Custom Patellofemoral Arthroplasty of the Knee

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Background: The treatment of isolated patellofemoral arthritis is controversial. Several surgical procedures have been used to treat the severely degenerated patellofemoral joint, with varying degrees of success. The purpose of this study was to determine the clinical results of a custom patellofemoral arthroplasty for the treatment of isolated patellofemoral degenerative arthritis of the knee.

Methods: From 1995 through 2002, twenty-five patellofemoral replacements, three of which were bilateral, were performed in twenty-two patients for the treatment of isolated patellofemoral arthritis of the knee. According to the Ahlback radiographic evaluation scale, the mean preoperative score for the severity of the arthritis was 4.65 points in the patellofemoral compartment and 0.5 point in both the medial and the lateral compartment. The patients included sixteen women (two of whom had a bilateral replacement) and six men (one of whom had a bilateral replacement) with a mean age of forty-five years at the time of the index arthroplasty. Seventeen patients (nineteen knees) had had a prior procedure on the knee. The mean preoperative Knee Society functional score was 49 points, and the mean preoperative Knee Society objective score was 52 points.

Results: At a mean of seventy-three months (range, thirty-two to 119 months) postoperatively, all twenty-five implants were in place and functioning well. There were eighteen excellent and seven good results. The mean Knee Society functional score was 89 points, and the mean Knee Society objective score was 91 points. No patient had required additional surgery or had component loosening.

Conclusions: On the basis of our relatively short-term follow-up study, custom patellofemoral arthroplasty appears to be a safe and effective treatment for isolated patellofemoral arthritis of the knee. We believe that the results presented in this paper justify the additional cost associated with the custom device.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

The treatment of isolated patellofemoral arthritis is controversial[1]. The etiology of the disease can be traumatic, secondary to malalignment, degenerative, idiopathic, or a combination of these. Many patients can be treated effectively with nonoperative means, including strengthening exercises, bracing, medications, and activity modifications. However, there is a group of patients with severe disease who are quite disabled and may require surgery.

Several surgical procedures have been used to treat the severely degenerated patellofemoral joint[2]. Osteotomy[3,4], which realigns and transfers load across the patellofemoral articulation, has been advocated for young patients. Patellectomy[5] has also been described for this condition. Total knee arthroplasty[6,7] is another option for elderly, less active patients with severe, isolated patellofemoral arthritis. Each of these procedures, however, has its own limitations and may not be the treatment of choice for young active patients.

Patellofemoral arthroplasty has also been advocated, and there are many advantages of this procedure. It has had some favorable long-term results[8,9]; it preserves the structural integrity of the joint[10]; and, in one study[11], it was associated with a lower rate of deep venous thrombosis and pulmonary embolus compared with total knee arthroplasty. A patellofemoral arthroplasty can be revised to a total knee arthroplasty, and good results of such revisions have been reported[12].

The early results of patellofemoral arthroplasty were disappointing because of the use of so-called off-the-shelf prostheses, which frequently did not match the patient's anatomy[13-17]. A custom patellofemoral prosthesis (Kinamed, Camarillo, California) was designed to recreate the patient's own anatomy and address the inherent problems associated with off-the-shelf designs. A software program utilizing a computed tomography scan constructs a three-dimensional model of the patient's femoral groove, which is converted into a cobalt-chromium custom implant.

A video supplement to this article will be available from the *Video Journal of Orthopaedics*. A video clip will be available at the JBJS web site, www.jbjs.org. The *Video Journal of Orthopaedics* can be contacted at (805) 962-3410, web site: www.vjortho.com.

The purpose of this study was to determine the clinical results of a custom patellofemoral arthroplasty for the treatment of isolated patellofemoral degenerative arthritis of the knee in active patients who were less than fifty-five years of age.

Materials and Methods

From March 1995 through August 2002, twenty-five consecutive patellofemoral arthroplasties, three of which were bilateral, were performed in twenty-two patients for the treatment of isolated patellofemoral arthritis of the knee. All patients who had undergone a patellofemoral arthroplasty during this time-period were included in this study. The three bilateral arthroplasties were staged, with the time between the procedures ranging from thirty-four to 120 weeks. During the time-period covered by this study, seventy medial compartment arthroplasties and 700 total knee arthroplasties were also performed at our institution. Custom patellofemoral arthroplasty represented 3.2% of all knee arthroplasties performed at our institution during the time-period.

