Abstract: In the past few years, there has been renewed interest in patellofemoral arthroplasty. Although the results of off-the-shelf patellofemoral prostheses have varied, the researchers’ results with patient-specific patellofemoral arthroplasty are encouraging. Our experience shows that patient-specific patellofemoral arthroplasty is a safe and effective treatment option for patients who have isolated end-stage patellofemoral arthritis. The surgical technique for patient-specific patellofemoral arthroplasty is straightforward because positioning and alignment of the patient-specific trochlear prosthesis are determined preoperatively, thus eliminating intraoperative guesswork. This paper describes the technique of patellofemoral arthroplasty that incorporates a custom-designed patient-specific prosthesis for resurfacing of the patellofemoral trochlea.

Key Words: patellofemoral, arthroplasty, knee, arthritis, patient-specific (Tech Knee Surg 2010;9: 188–192)

HISTORIC PERSPECTIVE

The origins of patellofemoral arthroplasty can be traced to 1955 with the introduction of the McKeever prosthesis.1 This prosthesis consisted of a Vitalium shell used to resurface only the patella. The procedure was eventually abandoned because of concerns regarding trochlear wear.2 Blazina et al3 reported in 1979 on the use of a patellofemoral prosthesis. In the decades that followed, a number of different patellofemoral prostheses were developed and studied.4-6 The clinical results with these designs have been highly variable, which has led to skepticism about the success of the procedure. Appropriate design is one of the most critical factors for successful patellofemoral arthroplasty.5 This paper describes the design rationale and surgical technique of a custom-fit, patient-specific patellofemoral arthroplasty prosthesis that has shown good-to-excellent midterm success.

INDICATIONS AND CONTRAINDICATIONS

Patellofemoral arthroplasty is indicated for isolated patellofemoral degenerative arthritis of the knee, specifically2,5:
- Degenerative or posttraumatic osteoarthritis limited to the patellofemoral joint, so that medial and lateral Ahlback scores4 are less than or equal to 1 point
- Severe symptoms affecting daily activity referable to patellofemoral joint degeneration unresponsive to lengthy nonoperative treatment and conservative procedures
- Patellofemoral malalignment/dysplasia induced degeneration with or without instability

Contraindications include but are not limited to:
- Medial and lateral tibiofemoral Ahlback scores8 greater than 1 point
- The lack of an attempt at nonoperative care or to rule out other sources of pain
- Systemic inflammatory arthropathy
- Uncorrected patellofemoral instability or malalignment

DESIGN RATIONALE

The design goal of patient-specific patellofemoral arthroplasty is to restore the mechanics of the patellofemoral compartment and maintain the native mechanics of the tibiofemoral compartments.5,7,8 Progression of arthritic disease into the medial and lateral knee compartments often contributes to the need for patellofemoral arthroplasty revision.9 Poorly fitting “off-the-shelf” prostheses can detrimentally affect the mechanics of the knee joint (including the medial and lateral compartments), leading to disease progression into these compartments. The researchers believe that patient-specific patellofemoral arthroplasty (Fig. 1) effectively addresses the design deficiencies and difficulties in surgical technique associated with off-the-shelf patellofemoral prostheses.

The patient-specific patellofemoral arthroplasty prosthesis described in this paper is designed to custom-fit the bony anatomy; that is, it is designed to conform to the bony anatomy of the patient’s femoral trochlea using computed tomographic (CT) modeling. This approach allows for a precise fit of the implant to the trochlea without resection of subchondral femoral bone, which is often necessary for off-the-shelf patellofemoral prosthetic designs. Only removal of the overlying cartilage is necessary to obtain a precise fit of the patient-specific prosthesis. The trochlear prosthesis is designed to approximate normal patellofemoral kinematics by reestablishing the alignment and depth of the trochlear groove and to improve quadriceps function by repositioning the patella anteriorly.

