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ORIGINAL ARTICLE

The influence of patellar resurfacing on patellar kinetics and retropatellar contact characteristics

Simone Wurm · Hans Kainz · Wolfgang Reng · Peter Augat

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Abstract
Background Femoropatellar complications are one of the most common problems after total knee arthroplasty (TKA). However, the question of whether to resurface the patella remains controversial. Therefore, we evaluated the kinetics and the retropatellar contact characteristics of patella resurfacing with fixed and gliding surfaces.
Methods Eight Thiel-embalmed cadaver knees were tested—first intact, then after TKA without patellar resurfacing, and finally with additional patellar resurfacing—while flexing the knee from 0° to 100°. We tested a fixed as well as a gliding patella surface. During the examination, quadriceps and hamstring forces were applied. The retropatellar pressure was determined with a special patella sensor, and the patellar kinetics were measured using an optical three-dimensional motion analysis system.
Results Resurfacing the patella caused a significant increase in retropatellar pressure and a significant decrease in retropatellar contact area. Using a fixed patella, the retropatellar pressure nearly quadrupled in higher flexion compared to the native patella. Furthermore, the lateral movement of the patella increased after TKA, especially after additional patellar resurfacing.
Conclusions Resurfacing the patella routinely is not advised. When osteoarthritis of the patella is found, the gliding patella should be preferred.

S. Wurm (✉) · H. Kainz · P. Augat
Institute of Biomechanics, Trauma Center Murnau,
Prof.-Küntscher-Str. 8, 82418 Murnau, Germany
e-mail: Simone.Wurm@bgu-murnau.de

S. Wurm · W. Reng
Department of Traumatology, Trauma Center Murnau,
Prof.-Küntscher-Str. 8, 82418 Murnau, Germany

Introduction

Total knee arthroplasty (TKA) has become the standard treatment for various disabling disorders of the knee, primarily for knee osteoarthrosis.

Primary TKA has proven to be highly successful at alleviating pain and improving function in patients with advanced arthritis of the knee. However, despite a rate of clinical success and patient satisfaction of nearly 90 % [1, 2], complications remain. Femoropatellar complications are the most common type after TKA, and are the major cause of aseptic revision surgery [3, 4]. Numerous studies have reported the presence of residual anterior knee pain in 5–45 % of patients after TKA [5, 6]. Despite this high incidence of anterior knee pain, its etiology is yet to be established clearly.

Some clinical studies have reported a lower rate of anterior knee pain after resurfacing the patella [3], but tricompartmental replacements were found to have problems such as component wear, loosening, fracture, avascular necrosis, ligament and tendon ruptures, and maltracking [3, 7]. Taken together, clinical studies comparing the overall rate of complications after resurfacing the patella with that seen when the patella is not resurfaced present conflicting conclusions [3, 7, 8].

Several in vitro studies concerning the problem of patellar resurfacing found a decrease in the retropatellar contact area, an increase of the retropatellar pressure, and an increase in the shear forces after resurfacing the patella [9, 10].

In addition, Chew et al. [11] found that, after TKA and patella resurfacing, there was a significantly greater degree of lateral tilting compared with the intact knee. Abnormal patella tracking has been identified as a major component of patellar pain in adults [12].

The limitation of most biomechanical studies is that they employ nonphysiological loading conditions for the knee joint. The quadriceps force is typically applied in the direction of the femoral longitudinal axis without considering the different components of the quadriceps. However, (particularly) the kinetics of the patella are greatly influenced by the direction of the quadriceps forces [13]. Loading the individual vasti (in contrast to applying force only in the direction of the femoral longitudinal axis) resulted in increased lateral movement of the patella [14]. Furthermore, most biomechanical studies have not considered the hamstrings. However, Li et al. [15] showed that co-contraction of the hamstrings led to a posterior shift and external translation of the tibia, resulting in increased retropatellar pressure. Thus, physiological loading of the muscles is essential when investigating patellar kinetics and retropatellar contact characteristics.

In addition, all previous studies evaluated the influence of patellar resurfacing on patellar kinetics and retropatellar contact characteristics using an anatomical or dome-shaped patellar component. However, all of these patellar components were fixed. To our knowledge, there are no studies that used a gliding patella. The advantage of a gliding patella is the capacity for anatomical adaptation during movement, thus improving the patellar kinetics, lowering contact stresses [16] and reducing the risks of loosening and patellar fracture [17].

Therefore, the objective of our study was to evaluate the kinetics of gliding patella resurfacing in TKA under physiological load directions. We evaluated the patellofemoral contact area and pressure as well as the patellar kinetics in the intact knee, in the knee after TKA with an unresurfaced patella, and after resurfacing the patella (with a fixed or gliding patellar component). The quadriceps and the hamstring muscles were loaded according to their physiological direction of tension. Our hypothesis was that resurfacing the patella leads to impaired kinetics of the patellofemoral joint and to increased retropatellar pressure. We further hypothesized that the patellofemoral kinetics can be improved by inserting a gliding patella surface rather than a fixed patella surface.

Materials and methods

Experimental setup

A total of eight cadaver knees were obtained from the Anatomical Institute of the University of Ulm. The specimens were embalmed in Thiel solution and had a mean age of 80.8 years (range 75–84). Knees with previous knee surgery or metastatic lesions were excluded.

The specimens were transected 30 cm proximal to the knee joint. The skin, subcutaneous tissues and the muscles were removed, apart from the quadriceps [rectus femoris (RF), vastus intermedius (VI), vastus medialis (VM), vastus lateralis (VL)] and the hamstrings (biceps femoris, semitendinosus, semimembranosus). Care was taken to keep all capsular and retinacular tissues intact. The components of the quadriceps muscle were separated from each other. The ends of the muscles were clamped with special aluminum pins, secured by straps. The femur was embedded with PMMA into an aluminum tube. This tube was mounted into a specially designed rig (Fig. 1). This configuration allowed complete freedom of movement of the joint. The amount of flexion–extension was secured with a variable stand.

During the measurements, static muscle loads were applied. We chose a total quadriceps load of 150 N. The load distribution was chosen according to the physiological cross-sectional area (PCSA) of the muscles [18]:

- Rectus femoris 15 % = 22.5 N
- Vastus intermedius 20 % = 30 N
- Vastus lateralis 40 % [vastus lateralis longus (VLL) 34 %; vastus lateralis obliquus (VLO) 10 %] = 60 N
- Vastus medialis 25 % [vastus medialis longus (VML) 15 %; vastus medialis obliquus (VMO) 10 %] = 37.5 N

The hamstrings were simulated with one-third of the quadriceps load (i.e., 50 N).

The direction of muscle tension was simulated physiologically. The RF and the VI were bundled. These muscles as well as the hamstrings were simulated in the direction of the longitudinal axis of the femur.

Both the VM and the VL consist of an oblique and a long part. Anatomical studies showed the following directions relative to the femoral axis [18, 19]:

- Vastus lateralis longus: 14° lateral
- Vastus lateralis obliquus: 35° lateral, 33° posterior
- Vastus medialis longus: 15° medial
- Vastus medialis obliquus: 47° medial, 44° posterior

A vector was calculated to respect the two different parts of the muscle force, so the VM loads were applied 25° medial and 18° posterior and the VL loads were applied 18° lateral and 7° posterior relative to the femoral axis.

The experiment was performed on the intact knee first to provide a baseline reference. A standard TKA was performed using the LCS Complete Primary System (DePuy, Warsaw, IN, USA) with an anterior–posterior glide inlay. The implantation of the TKA was performed according to the manufacturer's guidelines using a medial parapatellar approach. First, the patella was left intact and measurements