Patients with medial and/or lateral advanced arthritis were excluded. All of the patients included in the study had been followed for a minimum of two years, and no patient was lost to follow-up. All patients were evaluated on the basis of a history, physical examination, and radiographs, and all filled out a standard form that included the functional and objective scores of the Knee Society[18]. The study was approved by the institutional review board of the Sherman Oaks Hospital and Health Center. All patients gave informed consent to participate in the study.

The preoperative and postoperative radiographic examinations included standing anteroposterior, lateral, and Merchant[19] patellofemoral views of the knee. The radiographic evaluation scale described by Ahlback[20] was utilized to evaluate the severity of the disease in the three compartments of the knee joint on the basis of sclerosis, joint-space narrowing, subluxation, and the presence of osteophytes. All of the patients in our study group had isolated severe patellofemoral arthritis. Knees that had a lateral or medial compartment score of >1 point were not treated with the patellofemoral prosthesis. The knees in this study had a mean Ahlback score of 4.65 points (4 or 5 points) for the patellofemoral compartment. The medial and lateral compartments had a mean score of 0.5 point (0 or 1 point) each.

The patients included sixteen women (two of whom had a bilateral replacement) and six men (one of whom had a bilateral replacement). They had a mean age of forty-five years (range, twenty-three to fifty-one years) at the time of the arthroplasty. Nineteen knees (76%) in seventeen patients had been treated with a prior procedure. An arthroscopic lateral release with débridement had been performed in thirteen knees, and an arthrotomy with a lateral release and elevation of the tibial tubercle had been done in six knees. The mean preoperative Knee Society functional score was 49 points (range, 24 to 76 points), and the mean preoperative Knee Society objective score was 52 points (range, 30 to 60 points). All of the patients had anterior knee pain that was exacerbated by prolonged walking, rising from a sitting to a standing position, and ascending or descending stairs.

Design of the Prosthesis

The Custom Patellofemoral Arthroplasty (PFA) does not require femoral bone resection because computed tomography modeling technology is used to achieve a custom fit to the patient's femoral anatomy. The prosthesis is designed to approximate normal kinematics by reestablishing the alignment and depth of the trochlear groove and to reposition the patella anteriorly to improve quadriceps function. The thickness of the PFA implant along the patellar tracking arc was designed to reestablish the anterior position of the femur. The distal margin of the implant was designed to rest 3 to 5 mm from the apex of the femoral intercondylar notch. The implant has a thickened lateral border to compensate for bone loss along the lateral edge of the trochlear groove.

Surgical Technique

Preoperative Planning

The patients underwent a computed tomography scan according to the specific instructions provided by the manufacturer of the PFA implant. The computed tomography parameters included 120 to 140 kV, 200 to 300 mA, and a scan region of 5 mm distal to the femoral condyles to 10 mm proximal to the patella. The surgeon received a computed tomography-reconstructed bone model of the distal part of the femur to review prior to the surgery. The surgeon used the model to determine the need for osteophyte removal and communicated any planned osteophyte removal to the implant manufacturer by physically performing the planned removal on the bone model and returning the model to the manufacturer prior to final implant design.

Preparation of the Femur

A small standard midline incision was made, and a medial parapatellar approach was used to expose the patellofemoral trochlea. The patella was everted. Because the computed tomography data from which the implant is created models bone and not cartilage, a proper fit was achieved by excision of overlying articular cartilage. The custom drill-guide was used to assess the approximate fit of the implant onto the femoral groove. A scalpel was used to define the margin of the cartilage removal (Fig. 1). A curet was employed to completely remove the remaining articular cartilage within this outlined margin, exposing the subchondral bone. The custom drill-guide was then used to determine the exact fit of the custom PFA implant by moving the drill-guide on the distal part of the femur until it reached a natural fit, as it had the computed tomography bone model. With the drill-guide correctly positioned on the bone, three holes were drilled through the guide holes with an 8-mm stop drill. The drill holes were thoroughly irrigated, and suction was applied to remove bone particles and fluid (Fig. 2). The osseous bed of the distal part of the femur was prepared to receive bone cement. The PFA implant was trial-fitted by placing the implant pegs into the drilled holes and finding the best fit of the implant on the femoral trochlea.

