

# Patellofemoral Arthroplasty with a Customized Trochlear Prosthesis

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It has been estimated that isolated patellofemoral disease affects up to 11% of men and 24% of women who have painful arthritis of the knee joint [1]. Although conservative therapies and non-arthroplasty surgical treatments for isolated patellofemoral disease are well known [2], their effectiveness in treating the severely degenerated patellofemoral joint has been limited, especially in young, active patients. By contrast, it has been shown that total knee arthroplasty can provide excellent results for the treatment of isolated patellofemoral disease in elderly patients [3], but it is believed widely that total knee arthroplasty is not appropriate for patients under the age of 55 years. For these reasons, interest in patellofemoral arthroplasty has grown substantially in recent years.

A number of investigators have reported on the results of patellofemoral arthroplasty, with varying degrees of success (Table 1). These inconsistent results have contributed to controversy about the effectiveness of patellofemoral arthroplasty. Based on the collective historical experience with patellofemoral arthroplasty, failures generally are thought to be caused by a combination of inappropriate patient selection, prosthesis design, and surgical technique [18]. This article reviews the design rationale, clinical experience, and surgical technique of a unique approach to patellofemoral arthroplasty that incorporates a customized trochlear prosthesis designed to fit the individual patient's patellofemoral groove.

## Design rationale

The customized trochlear prosthesis does not require femoral bone resection because CT modeling is used to model an exact fit to the femoral trochlear anatomy of the individual patient. The customized trochlear prosthesis is designed to approximate normal patellofemoral kinematics by re-establishing the alignment and depth of the trochlear groove and to improve quadriceps function by repositioning the patella anteriorly. The distal margin of the trochlear 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 customized femoral prosthesis appears thick on lateral radiographs because the radiograph is a two-dimensional projection of a complex three-dimensional "saddle-like" shape whose functional thickness is obscured by its lateral border.

The customized trochlear prosthesis is designed to restore the anterior position of the normal, non-degenerated 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 [19]. The customized 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

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Table 1  
Published results of patellofemoral arthroplasty

Study	N	Follow-up (years)	Implant (manufacturer)	Salient results
Ackroyd and Chir [4]	306	2–5	Avon (Stryker, Allendale, NJ)	87% not revised and complication-free
Arciero and Toomey [5]	25	3–9	Blazina II (Richards, Memphis, TN) and CFS (Wright, Arlington, TN)	72% good or excellent; 12% revised
Argenson et al [6]	66	2–10	Autocentric (Medinov, Roanne, France)	85% not revised
Argenson et al [7]	66	12–20	Autocentric (DePuy, Warsaw, IN)	56% not revised
Blazina et al [8]	57	1–3.5	Blazina I & II (Richards)	78% “much improved”
Cartier et al [9]	72	2–12	Blazina II & III (Richards)	85% good or excellent; 8% mechanical complications
de Winter et al [10]	26	1–20	Blazina II (Richards)	61% good or excellent; 19% re-operation rate
Kooijman et al [11]	45	15–21	Blazina II (Richards)	62% not revised
Krajca-Radcliffe & Coker [12]	16	2–18	Bechtol I & II (Richards)	88% good or excellent; 19% re-operation rate
Lubinus [13]	14	0.5–2	Lubinus (Link, Hamburg, Germany)	“All improved”
Merchant [14]	15	2.2–5.5	LCS (DePuy)	93% good or excellent on ADL scale
Sisto & Sarin [15]	25	2.7–9.9	Custom (Kinamed)	100% good or excellent; no revisions or complications
Smith et al [16]	45	0.5–7.5	Lubinus (Link)	64% good or excellent; 19% revised
Tauro et al [17]	62	5–10	Lubinus (Link)	45% “satisfactory”; 28% revised

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. If concerns about overstuffing persist, accommodations can be made by resecting more bone on the patellar side or by selecting a thinner patellar implant.

The precise fit achieved by the customized approach to patellofemoral arthroplasty is illustrated best by examining the customized trochlear prostheses that are designed for individual femurs of varying shape (Fig. 1A–D). Despite considerable variations in the alignment, shape, and depth of these native trochlear grooves, all the customized trochlear prostheses are adapted precisely to the bony contours of the native femur and conform to the patellofemoral articulation without overhang into the intercondylar notch.