The distal margin of the patient-specific prosthesis is designed to rest 3 to 5-mm proximal to the apex of the femoral intercondylar notch. The prosthesis has a thickened lateral border to compensate for bone loss along the lateral edge of the trochlear groove and to provide congruency and tracking stability with the patellar implant. The thickened implant border does not anteriorize the patella because the anterior position of a given patella is defined by the thickness of the femoral implant’s trochlear groove. The patient-specific femoral prosthesis may seem thick on lateral radiographs because the radiograph is a 2-dimensional projection of a complex 3-dimensional “saddle-like” shape whose functional thickness is obscured by its lateral border in this view.

The articular side of the patellofemoral implant has a radius of curvature matched to the curvature of a standard dome patellar implant. It is designed to constrain the patellar implant medially and laterally as it tracks along the trochlear groove. This patient-specific design is therefore, able to compensate for a deficient or dysplastic trochlear groove, which is often present in patellofemoral surgery candidates. Patellofemoral tracking and kinematics are addressed as a result.
The patient-specific trochlear prosthesis is designed to restore the anterior position of the normal, nondegenerated patella. The thickness of normal articular cartilage is approximately 4 to 5 mm on the patella and 2 to 3 mm in the trochlea, yielding a combined total cartilage thickness of 6 to 8 mm. The patient-specific trochlear prosthesis typically is 2 to 5-mm thick along the tracking arc of the patella. The maximal thickness along the tracking arc of the patella is a function of native trochlear groove depth (ie, thinner implants are associated with shallower grooves). The thinner implants are designed specifically to avoid overstuffing the more dysplastic trochleas. Coupled with an anatomic restoration of the patella, the extensor lever arm is intended to be unchanged from the normal, healthy condition. Although the concept of patellofemoral overstuffing has recently been called into question, accommodations can be made by resecting more bone on the patellar side or by selecting a thinner patellar implant if concerns about overstuffing persist.

The design rationale of patient-specific patellofemoral arthroplasty, therefore eliminates the tradeoff between fit and alignment that is inherent to off-the-shelf patellofemoral implants.

**PREOPERATIVE PLANNING**

A CT scan of the patient’s knee is obtained using these settings specified by the manufacturer of the prosthesis (Kinamed Inc., Camarillo, CA):
- Voltage: 120 to 140 kV
- Amperage: 200 to 300 mA
- Scan Region: 5-mm distal to the femoral condyles to 10-mm proximal to the patella.

Computer modeling is then used to create a 3-dimensional physical model of the patient’s distal femoral bone which is sent to the surgeon. The manufacturer identifies the perimeter of coverage of the trochlear implant on this model. If deemed necessary, the surgeon physically removes osteophytes from the model and communicates these changes by returning the model to the implant manufacturer. The final design for the trochlear implant is then created after surgeon approval.

Patellofemoral arthroplasty is not a substitute for a patellar realignment procedure. Patella tracking must be evaluated for instability and soft tissue imbalance. Malalignment of the patella is determined through physical examination and standard radiographic evaluation. Assessment of patellar tracking and the Q angle are important in preoperative planning, as patellar instability is the most often reported cause of dysfunction after patellofemoral arthroplasty. Tightness of the lateral retinaculum is often associated with lateralization and patellar tilt, which may be determined upon physical examination. Examination of medial structures for deficiency should also be done. Axial and lateral radiographs are normally sufficient to quantify measures of patellar malalignment, including patella alta or baja, medial-lateral displacement and patellar tilt. Treatments are generally
customized to each patient, although it remains to be determined if there are 1 or more standard procedures that will be optimal for most patients.13

**TECHNIQUE**

**Femur Preparation**

A standard midline incision is made to expose the patellofemoral joint, and the patella is everted or tilted 90 degrees. The length of the incision is typically 2/3 the length of a standard total knee incision because tibial exposure is not necessary. The margin of cartilage to be removed is determined by placing the patient-specific drill guide and marking template on the trochlea (Fig. 2) and tracing the border around the drill guide with methylene blue. On account of overlying cartilage, the patient-specific physical bone model may be consulted during surgery to determine the proper location of the patient-specific drill guide. A scalpel is then used to incise around the margin of the cartilage perimeter. Cartilage is then removed down to subchondral bone within this border using a sharp curette. Osteophytes are removed as necessary. The patient-specific drill guide is then placed on the subchondral bone of the trochlea and moved slightly back and forth until it seats in its intended position as determined by the CT scan. Two headless nails are then used to secure the drill guide in place while the first hole is being drilled (Fig. 3). An 8-mm stop-drill is used to drill through 1 guide hole, and an alignment pin is then inserted in the hole to stabilize the drill guide. A second hole is drilled, and another alignment pin is inserted. Finally, a third hole is drilled, and the pins, nails, and drill guide are removed (Fig. 4). The holes are then thoroughly irrigated to remove any debris that may be present.