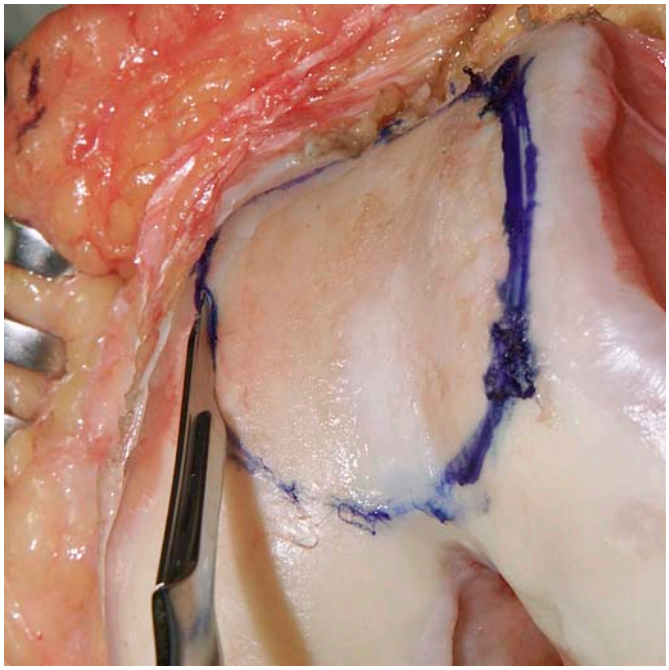

Fig. 1

A scalpel is used to define the margin of cartilage to be removed.

Preparation of the Patella

The PFA implant was designed to articulate with a standard all-polyethylene patellar component with any articular shape. We selected a standard dome-shaped patellar component so that the patella had a thickness of ≥15 mm after resection, thus maintaining the overall patellar thickness with the implant in place.

Implantation

Bone cement was prepared and injected into the drilled holes in the distal part of the femur, and the femoral implant was cemented in place. The patellar implant was also cemented in place and was held in position by the patellar clamp until the cement had cured. Next, the patella was reduced to its anatomic position and the implants were tested through a range of motion to be certain that patellar tracking was anatomic; soft-tissue releases were performed as needed. The "no thumb" test of patellar tracking was used as a guide to determine that patellar stability was adequate. The patella was observed as it articulated with the femoral trochlea during the entire range of knee motion before capsular closure. With the "no thumb" test, patellofemoral tracking is considered to be adequate when the patellar implant tracks congruently with minimal or no pressure applied to the lateral side of the patella. A lateral patellar retinacular release is done when the patella subluxates laterally during the "no thumb" test. Three of the six knees with no previous surgery underwent a lateral release, and nine of the thirteen knees with a previous arthroscopic release underwent a revision lateral release. Thus, a total of twelve lateral releases were performed, all with the technique described by Metcalf[21]. The arthrotomy site was closed without the use of drains. A tourniquet was utilized for an average of fifty-five minutes (range, forty-five to seventy minutes). Intravenous antibiotics were given preoperatively.

Rehabilitation

The average hospital stay was three days (range, two to five days). No patient was given prophylaxis against deep vein thrombosis because there was no violation or reaming of the femoral medullary canal. A continuous-passive-motion machine was used for two weeks, and range-of-motion exercises were begun on the first postoperative day. Patients were allowed to walk immediately with full weight-bearing and the aid of a walker or crutches.

Clinical and Radiographic Evaluation

All patients were evaluated with use of the Knee Society functional and objective rating scales[18]. A score of >90 points was considered to be an excellent outcome; a score of 80 to 90 points, a good outcome; a score of 70 to 79 points, a fair outcome; and a score of <70 points, a poor outcome.

The data were analyzed with the assistance of a clinical biostatistician. The Wilcoxon signed-rank test was used to compare preoperative and postoperative Knee Society scores. The level of significance was set at $p < 0.05$.

