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Fresh Osteochondral Allografts

Results in the Patellofemoral Joint

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Twenty knees in 18 patients were treated (mean age, 42 years; range, 19–64 years) with fresh osteochondral allografting limited to the patellofemoral joint. The knees were analyzed retrospectively to determine the rate of successful outcomes. The trochlea and patella were treated in 12 patients and the patella was treated in eight patients. There were 11 women and seven men. The primary outcome measures were revision allografting, arthrodesis, or arthroplasty, and clinical scoring using a modified Merle D'Aubigné-Postel 18-point scale. Radiographs were available for 12 knees. There were five failures. For the remaining knees, the clinical scores increased from a mean of 11.7 points (range, 7–15 points) to 16.3 points (range, 12–18 points). Of the knees evaluated radiographically, four had no evidence of patellofemoral arthrosis, and six had only mild arthrosis. Fresh osteochondral allografting is a salvage procedure for the young, active patient with severe articular cartilage disease of the patellofemoral joint. The results of this procedure are comparable to results of described other techniques in the literature. If allograft incorporation does occur, the procedure is associated with improved pain, function, range of motion, and a low risk of progressive arthritis.

Level of Evidence: Level IV (case series—no, or historical control group). See the Guidelines for Authors for a complete description of levels of evidence.

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Articular cartilage disease of the patellofemoral joint is an unsolved problem in orthopaedic surgery. Potential solutions have been suggested, including marrow-stimulating techniques, cell-based treatments, patellofemoral arthroplasty, and total knee arthroplasty (TKA).[5,9,15,30,40]

Marrow-stimulating techniques such as abrasion arthroplasty and microfracture stimulate fibrocartilage repair tissue with mechanical properties inferior to hyaline cartilage.[10,21] Autologous chondrocyte implantation has been used in the patellofemoral joint, but it has 69% and 58% success rates in patellar and trochlear lesions at 2–9 years, respectively. Realignment procedures such as anteromedialization of the tibial tubercle have been successful, particularly in patients with symptomatic patellar subluxation.[11] This technique had a 60–70% success rate.[12,32] Despite the decrease in patellofemoral contact pressures, there is no restoration of articular cartilage tissue with such procedures done in isolation. As a result, patients with diffuse patellar and central trochlear lesions have had consistently poor results.[37]

Patellofemoral arthroplasty was developed as a prosthetic solution to this clinical problem and has been successful in a limited number of patients at short-term followup, but with a high complication rate.[3,42] The durability of this procedure is unknown in young, active patients. The use of TKA for treatment of isolated patellofemoral arthritis has been described with patients reporting improved pain and function.[31,35] However, this procedure is not attractive for the young, active patient with isolated patellofemoral arthritis.

Fresh osteochondral allografts have been used at our institution as a biologic resurfacing procedure for more than 20 years. We hypothesized that: (1) fresh osteochondral allografting would have a success and revision rate comparable to osteochondral allografting of other portions of the knee, and to other surgical treatments for the patellofemoral joint; (2) in patients who did not require revision surgery, there would be a high degree of functional restoration and pain relief; and (3) if the allograft-host interface healed the grafts would have a low rate of radiographic arthrosis.

MATERIALS AND METHODS

We retrospectively reviewed 264 fresh osteochondral allografting procedures of the knee from our database from December 1983 until October 2000. Inclusion criteria were having a fresh osteochondral allograft limited to the patellofemoral joint and a minimum clinical followup of 24 months. The exclusion criterion was osteochondral grafting of any other portion of the knee including the femoral condyles or tibial plateaus. A consecutive case series of 20 knees in 18 patients met these inclusion criteria (Table 1). The patients had an average clinical followup of 94 months (range, 24–214 months). Allografts were done on the patella in all 20 knees and on the trochlea in 12 knees.

