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The effect of axial rotation of the anterior resection plane in patellofemoral arthroplasty

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ABSTRACT

Background: Patellofemoral arthroplasty (PFA) has a small but definite place in replacement surgery of the knee, especially in young patients. The main surgical considerations in PFA are the patient's anatomy, the type of prosthesis and the surgical technique. The surgical technique and PFA success rely heavily on the anterior resection. In this study we investigate the effect of axial rotation of the anterior resection plane.
Methods: We tested the outcome of PFA fit based on resection footprint measurements, axial and coronal groove angles, and lateral trochlear inclination (LTI) angle in a virtual PFA model. The range of anterior resection plane axial rotations was from five degree internal to five degree external with an increment of one degree.
Results: Axial rotation of anterior resection plane changes the resection footprint dimension, which leads to coronal rotation of the femoral component. External rotation of the resection plane results in valgus rotation of the trochlear groove and decreased LTI after PFA and the opposite was observed for internal rotation.
Conclusion: Our study showed that by changing the axial rotation of the anterior cut, the coronal groove of the prosthesis can be altered to lie more closely with the native groove line without compromising the prosthesis–cartilage transition.

1. Introduction

Patellofemoral arthroplasty (PFA) has evolved over the last 30 years to become an effective treatment for isolated grade 4 patellofemoral degeneration since the first-generation PFA was introduced in the late 1970s [1,2]. Long term and short term surgical outcomes have improved as second-generation and third-generation trochlea designs were introduced with more sophisticated component alignment instruments [3–5]. The Avon (Stryker) reduced the occurrence of patellar maltracking to less than 1 percent [3,6]. It has a symmetrical design with a wide and flat proximal flange, which gives relative freedom for patellar movement. Newer third-generation designs such as the Kneetec (Tornier) are side specific asymmetric prostheses with a built-in valgus trochlea to accommodate the Q angle [7,8].

The coronal alignment of PFA is completely dependent on the distal femoral anatomy because the medial and lateral edges of the prosthesis should be congruent or slightly below the neighbouring condylar cartilage [3,9,10]. This "flushness" is important to avoid soft tissue catching and ensure smooth patellar movement over the prosthesis–cartilage transition. This leaves very little room to adjust the coronal alignment of the prosthesis once the anterior cut is made. The anterior cut is suggested to have three degrees of external rotation to the posterior condylar line or be parallel to the surgical epicondylar axis to facilitate normal patellar tracking and less soft tissue tension [2,10–12].

In following these guidelines, we have observed in some cases an excessive change of the coronal groove alignment from the original. It was more frequently encountered with a third-generation implant with a built-in valgus trochlea than in a second-generation prosthesis with a neutral groove design. In order to better understand this observation, we undertook a 3D computer simulated study to examine the relationship between the axial rotation of the anterior cut and the femoral component alignment both in axial and coronal planes.

2. Materials and methods

Three dimensional computer models of femoral cartilage and the femur were segmented from computed tomography (CT) and magnetic resonance (MR) images of a young healthy 30 year old female volunteer

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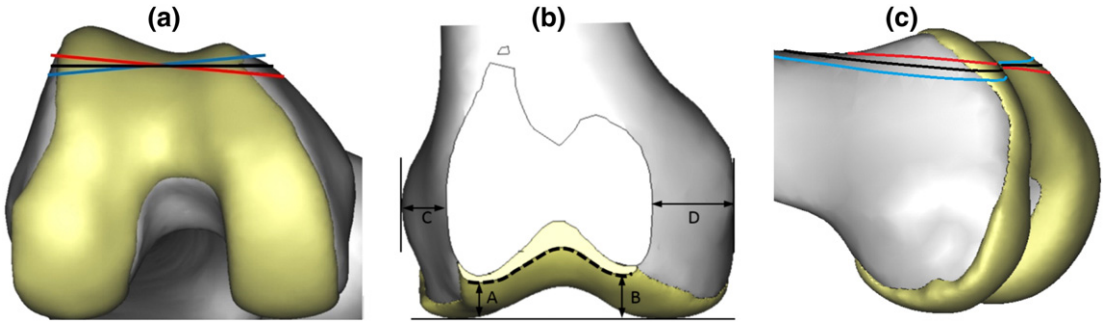

Figure 1. a) Axial rotation of the anterior cut in neutral (black), internal (red), and external (blue) positions; b) distance between the distal condylar line and the flush line at lateral condyle (A), and medial condyle (B); lateral space (C), medial space (D), to the cut edge; c) side view.

using commercial segmentation software (Mimics, Materialise). She had asymptomatic knees with no prior knee surgery and normal patellofemoral tracking [13]. The CT scan was done with one millimeter slice thickness and the MRI with 1.5 mm slice thickness. She gave informed consent to participate in the study and ethical approval was received from the Committee for Human Research at Stellenbosch University, project number N08/02/029.