Results

There were eighteen excellent and seven good results at a mean of seventy-three months (range, thirty-two to 119 months) postoperatively. The most recent mean postoperative Knee Society objective score was 91 points (range, 82 to 96

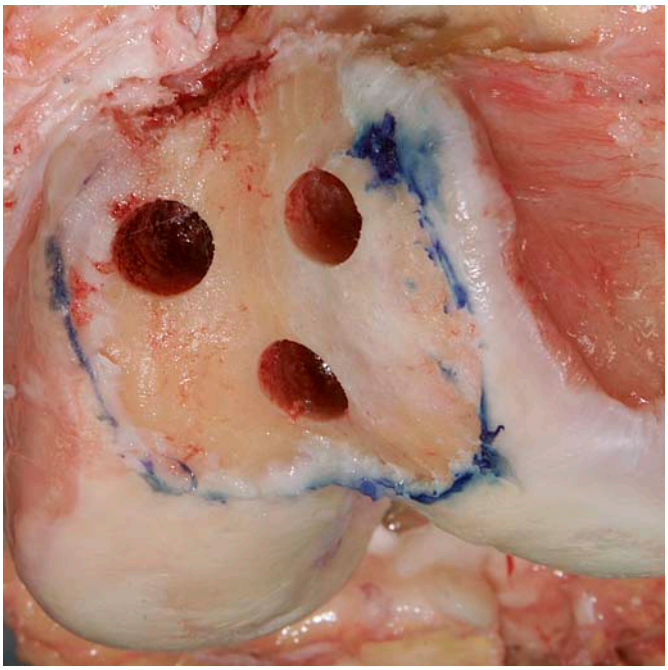

Fig. 2

The drill holes are thoroughly irrigated, and suction is applied to remove bone particles and fluid.