The procedures in our series were done within 2–5 days from the time of donor tissue harvest to maximize graft viability. The grafts were obtained from our institutional tissue bank and were kept refrigerated at 4°C in tissue culture medium. Currently, fresh allograft tissue is not available until at least 14 days after recovery to complete processing and testing. The patients are scheduled for surgery as the grafts become available. Because of the relatively small volume of bone, tissue matching is not done for fresh osteochondral allografts. We do approximately 30–40 fresh osteochondral allografts of the knee annually. All patients are given prophylactic antibiotics. The procedure is done through an arthrotomy with proximal splitting of the fibers of the vastus medialis obliquus. The patella is everted. Based on the size of the lesion, the surgeon determines the need for resurfacing the entire patella or a portion of the patella. The recipient bed must be prepared to the level of a healthy, bleeding cancellous bone bed. In patients with small lesions, a cylindrical graft can be used (Fig 1). With more extensive lesions the entire patella or trochlea or both are resurfaced. In patients with articular cartilage damage to the entire patella, the recipient and donor patellae are resected similar to patellar resurfacing in arthroplasty, typically with a graft 10–12 mm thick (Fig 2). Increased composite patellar thickness is avoided by resecting additional bone from the host or the graft to reconstitute the patient's native patellar thickness.

Allografting is more challenging for large trochlear grafts. Although such lesions can be resurfaced with several adjacent, interlocked cylindrical grafts, we used the entire trochlea as one graft. This technique requires precise measurements of the donor and recipient trochleas. Once the desired dimensions are obtained, a small oscillating saw is used to outline the rectangular dimensions of the recipient trochlea. Next, an oscillating or reciprocating saw is used to remove the trochlea of the recipient, aiming approximately 10 mm proximal to a line tangential to the articular surface. The recipient site is typically 10–12 mm deep. Care is required to avoid undercutting the medial and lateral femoral condyles. The defect then is prepared using osteotomes, rasps, and a motorized burr. The identical cut is made on the donor allograft knee, allowing at least 5 mm of increased thickness in each dimension. Next, a tabletop burr, rongeurs, and oscillating saws are used to match the graft to the recipient bed. Incremental sizing and testing of the donor graft allows for press-fit. Care must be taken to protect the articular cartilage of the femoral condyles and the cruciate ligaments. Before final implantation, the graft is treated with high-pressure pulse lavage irrigation to remove blood from the allograft bone and to decrease immunogenic load. In patients with inadequate press-fit stability, or patients with resurfacing of the entire patella, additional fixation is achieved using small interfragmentary screws or absorbable pins. The patella then is reduced and tracking of the patellofemoral joint is checked. Efforts are made to avoid overloading or eccentric loading of the graft. Lateral retinacular release and/or proximal and distal realignment procedures can be combined with the allograft as indicated by the intraoperative tracking evaluation. In our series of knees, no proximal or distal realignment procedures were done at the index operation.

The postoperative treatment regimen includes the use of continuous passive motion. Patients with isolated patellofemoral grafts are allowed weightbearing in extension. The patients can bear full weight in flexion and extension at 3 months. Return to activity usually is allowed after 4 months. All surgeries were done by one of four surgeons, all with extensive experience with fresh osteochondral allografting.

All patients were evaluated preoperatively by history, physical examination, and standard radiographs. Patient history and examination information was gathered and recorded by three of the authors (FRC, WDB, AAJ) in an unblinded fashion. A clinical score was generated using an 18-point Merle D'Aubigné-Postel score[29] as modified by Chu et al,[5] with a score of 18 being excellent, 15–17 being good, and 12–14 being fair. This score was the principal outcome measure. An excellent knee was pain-free and had full range of motion (ROM) with no activity restrictions. A good knee allowed moderate activity and was not associated with any work restrictions. A score less than 11 was classified as poor based on severe pain, limitation to household ambulation, and flexion less than 60° in any one subcategory, or a combination of moderate functional loss, pain, and ROM based on all three subcategories. Failure was defined as a poor score with the need for revision allografting, patellectomy, arthrodesis, or TKA. An internal control group was not available. The rate of good and excellent results was compared with historic literature controls for other procedures done for patellofemoral arthritis and for fresh osteochondral allografting of other anatomic sites.

In addition to the standard preoperative and postoperative information, the 16 patients available at latest followup answered a questionnaire in person or via telephone interview. This questionnaire was used to determine: (1) current pain and functional status compared with preoperative status; (2) willingness to undergo a similar procedure again under the same circumstances; (3) overall satisfaction with the allograft surgery on a four-point ordinal scale; and (4) overall condition of the involved knee on a six-point scale from significantly improved to significantly worse.