### Indications and contraindications

The indications and contraindications for patellofemoral arthroplasty have been summarized

in detail by Leadbetter and colleagues [20]. Indications include but are not limited to

- Degenerative or posttraumatic osteoarthritis limited to the patellofemoral joint, so that medial and lateral Ahlback [21] scores 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 compartment Ahlback scores 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

No indications or contraindications are associated specifically with the customized approach to patellofemoral arthroplasty.



Fig. 1. (A) Variation in geometry of four trochlear grooves and precise fit of the customized trochlear prostheses in anterior view. (B) Precise fit of the customized prostheses at the top of the trochlear groove and build-up of lateral border thickness for increasing patella-tracking stability. Views of (C) lateral and (D) medial aspects show precise adaptation of the prostheses in the sagittal plane.

### Clinical experience

The authors previously reported on the results of patellofemoral arthroplasty using a customized trochlear prosthesis and an off-the-shelf patella button prosthesis [15]. Twenty-five patellofemoral arthroplasties (3 bilateral) were performed in 22 patients for the treatment of isolated patellofemoral arthritis. There were 16 women (2 had bilateral arthroplasties) and 6 men (1 had bilateral arthroplasty) with a mean age of 45 years at surgery. Seventeen patients (19 knees) had had a prior surgical procedure on the knee. The mean preoperative Knee Society functional and objective scores were 49 points and 52 points, respectively. At a mean follow-up of 73 months postoperatively (range, 32–119 months), all 25 implants were in place (Fig. 2A–C) and were functioning well.

There were 18 excellent results and 7 good results according to the Knee Society scoring system. The mean Knee Society functional and objective scores were 89 points and 91 points, respectively. No patient had required additional surgery or had component loosening. The patients included in this study were monitored for an additional 30 months. All maintained their good to excellent Knee Society Score status without need for additional knee surgery.

### Surgical technique

The surgical technique for patellofemoral arthroplasty using a customized trochlear prosthesis has been described previously in detail [22]. Because the customized trochlear prosthesis is

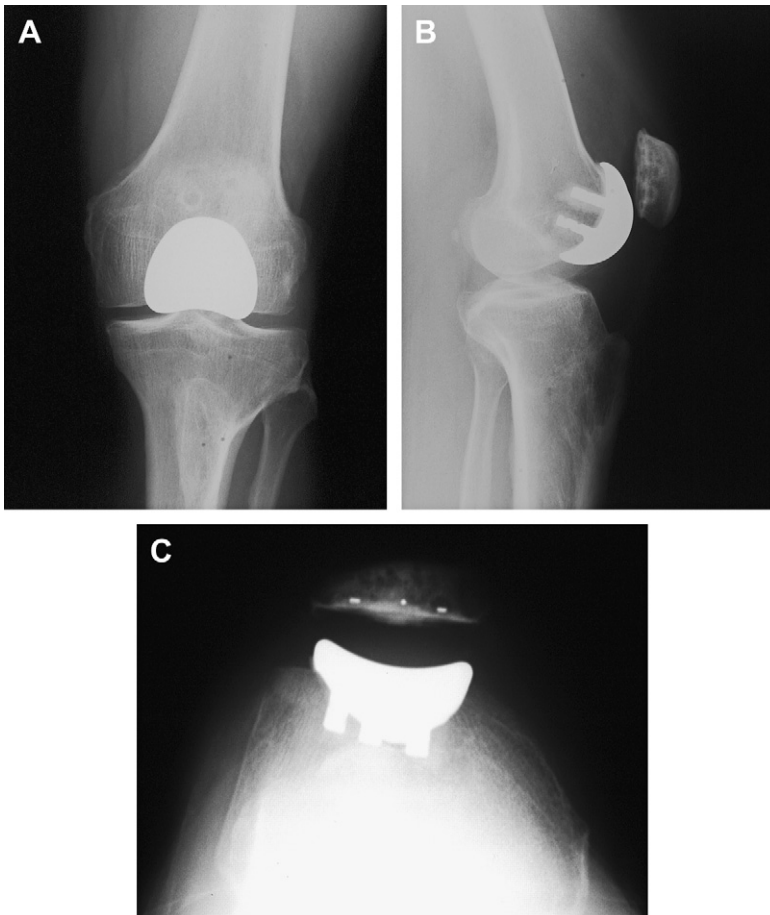


Fig. 2. Postoperative (A) anteroposterior, (B) lateral, and (C) Merchant-view radiographs reveal proper position of the customized patellofemoral prosthesis. (From Sisto DJ, Sarin VK. Custom patellofemoral arthroplasty of the knee: surgical technique. *J Bone Joint Surg [Am]* 2007;89(Suppl 2, Part 2):223; with permission.)



designed from CT data, the prosthesis fits precisely against the subchondral bone of the femoral trochlear groove, virtually eliminating the trade-off between alignment and fit that is common with off-the-shelf patellofemoral prostheses. Moreover, because the fit and alignment of the customized trochlear prosthesis is defined preoperatively, there is no need for intramedullary instrumentation or bone resection.