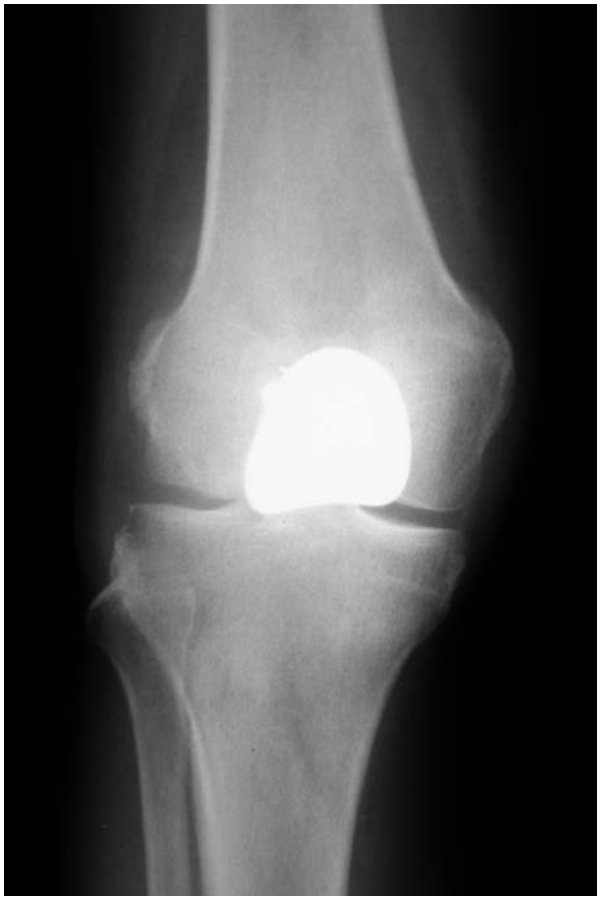

Fig. 3-A

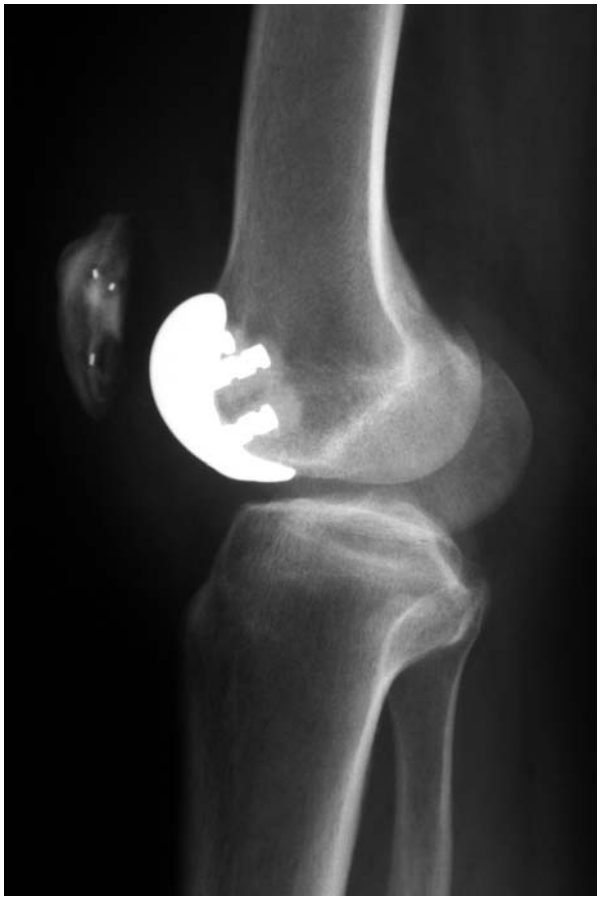

Fig. 3-B

Postoperative anteroposterior (Fig. 3-A), lateral (Fig. 3-B), and sunrise (Fig. 3-C) radiographs reveal proper component position and no evidence of patellar dislocation.

points), which was a significant improvement from the mean preoperative score of 52 points (range, 30 to 60 points) ($p < 0.0001$). The most recent mean postoperative Knee Society functional score was 89 points (range, 81 to 94 points), which was a significant improvement from the mean preoperative score of 49 points (range, 24 to 76 points) ($p < 0.0001$). The mean range of active flexion improved from 110° (range, 85° to 120°) preoperatively to 122° (range, 110° to 130°) at the time of final follow-up.

There were no infections and no clinical findings of patellar subluxation or dislocation. No lateral release or revision of a previous arthroscopic release was associated with complications.

All twenty-two patients (twenty-five knees) reported no pain during normal walking. No patient reported weakness, instability, or night pain. Three patients had anterior knee pain, which occasionally required analgesics, when ascending and descending stairs. The pain occurred within the first six months following the surgery and eventually resolved in all three patients. No patient required an assistive device to ascend or descend stairs.

There had been no subsequent operations as of the time of the last follow-up.

No evidence of patellar dislocation was seen radiographically (Figs. 3-A, 3-B, and 3-C). Preoperatively, twenty-one knees had had a lateral patellar tilt (mean, 3°) and no knee had had a medial tilt. Twenty-two knees had been laterally dis-

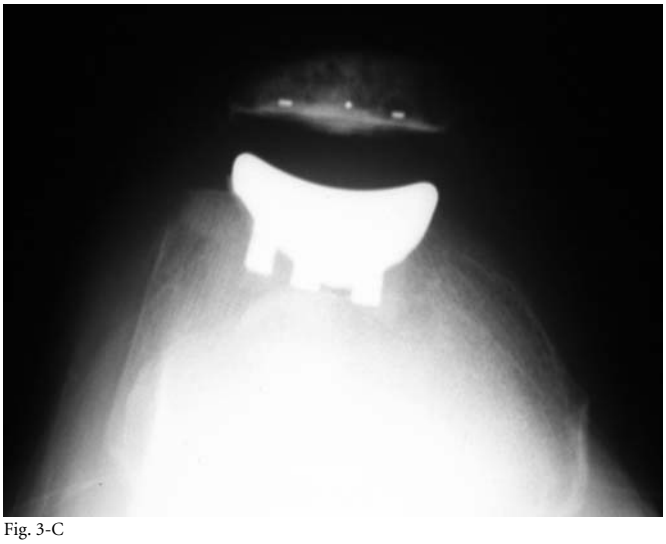

Fig. 3-C

placed (mean displacement, 4.4 mm; range, 1 to 7 mm) before the operation, and only two patellae were laterally displaced (1.2 and 1.8 mm) after the operation. There was no change in patellar height or the length of the patellar tendon postoperatively. No progressive radiolucent lines or other radiolucencies measuring >2 mm in width were found around the implants in any knee. One knee was seen to have a nonprogressive patellar radiolucent line measuring <2 mm in width on the Merchant radiograph.

Discussion

The surgical management of young patients (less than fifty-five years old) with isolated patellofemoral arthritis is initially aimed at preserving the patellofemoral joint. Osteotomy to transfer load from lateral to medial and from distal to proximal on the patella has been described[3,4]. The short-term results of these osteotomy procedures have been good, but the patient must have early arthritis isolated to the lateral and/or distal aspect of the patella. Patients with advanced arthritis including femoral trochlear disease are not good candidates for osteotomy. All of the patients in our study had advanced degenerative arthritis on both sides of the patellofemoral articulation. Patellectomy[22-24] and isolated patellar resurfacing[25-28] have been advocated in the past, but the long-term results of both procedures have usually been poor[29-33]. These techniques are rarely, if ever, indicated in young patients with advanced patellofemoral arthritis. Furthermore, patellectomy reduces the probability of a successful total knee arthroplasty in the future[34,35].