**Patella Preparation**

The trochlear prosthesis is designed to be used in conjunction with a standard off-the-shelf all-polyethylene patellar button of inset or onlay design having an articular radius of curvature of 25 mm. A minimum residual patellar thickness of at least 15 mm after resection is recommended, and an attempt is made to maintain the native thickness of the patella with the patella-implant construct.

**Trial Reduction and Tracking Check**

Trialing is carried out with the definitive trochlear implant and the selected patellar trial component. The patellofemoral joint is reduced and taken through a range of motion to determine if patellar tracking is adequate. Patellar tracking is checked using the “no thumb” test; the knee is taken through a full range of motion, and tracking is considered adequate when the implant tracks congruently and centrally with minimal or no pressure applied to the lateral side of the patella. Particular attention is paid to identify patellar tilt, subluxation, or catching of the components.5 If realignment is necessary, soft tissue balancing is carried out in the same manner as a nonprosthetic or total knee arthroplasty procedure. To correct patellar tilt or lateral displacement of the patella, a proximal realignment procedure such as a lateral retinacular release, medial plication, vastus medialis obliquus advancement, and/or medial patellofemoral ligament repair may be carried out.13 In the presence of a high Q angle, a distal realignment procedure such as transfer of the tibial tuberosity may be carried out to correct alignment of the extensor mechanism.13 Any realignment or soft-tissue balancing strategy should be oriented toward addressing specific identifiable pathology.13

**Cementation and Closure**

Cement is injected into drilled holes in the femur until the holes are completely filled with cement. The posterior surface of the trochlear implant is coated with cement and the implant is placed in its intended position as determined by the CT scan and bone model (Fig. 5). Excess cement around the implant is carefully removed, and the implant is held in place by an impactor until the cement hardens (Fig. 6). Similarly, the patellar implant is cemented in place and held by a patellar...
clamp until the cement has hardened. Patellofemoral tracking is again evaluated and soft tissue corrections are carried out as necessary to ensure optimal patellar tracking (Fig. 7).

RESULTS

In an earlier published investigation, a series of 25 patient-specific patellofemoral arthroplasties was carried out in 22 patients from 1995 through 2002. All implants were in place and functioning well at a mean of 73 (range, 32 to 119) months. There were 18 excellent and 7 good results at the latest follow-up. The mean postoperative Knee Society objective score was 91 (range, 82 to 96) points, and the mean postoperative Knee Society functional score was 89 (range, 81 to 94) points. All patients maintained their good to excellent Knee Society Score status without need for additional knee surgery.

Complications

Postoperative complications may include anterior knee pain and/or stiffness, although these are generally related to prior operations or some degree of existing tibiofemoral arthritis. Progression of arthritis into the tibiofemoral compartment can occur, requiring revision to a total knee arthroplasty, although this has not been found in our patient cohort. Progression into the tibiofemoral compartment is more likely to develop in a patient in whom the patellofemoral arthritis does not have a clear origin, such as malalignment, dysplasia, or trauma. Patellar maltracking after patellofemoral arthroplasty may also occur and is often a result of insufficient or excessive realignment measures taken during the index surgery.

Postoperative Management

Prophylaxis against deep venous thrombosis is not necessary, as the femoral medullary canal is not violated. Postoperative rehabilitation consists of range of motion exercises on the first postoperative day, followed by the use of a continuous-passive motion machine for the next 2 weeks to increase the range of motion. Patients are allowed immediate full-weight bearing and walking with the aid of a walker or crutches if necessary. No specific activity modifications are recommended.
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