A CT scan of the patient's distal femur is performed according to the specific instructions provided by the manufacturer of the customized trochlear prosthesis (Kinamed, Camarillo, California). The surgeon receives a CT-reconstructed bone model for review before the surgery. Any planned osteophyte removal is communicated to the prosthesis manufacturer by physically performing the planned removal on the bone model and returning the model to the manufacturer before final prosthesis design.

After the femoral trochlea is exposed and the patella is everted (Fig. 3), a customized marking template and drill-guide is used to mark the perimeter for cartilage removal (Fig. 4). Because the CT scan models bone only, proper fit of the prosthesis is achieved by using a curette to excise any articular cartilage inside the marked perimeter (Fig. 5). The customized drill-guide then is used to drill three holes for the pegs of the prosthesis (Fig. 6). After the trochlear groove has been

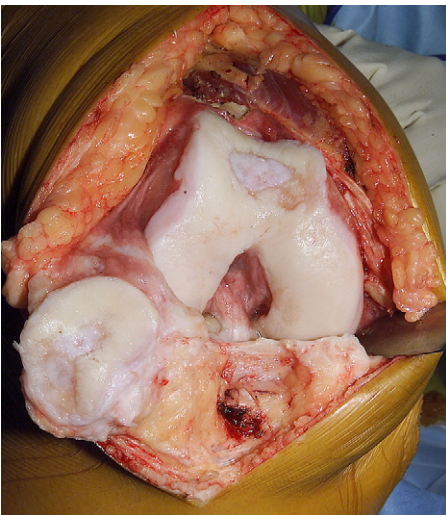


Fig. 3. Intraoperative view showing cartilage degeneration isolated to patellofemoral articulation. (*Adapted from Sisto DJ, Sarin VK. Custom patellofemoral arthroplasty of the knee: surgical technique. J Bone Joint Surg [Am] 2007;89(Suppl 2, Part 2):216; with permission.*)

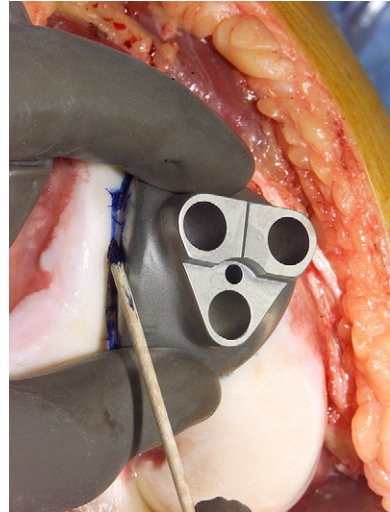


Fig. 4. The customized marking template and drill-guide is used to mark the perimeter for cartilage removal. (*Adapted from Sisto DJ, Sarin VK. Custom patellofemoral arthroplasty of the knee: surgical technique. J Bone Joint Surg [Am] 2007;89(Suppl 2, Part 2):217; with permission.*)

prepared (Fig. 7), the customized trochlear prosthesis is trial-fitted by placing the prosthesis pegs into the drilled holes and finding its natural fit on the femoral trochlea (Fig. 8).



Fig. 5. Exposed subchondral bone inside the perimeter of the customized trochlear prosthesis. (*Adapted from Sisto DJ, Sarin VK. Custom patellofemoral arthroplasty of the knee: surgical technique. J Bone Joint Surg [Am] 2007;89(Suppl 2, Part 2):219; with permission.*)

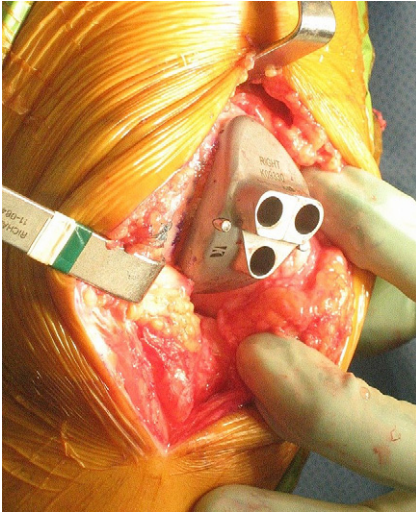


Fig. 6. Customized marking template and drill-guide affixed to the trochlear groove.