The patients were 19–64 years (mean, 42 years) of age. Two patients (two knees) were unavailable for the most recent followup, although they were evaluated previously at more than 24 months. All patients meeting the indications of the study had been evaluated clinically by the 18-point score at a minimum of 24 months postoperatively. Patients weighed an average of 80 kg (range, 44–137 kg) and had an average height of 170 cm (range, 150–193 cm). Their body mass index (BMI) averaged 27 (range, 19–44). There were 11 women and seven men. Eighteen of 20 knees had been examined arthroscopically before the allograft

TABLE 1. Clinical Results of Fresh Osteochondral Allografting of the Patellofemoral Joint

Patient Number	Gender	Diagnosis	Age at Surgery (years)	Clinical Followup (months)	Trochlear Allografting	Pre-operative 18-point Score*	Post-operative 18-point Score*	Final Outcome
1	Female	Posttraumatic arthrosis	35	75	No	10	18	No revision at 75 months
2	Female	Posttraumatic arthrosis	35	200	Yes	6	8	Failure: arthrodesis at 52 months postoperatively
3	Female	Primary patellofemoral arthrosis	41	24	Yes	10	13	No revision at 24 months
4	Female	Patellar subluxation or tilt (secondary arthritis)	26	198	No	11	18	Failure: revision allografting at 38 months
5	Male	Primary patellofemoral arthrosis	32	51	Yes	13	17	No revision at 36 months
6	Female	Posttraumatic arthrosis	63	135	Yes	10	16	No revision at 135 months
7	Female	Patellar subluxation or tilt (secondary arthritis)	64	214	No	12	8	Failure: revision from fall at 13 months postoperatively
8	Female	Patellar subluxation or tilt (secondary arthritis)	55	34	Yes	12	17	No revision at 34 months
9	Male	Posttraumatic arthrosis	42	46	No	10	18	No revision at 46 months
10	Male	Primary chondromalacia patellae	63	66	Yes	14	18	No revision at 66 months
11	Male	Patellar subluxation or tilt (secondary arthritis)	54	169	Yes	14	17	No revision at 169 months
12	Female	Patellar subluxation or tilt (secondary arthritis)	43	103	Yes	11	8	Failure: patellectomy at 16 months postoperatively eventually leading to total knee arthroplasty
13	Male	Primary patellofemoral arthrosis	31	38	Yes	7	12	No revision at 38 months
14	Female	Posttraumatic arthrosis	34	67	No	11	13	No revision at 67 months
15	Male	Patellar subluxation or tilt (secondary arthritis)	34	25	No	13	17	No revision at 25 months
16	Male	Primary patellofemoral arthrosis	32	42	No	13	17	No revision at 42 months
17	Male	Primary patellofemoral arthrosis	64	51	Yes	15	18	No revision at 51 months
18	Female	Patellar subluxation or tilt (secondary arthritis)	50	46	Yes	14	0	Failure: total knee arthroplasty at 42 months postoperatively
19	Male	Posttraumatic arthrosis	33	99	Yes	11	17	No revision at 99 months
20	Female	Primary chondromalacia patellae	19	188	No	12	17	No revision at 188 months