Laskin and van Steijn[6] as well as Mont et al.[7] reported excellent results following total knee arthroplasty for the treatment of isolated patellofemoral arthritis in elderly patients. Mont et al., however, recommended that total knee arthroplasty not be performed in young patients. Young patients with advanced isolated patellofemoral arthritis, therefore, may not be candidates for osteotomy, patellectomy, isolated patellar resurfacing, or total knee arthroplasty. Patellofemoral arthroplasty is an alternative with clear advantages. Lubinus[36] and Blazina et al.[13] reported fair results after use of a so-called off-the-shelf design. Recent studies with longer follow-up have demonstrated good-to-excellent prosthetic survival[8,9,11,21,37]. Ackroyd and Chir[38] recently reported short-term results following use of a new patellofemoral arthroplasty (Avon; Stryker, Kalamazoo, Michigan) that was designed with the aim of maintaining accurate patellar tracking. The patellofemoral prosthesis is unconstrained in full extension, and the patella is captured by the groove with a congruent contact to ≥90° of flexion. The short-term results were encouraging, but eleven knees (3.6%) required revision to a total knee arthroplasty and persistent anterior pain was recorded in fourteen knees (4%). Merchant[39] also recently reported favorable early results following use of a modular prosthesis for patellofemoral arthroplasty. Fourteen of fifteen patients had a good or excellent result at 2.25 to 5.5 years postoperatively.

The disadvantages of an off-the-shelf design include soft-tissue impingement secondary to a high lateral femoral trochlear groove, an increase in the thickness of the femoral component leading to overstuffing of the patellofemoral joint, and loss of anterior femoral bone stock due to reaming or resection during implantation[40]. These disadvantages are difficult to avoid with a generic design, and the availability of multiple femoral groove sizes has not eliminated these problems.

Use of a custom patellofemoral arthroplasty is associated with costs, including those for a preoperative computed tomography scan, the custom implant itself, and the time involved in the manufacturing of the custom implant. The cost of a computed tomography scan in the United States in 2005 was approximately $400.00. It should be noted that no consultation or review by a radiologist is required, so there is no radiologist's fee associated with the scan. The selling price of the custom patellofemoral implant is approximately 15% to 30% higher than the price of off-the-shelf patellofemoral and unicompartmental knee implants but is lower than the price of typical "high performance" total knee implants such as high-flexion designs and those with alternate bearing surfaces. The time needed to manufacture the custom patellofemoral implant is approximately eight weeks, which is not considered substantial because the typical candidate for this device has chronic disease. We believe that a modest delay in the delivery of a clinically effective treatment to such patients is warranted. Finally, it is important to consider that intraoperative time may be saved through use of a custom patellofemoral arthroplasty because off-the-shelf patellofemoral implants require standardized instrumentation for femoral alignment and resection; the need for such instrumentation and attention to femoral alignment and resection is substantially reduced in a custom patellofemoral arthroplasty. In light of these factors, we believe that custom patellofemoral arthroplasty is a feasible option for patients with isolated patellofemoral disease. A comparison of the clinical results reported in this study with those following use of off-the-shelf implants appears to justify the use of custom patellofemoral arthroplasty.

We consider custom patellofemoral arthroplasty to be a viable option for patients who are less than fifty-five years of age and have isolated, severe patellofemoral arthritis. Of the twenty-five knees in our study, eighteen had an excellent result and seven had a good result at a mean of seventy-three months postoperatively. There were no failures or additional surgical procedures. Our results compare favorably with those of total knee arthroplasties performed in similar but older groups of patients[6,7]. A custom patellofemoral arthroplasty can be converted to a total knee arthroplasty when necessary, and the results have compared favorably with those of primary arthroplasty[12]. We conclude that a custom patellofemoral arthroplasty appears to be a safe and effective treatment for patients with isolated patellofemoral arthritis of the knee, but additional follow-up is needed to assess its longer-term efficacy. ■

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