The customized trochlear prosthesis is designed to articulate with an off-the-shelf all-polyethylene domed patellar prosthesis. A dome-shaped patellar prosthesis (either inset or onlay) is selected so that the residual patella has a thickness of 15 mm or more after resection, thus maintaining the overall patellar thickness with the prosthesis in place. After a successful trial reduction, both the trochlear and patellar prostheses are cemented in place (Fig. 9). The patella is reduced to its anatomic position, and the knee is tested



Fig. 7. Trochlear groove prepared to accept the customized trochlear prosthesis.

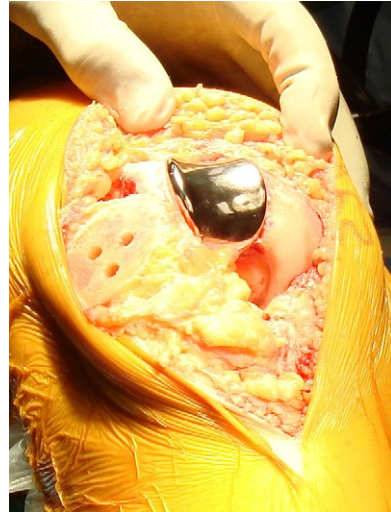


Fig. 8. Customized trochlear prosthesis trial-fitted in place. (Image courtesy of Robert Jackson MD, Provo, Utah.)

through a range of motion to be certain that patellar tracking is anatomic. Lateral retinacular releases are performed as indicated by the “no-thumb” test of patellar tracking.

#### Keys to success

The authors' experience with customized patellofemoral arthroplasty suggests several preoperative and intraoperative keys to success [22].

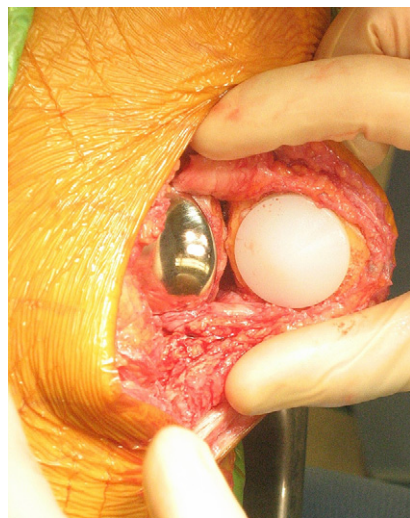


Fig. 9. Customized trochlear prosthesis and patellar prosthesis cemented in place.

### *Preoperative*

1. The manufacturer's CT scanning protocol must be followed to ensure that bone geometry data are collected in the proper format and with sufficient resolution.
2. Because the posterior surface of the customized trochlear prosthesis is defined by CT scan data, any planned intraoperative osteophyte removal within the femoral trochlea must be communicated to the manufacturer before final prosthesis design. Removal of osteophytes is communicated readily through the customized bone model that is created for each case.
3. The strict indications and contraindications for patellofemoral arthroplasty must be respected. In the authors' experience, approximately 3% of patients undergoing knee arthroplasty are candidates for isolated patellofemoral arthroplasty.

### *Intraoperative*

1. Residual problems with patellar alignment and tracking must be corrected at the time of surgery.
2. Only cartilage should be removed within the trochlear groove of the distal femur. The customized trochlear prosthesis is designed to rest against the subchondral bone of the trochlear groove. Unintentional removal of subchondral bone can compromise the fit of the customized trochlear prosthesis.
3. Patellofemoral joint overstuffing can be avoided by resecting more bone on the patellar side or by selecting a thinner patellar prosthesis.

### **Summary**

The authors believe that the customized approach to patellofemoral arthroplasty effectively addresses the design deficiencies and difficulties in surgical technique associated with off-the-shelf trochlear prostheses. Progression of arthritic disease into the medial and lateral knee compartments often contributes to the need for patellofemoral prosthesis revision. Poorly fitting off-the-shelf prostheses can affect the mechanics of the knee joint (including the medial and lateral compartments) negatively, leading to disease progression into these compartments. The customized approach to patellofemoral arthroplasty is designed to restore the mechanics of the

patellofemoral compartment and therefore maintain the native mechanics of the tibiofemoral compartments. Furthermore, the learning curve for customized patellofemoral arthroplasty is extremely short, because positioning and alignment of the customized trochlear prosthesis is determined preoperatively, thus eliminating intraoperative guesswork.