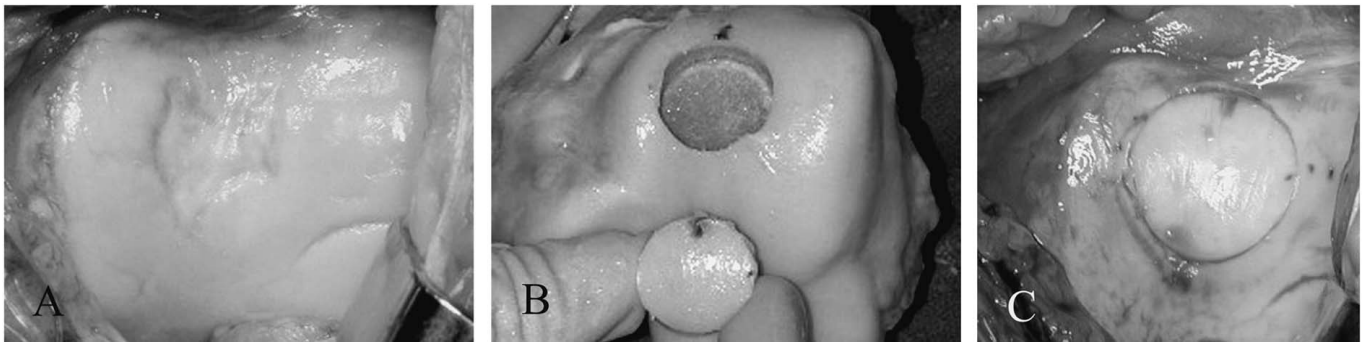

Fig 1A–C. (A) An intraoperative photograph shows a large full thickness articular cartilage defect of the trochlea. (B) An allograft plug is taken from a matching portion of the allograft trochlea. (C) The trochlear graft is placed into the recipient site with minimal step-off and smooth transitions to recipient articular surface.

procedure. Radiographs and magnetic resonance imaging (MRI) were used to diagnose isolated patellofemoral maltracking (one knee) and patellofemoral chondromalacia (one knee) in two patients. Indications included secondary arthrosis from patellar subluxation in seven knees (seven patients), posttraumatic arthrosis in six knees (six patients), primary patellofemoral arthrosis in four knees (four patients), and primary chondromalacia patellae in three knees (three patients). Patellar subluxation was defined as abnormal tracking of the patella relative to the trochlea with active extension or abnormal alignment of the patella within the trochlea on Merchant[28] view radiographs. Patellofemoral arthrosis referred to full thickness articular cartilage loss and exposed bone. In some patients the pathologic features were linked to a previous traumatic event (posttraumatic arthrosis). If none could be identified the patients were diagnosed with primary patellofemoral arthrosis. Chondromalacia is softening or disruption of the cartilage architecture defined as greater than 50% loss of thickness, but without exposed bone seen at arthroscopic or MRI examinations.

Of the 18 patients (18 knees) with available operative notes, 15 patients had the entire patella resurfaced and three patients had a portion resurfaced using a cylindrical plug system (Arthrex, Naples, FL). In these three patients the average surface area of the cylindrical plug was 7.1 cm^2 (range, 1.8–17.8 cm^2). The fixation was press-fit (two knees) or press-fit with additional screws (one knee). The type of fixation of the entire patella was available for 13 of 15 knees. Four knees had fixation using a press-fit technique and five knees had fixation with press-fit and screws only (average, 2.2 screws). Four knees had press-fit fixation with poly-p-dioxanone pins (PDS, Orthosorb®, DePuy-ACE, Warsaw, IN) alone or in combination with standard screws.

