INTRODUCTION:

Weight-bearing at the patellar-femoral articulation in the knee is complex and patellar complications after total knee arthroplasty (TKA) remain a common reason for failure. Loads at the patello-femoral joint are approximately 3 times body weight during level walking and increase to approximately 7 times body weight at 90º of flexion. In the normal knee, the lateral facet carries a greater load than the medial facet. As the knee flexes from 0º to 90º during normal activities, the patellar surface contact area moves from inferior to superior and the patellar contact stresses increase.

Increased load bearing in the superior lateral region corresponds to the location of surface deformation (creep) noted on modified dome-shaped patellar components retrieved after revision TKA and at autopsy. It has been suggested that a fully congruent patellar component, with a larger contact area in flexion and a polyethylene articular surface that is free to rotate in the frontal plane (LCS design), will not experience similar deformation. However, mean contact stresses for fully conforming patellar components (LCS design) are approximately 3 times greater at 120º compared to 30º of flexion, similar to the magnitude measured for dome-shaped patella designs.

The purpose of this study is to correlate patterns of delamination on congruent mobile-bearing patellar components retrieved after more than 10 years in situ with patellar mechanics that existed after TKA.

METHODS:

Uncemented metal-backed patellar components were retrieved at revision surgery from 24 knees with meniscal bearing (22 knees) and rotating platform (2 knees) LCS mobile bearing prostheses (DePuy Orthopaedics). The mean patient age at revision was 75±11 years and the mean time in situ was 11±3 years (range, 4 to 15 years). Reasons for revision included bearing wear (10), patella wear (6), instability (3), pain (3), osteolysis (1), and unknown (1). The polyethylene tibial inserts included 22 meniscal bearing and 2 rotating platform designs. The polyethylene tibial and patellar components were sterilized using gamma radiation and stored in an air environment prior to implantation. All knees received the same uncemented femoral and tibial component designs, although the superior lateral surface was modified in 2 cases to accommodate the rotating platform inserts.

Articular surface damage on the retrieved patellar components was visually assessed using light microscopy. Wear severity was assessed on a scale of 0 to 3, with a score of 0 representing no wear, 1 representing <10% wear area, 2 representing 10% to 50% wear area, and 3 representing >50% wear area. The articular surface was divided into 4 quadrants and the location of delaminated regions was determined.

RESULTS:

Delamination on the polyethylene surface was noted on 21 (88%) of the retrieved patellae. The highest incidence of delamination was noted in the superior-medial and inferior-medial quadrants (Figure 1). The polyethylene patella was fractured in 5 (21%) knees, with the fracture plane oriented in the medial-lateral direction in each case (Figure 2). In addition, 10 patellae had a narrow band of subsurface delamination oriented along the superior-inferior axis on the extreme lateral edge of the articular surface. Subsurface cracks oriented along the medial-lateral axis were noted to originate from this region. The average delamination wear severity score was 1.9±1.1 (range, 0-3), including 6 patellae with severity 1, 6 patellae with severity 2, and 9 patellae with severity 3.

The original femoral and tibial components were left in situ in all knees at the time of revision, such that only the polyethylene tibial and patellar articulations were exchanged. Although severity was not evaluated, delamination was noted on 37 (84%) of the 44 tibial meniscal bearings, including 17 (39%) bearings with fractured articular surfaces. Delamination was also observed on the 2 meniscal bearing tibial components.

DISCUSSION:

Despite severe wear on the majority of the patellar and tibial polyethylene components, there was only a 5% incidence of osteolysis noted intraoperatively. Only exchange of the mobile bearing tibial and patella polyethylene components was necessary to alleviate clinical symptoms for these patients whose implants were retrieved after 4 to 15 years of in vivo function. The high incidence of delamination and brittle polyethylene fracture on the retrieved patellar components suggests that the contact stresses exceeded the yield strength of the material. This is likely due to the combined effects of 1) degraded materials properties due to oxidative changes associated with gamma sterilization in air, 2) a small area of contact between the patellar and femoral components, and 3) high compressive forces from the extensor mechanism.

In normal and implanted knees, the patella internally rotates (distal pole moves laterally) and shifts laterally with increasing knee flexion. The bearing surface geometry of the LCS patellar component is designed to accommodate this rotational motion, while allowing for full congruency in both 0º and 90º of flexion. However, the delamination patterns on the retrieved patellae in the current study are consistent with rotation into an incongruent bearing position during knee flexion, with presumably high contact stresses occurring in the superior-medial quadrant. These data suggest that the mobility of the polyethylene articular surface was compromised for some duration of in vivo function. In addition, more than 20% of the retrieved polyethylene patellae were fractured. As the knee flexes, the contact zone moves from distal to proximal. This cyclic compressive and tensile forces likely caused initiation and propagation of the cracks oriented along the medial-lateral axis.

Fully congruent mobile-bearing patella components must maintain mobility between the articular surface and metal back so that areas of incongruent contact, and associated high contact stresses and delamination, do not occur during in vivo function.