief. Nineteen patients (19 knees) complained of anterior pain not requiring analgesia. Seven (7%) of these patients were in the resurfaced group, and 12 (10%) were in the unresurfaced group. This difference is not statistically significant. The mean range of flexion preoperatively in the resurfaced group was 85° as compared with 100° in the unresurfaced group. The postoperative range at 1 year in the resurfaced group was 98° and in the unresurfaced group 99°.

Radiologic Results

One patella in the resurfaced group and 2 in the unresurfaced group made contact with the lateral side wall of the prosthetic trochlea, not with the floor. All other prostheses made contact with the floor of the trochlea.

The presence or absence of tilt among prostheses (or patellae) contacting the floor of the trochlea could not be accurately assessed because the appearances changed from radiograph to radiograph (perhaps because sky-line radiographs were obtained at slightly different degrees of flexion). In the unreplaced group, no clear reference line could be established, whereas the absence of radiopaque cement in the replaced group made it difficult to establish the attitude of the prosthesis relative to the femur.

In the replaced group, 1 patella sustained a fracture at 12 years. Three patellae sustained fractures between years 1 and 4 in the unreplaced group. All 4 fractures were treated conservatively, leaving the patient with functioning extensor mechanisms and without a significant gap in the bone.

One prosthesis migrated anteriorly within the patella accompanied by osteolysis at 7 years (Fig. 2). The knee was symptomless but remains under review. No other patellae displayed osteolysis. Twelve patellae (10%) displayed increasing lateral sclerosis, suggesting the possibility of increased pressure between the lateral shoulder of the prosthesis and the patella. No symptoms could be associated with this change.

Revision Surgery

No revision was performed for clinical or radiologic patellar loosening in the resurfaced group. One patient with anterior pain in the unreplaced group (noted previously) underwent resurfacing but without relief of symptoms. The cause of this patient's pain remains unclear.

Sixteen knees that had undergone a press-fit cementless tibiofemoral fixation in center A were revised because of aseptic loosening of the tibia, femur, or both. Eleven knees with unreplaced patellae were similarly revised in center B. Of the 16 replaced patellae, the component was found to be rotationally loose (at operation) in 3 knees and was revised to cemented fixation. There was no radiographic evidence of patellar loosening before revision. In 7 knees, the patella was not loose but was revised nevertheless, along with the tibial and femoral components. In the remaining 6 knees, the patella was not revised: These had a satisfactory patellar outcome at review.

Survival

Survival for the patellar prosthesis fixed without cement at center A on a best-case scenario was 100% using revision (for patellar component loosening) as the endpoint. Considering loosening (as found in 3 patellae during revision carried out for aseptic loosening of the tibiofemoral components) as the criterion of failure, the survival was 97% (95% confidence interval, 94–100%; standard error, 2%). On a worst-case scenario (defining 2 patients who were lost to follow-up, the 3 patellae that were found to be loose at operation at the time of revision and the 1 migrated and radiologically loose patellar component that is under review as having failed), the survival at 10 years was 96% (95% confidence interval, 91.6–99.6%; standard error, 2%; 99 knees at risk in year 10). Exactly comparable figures cannot be calculated for center B because the same endpoint (revision for patellar component loosening) cannot be used. In center B, however, 143 knees entered the study, 1 was revised for anterior pain at 18 months, 4 were lost, and 115 were at risk in year 10. Using revision for (presumed) patellofemoral complications as the endpoint, survival on a best-case scenario in center B at 10 years was 99%. On a worst-case scenario (counting the 4 lost knees as failed), it was 95%.

Discussion

The 2 groups of knees on which a comparison of patellar replacement versus no replacement might have been based were significantly dissimilar: They were treated by different surgeons in different countries. This fact would have made it difficult for us to have based any conclusions on this study had the outcome in the 2 groups been different from each other or unsatisfactory. The outcome in the 2 groups is similar, however, and both are satisfactory compared with some reports in the literature. This finding leads us to the conclusions that, first, with the particular design of trochlear surface that we have used, there is no important difference between the outcome of replacing the patella with an unconventional method (an uncemented HDP patellar component) and not replacing it at all; second, both outcomes are satisfactory; and third, the outcome may depend not on the patellar surface of the patellofemoral joint but on the way in which the opposite surface, the trochlear surface of the femur, is reconstructed.