In the past few years, there has been a resurgence of interest in patellofemoral arthroplasty. Although the results of off-the-shelf patellofemoral prostheses have varied, the authors' results with a customized approach to patellofemoral arthroplasty are encouraging. The results of this customized approach demonstrate that it is a safe and effective treatment option for patients who have isolated patellofemoral arthritis.

### **References**

- [1] McAlindon TE, Snow S, Cooper C, et al. Radiographic patterns of osteoarthritis of the knee joint in the community: the importance of the patellofemoral joint. *Ann Rheum Dis* 1992;51(7):844-9.
- [2] Lonner JH. Patellofemoral arthroplasty. *J Am Acad Orthop Surg* 2007;15(8):495-506.
- [3] Mont MA, Haas S, Mullick T, et al. Total knee arthroplasty for patellofemoral arthritis. *J Bone Joint Surg Am* 2002;84:1977-81.
- [4] Ackroyd CE, Chir B. Development and early results of a new patellofemoral arthroplasty. *Clin Orthop Relat Res* 2005;436:7-13.
- [5] Arciero RA, Toomey HE. Patellofemoral arthroplasty. A three- to nine-year follow-up study. *Clin Orthop Relat Res* 1988;236:60-71.
- [6] Argenson JN, Guillaume JM, Aubaniac JM. Is there a place for patellofemoral arthroplasty? *Clin Orthop Relat Res* 1995;321:162-7.
- [7] Argenson JN, Flecher X, Parratte S, et al. Patellofemoral arthroplasty: an update. *Clin Orthop Relat Res* 2005;440:50-3.
- [8] Blazina ME, Fox JM, Del Pizzo W, et al. Patellofemoral replacement. *Clin Orthop Relat Res* 1979;144:98-102.
- [9] Cartier P, Sanouiller JL, Grelsamer R. Patellofemoral arthroplasty. 2- 12-year follow-up study. *J Arthroplasty* 1990;5:49-55.
- [10] de Winter WE, Feith R, van Loon CJ. The Richards type II patellofemoral arthroplasty: 26 cases followed for 1-20 years. *Acta Orthop Scand* 2001;72:487-90.
- [11] Kooijman HJ, Driessen AP, van Horn JR. Long-term results of patellofemoral arthroplasty. A report of 56 arthroplasties with 17 years of follow-up. *J Bone Joint Surg Br* 2003;85:836-40.
- [12] Krajca-Radcliffe JB, Coker TP. Patellofemoral arthroplasty. A 2- to 18-year followup study. *Clin Orthop Relat Res* 1996;330:143-51.

- [13] Lubinus HH. Patella glide bearing total replacement. *Orthopedics* 1979;2:119–27.
- [14] Merchant AC. Early results with a total patellofemoral joint replacement arthroplasty prosthesis. *J Arthroplasty* 2004;19:829–36.
- [15] Sisto DJ, Sarin VK. Custom patellofemoral arthroplasty of the knee. *J Bone Joint Surg Am* 2006;88(7):1475–80.
- [16] Smith AM, Peckett WR, Butler-Manuel PA, et al. Treatment of patello-femoral arthritis using the Lubinus patello-femoral arthroplasty: a retrospective review. *Knee* 2002;9:27–30.
- [17] Tauro B, Ackroyd CE, Newman JH, et al. The Lubinus patellofemoral arthroplasty. A five- to ten-year prospective study. *J Bone Joint Surg Br* 2001;83:696–701.
- [18] Lonner JH. Patellofemoral arthroplasty: pros, cons, and design considerations. *Clin Orthop Relat Res* 2004;428:158–65.
- [19] Fulkerson JP. Disorders of the patellofemoral joint. 4th edition. Philadelphia: Lippincott Williams & Wilkins; 2004.
- [20] Leadbetter WB, Seyler TM, Ragland PS, et al. Indications, contraindications, and pitfalls of patellofemoral arthroplasty. *J Bone Joint Surg Am* 2006;88(Suppl 4):122–37.
- [21] Ahlback S. Osteoarthritis of the knee. A radiographic investigation. *Acta Radiol Diagn (Stockh)* 1968;277(Suppl):7–72.
- [22] Sisto DJ, Sarin VK. Custom patellofemoral arthroplasty of the knee: surgical technique. *J Bone Joint Surg Am* 2007;89(Suppl 2, Part 2):214–25.