A neutral anterior cut was made on the femoral model. The neutral cut was defined as a cut parallel to the posterior condylar line and flush with the anterior cortex in line with the anatomical axis. The neutral anterior resection plane was rotated axially about the projection of the anatomical axis on the neutral resection plane from five degrees of internal rotation (red line, Figure 1a) to five degrees of external rotation (blue line, Figure 1a) with increments of one degree. The flexion–extension position of the anterior cut was not changed along the anatomical axis.

The "flush line" (Dejour D, Personal communication; dashed line, Figure 1b) refers to the distal border of the articular cartilage on the anterior resection plane. In PFA, the idea is to place the femoral component in such a way that the prosthesis is flush with the articular cartilage of both the lateral and medial femoral condyles. The distance to the flush line on the lateral and medial femoral condyles was measured from the distal condylar line (arrows A and B, Figure 1b). The lateral (C, Figure 1b) and the medial (D, Figure 1b) spaces to the footprints were measured from the epicondyles.

Two different types of generic PFA prostheses were virtually implanted. One, second-generation with a neutral groove design (Avon, Stryker) suitable for both left and right knees. The other was a third-generation side specific design, with a built-in seven degree valgus groove angle (Kneetec, Tornier). These prostheses were reverse engineered to build computer models using a 3D scanner (NextEngine).

The femoral components were positioned to achieve a congruent prosthesis-articular cartilage fit, at the flush line, by rotating the prosthesis into valgus/varus; translating it medial/lateral or distal/proximal while avoiding overhang, overstuffing and impingement as best as possible [3,9,10]. If a smooth prosthesis transition could not be achieved,

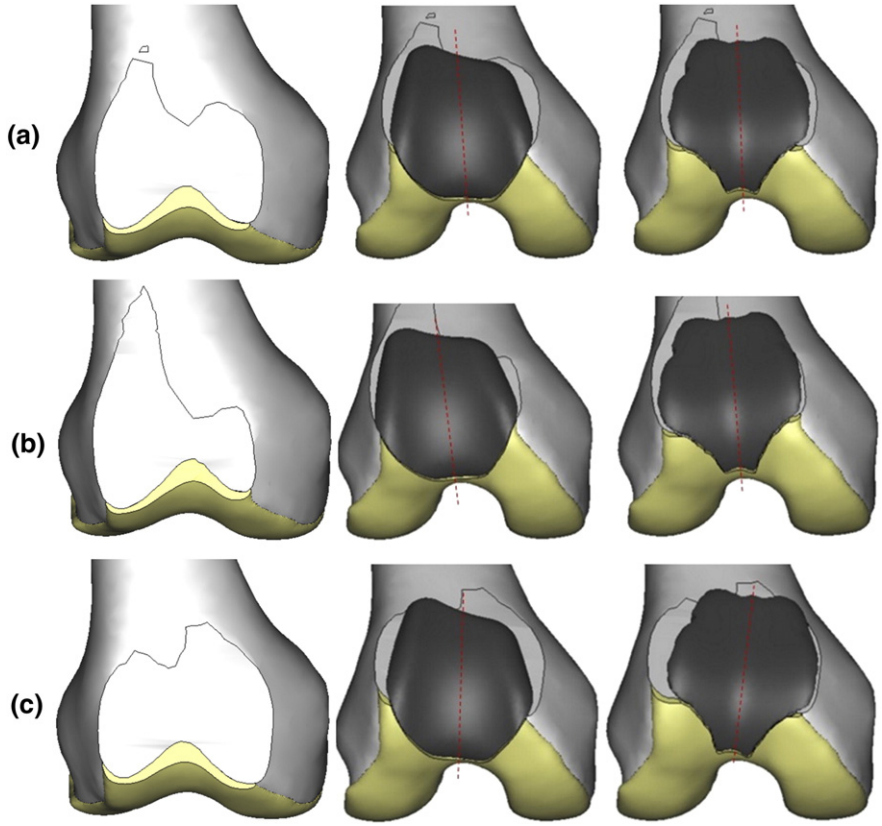

Figure 2. The resected femur (left), post PFA with Kneetec (middle), and post PFA with Avon (right). a) neutral; b) five degree external; c) five degree internal axial rotation positions.