In 1982, when the first knees reported in this study were replaced, a technique of cementless fixation in which polyethylene was interfaced with bone was under evaluation by 1 of the authors. At the tibia, this technique failed, and as a consequence 31 knees originally in the groups now reported failed because of tibiofemoral loosening [5–7]. From the point of view of the patellofemoral joint, these knees did not fail and are treated here as if the patient had died. In 3 of these cases, the patellar component was found to be rotationally slightly mobile at reoperation, although the prerevision radiographic appearances were unremarkable. This finding raises the possibility that some of the patellar components in unrevised knees were also loose in this way, perhaps causing anterior knee pain. The cementless technique used in center A for the patella was clinically successful, with only 1 case of lysis in the patella (an observation that suggests the relatively constrained patellar component did not rotate against the bone itself and become abraded). We would today recommend that the component be cemented.

Most of the articles reporting patellofemoral complications describe the patella and its mode of replacement but do not describe the shape of the trochlea surface in the prosthesis used. Consequently, it is not possible to determine which shapes have and which have not been associated with patellar symptoms. In particular, the shape of the trochlea in sagittal section is often ignored even though the design is said to be *anatomic* [12,13]. We believe that the following features are important.

First, a number of patellofemoral joints have been designed with a discontinuity halfway along the floor of the trochlea represented by what is effectively a *corner* facing anterodistally. This feature comes about because the femoral bone cuts have included a limited anterodistal shamfer or because the use of a posterior stabilizing mechanism has resulted in a box in the femoral component intruding into the trochlear surface anterodistally. If the knee is imagined as a joint in which the femur rotates in a concave surface composed of the patella and tibia in combination (and on this analogy is comparable with the femoral head rotating in a concave acetabulum), it seems clear that such a corner may interfere with patellar tracking: Were a similar corner to be provided on the femoral head, the effect would be unsatisfactory.

Second, the prosthetic trochlear surface has often been terminated proximally at the level of the proximal extent of the articular cartilage on the natural femur. In the normal knee, the patella contacts the area of the suprapatellar pouch when the quadriceps are contracting in full extension and only just contacts the cartilage surface when the quadriceps relax. A prosthetic reconstruction imitating the natural knee results in a patella (replaced or otherwise) that is not engaged in the femoral prosthesis at the start of extension. The possibility then exists that tracking abnormalities could arise as the patella enters or fails to enter the trochlear groove. This situation mimicks that in the natural knee with recurrent patellar subluxation. In such knees, the defect has been shown to affect the lateral wall of the trochlea in its most proximal extent: It is not that such patellae enter a normal groove then dislocate, but rather that they do not securely enter the groove as flexion begins [14]. In general, once the patella is in the trochlea groove of the flexed knee, it is stable. In contrast, in the fully extended relaxed knee, the patella is mediolaterally mobile.

Third, the prosthetic trochlear surface frequently ends at or even proximal to the distal level seen in the natural knee. This ending comes about in an effort to provide maximal access through the reconstructed intercondylar notch to enable the surgeon to reach excess posterior cement or because of the use of a posterior stabilizing mechanism. In the natural knee in deep flexion, the patella tracks onto the medial and lateral shoulders of the intercondylar notch and is carried somewhat away from the femur by the backward displacement of the trochlea relative to the tibia during deeper degrees of flexion. In the prosthetic knee, it is hard to replicate the natural tracking mechanism on the shoulders of the intercondylar notch. In addition, if the femur is not adequately stabilized anteroposteriorly, it may sublux forward and be driven against the patella as it does so. We believe that the best that can be done to meet these difficulties is to extend the floor of the trochlea posteriorly as far as access to the posterior compartment of the knee allows.

In the light of this analysis, we believe that 4 features are essential for a successful prosthetic trochlear surface. First, viewed from the side, the trochlear surface over the loaded part of the flexion-extension range should be circular and inset into the anterodistal femur (as it is in the normal knee) [15,16]. Second, the surface should be extended proximally sufficiently to enable even the highest patella to articulate with the femur in full extension. This part of the femoral prosthesis should be provided with (at least) a lateral wall and floor to ensure that the patella remains in contact with the floor of the trochlea from 0° to 20° of flexion because it is within this arc that the natural patella may dislocate [12]. Third, the floor of the patellar groove should be continued posteriorly to roof the intercondylar notch, providing a surface against which the patella can articulate in full flexion. Fourth, the lateral wall of the trochlear groove should be sufficiently steep to provide a distinct resistance to lateral subluxation. It is not clear that a medial shoulder has any function.

The key to successful reconstruction of the patellofemoral joint is perhaps not so much the management of the patella itself but rather the design of the trochlear surface. With what we believe to be a suitably designed trochlear surface, we have shown that satisfactory results may be obtained with or without replacement of the patella, provided that the patella is not so thin as to make replacement impossible and that the bone can be shaped to fit the trochlea.

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