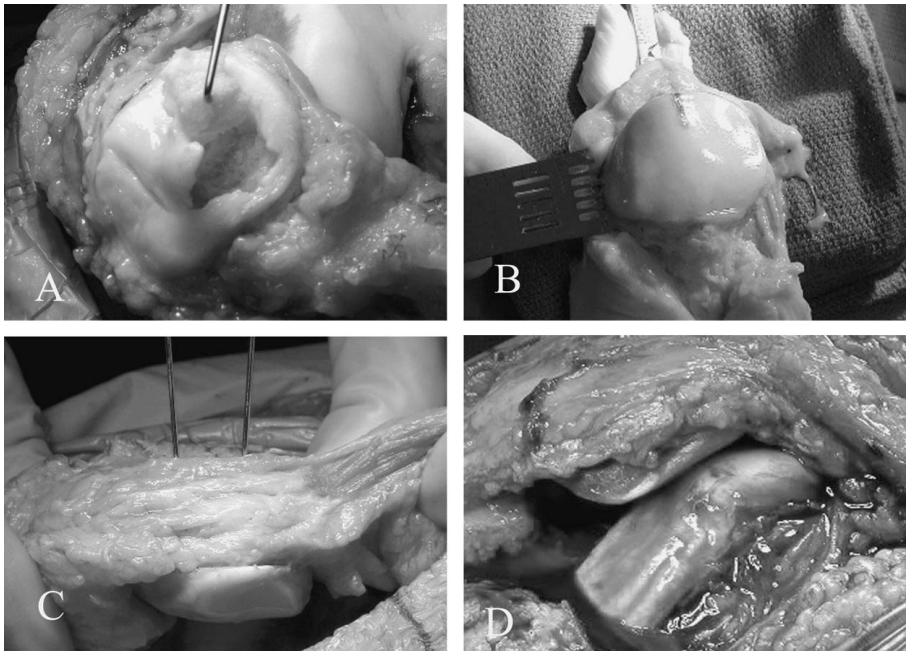

Fig 2A–D. (A) An intraoperative photograph shows a large osteochondral defect of the patella. (B) A matching allograft patella is shown before being cut using an oscillating saw. (C) The patellar allograft is stabilized with two cannulated guide pins through the anterior patellar cortex. (D) The patellofemoral joint is reduced with acceptable patellar tracking and symmetric contact with the trochlea.

The entire femoral trochlea or a portion of the femoral trochlea was treated with allografting in 12 patients. Information regarding graft size and type was available for eight knees. Six knees had a rectangular graft and two knees had a cylindrical graft. The mean trochlear graft size was 13.2 cm^2 (range, 2.5–22.5 cm^2). Fixation was achieved with press-fit in two knees, press-fit with screws in two knees, and press-fit with PDS pins alone or in combination with screws in four knees.

Nine knees (eight patients) had lateral retinacular release at the time of allografting (45%). Six of these knees had chronic patellar subluxation or tilt and three knees had primary patellofemoral arthrosis. The decision to do lateral release was made intraoperatively based on contact of both facets of the patella with the trochlea, or as an additional measure to decrease eccentric loads on the allografts. Because of the small patient cohort, no attempt was made to separately analyze the patients based on the performance of a lateral retinacular release.

The 18 patients had 52 previous operations (mean, 2.6 operations per knee; range, 0–8 operations per knee) before the index allograft. The operations consisted of 29 diagnostic arthroscopies, four arthroscopic chondroplasties, three Maquet tibial tubercle transfers, three arthroscopic lateral releases, and two patellofemoral soft tissue realignments. Other operations included abrasion arthroplasty, open and arthroscopic meniscectomy, and arthroscopic microfracture.

Radiographs were reviewed at the latest followup or were obtained by mail (Table 2). Three patients were lost to followup. Five patients who had revision allografting, patellectomy, arthrodesis, or TKA were excluded. Twelve patients were available for radiographic analysis. The mean radiographic followup was 70 months (range, 18–183 months). These included anteroposterior, lateral, and Merchant[28] view radiographs (Fig 3). All radiographs were evaluated by an independent musculoskeletal radiologist who was blinded to patient identity, treatment, and to the timing of the radiographs. Interobserver and intraobserver reliability measurements were not done because of the small number of radiographs and the participation of one radiologist. Patellofemoral arthrosis and tibiofemoral arthrosis in the medial and lateral compartments were classified using the modified Fairbank[8] and Ählback[2] criteria as described by Lundberg and Messner.[23] Radiographs were evaluated for visibility of the allograft-host junctions, allograft radiodensity when compared with the surrounding bone (increased, decreased, or the same), and the presence of subchondral cysts.

The technique of osteochondral allografting varies depending on the surfaces to be grafted. Preoperatively, the donor and recipient are matched by size. Using the mediolateral dimension of the tibia, the donor is measured directly from the graft and the recipient is measured radiographically with correction for magnification. A match typically is considered to be a difference of 5 mm or less. The mediolateral dimension of the tibia traditionally has been used for sizing, as this value is readily available from most commercial allograft suppliers and has been correlated with the mediolateral dimension of the femur and the width and length of the patella.[27] Potential candidates are placed on a waiting list until a suitable donor is available.

Modified Merle D'Aubigné-Postel[29] scores were analyzed using nonparametric testing with the Wilcoxon signed rank test comparing the preoperative and latest followup scores. Statistical significance was set at $p < 0.05$. Survival analysis was done with the end point of failure defined as revision allograft surgery, patellectomy, arthrodesis, or TKA according to the Kaplan and Meier method.[19] All analyses were done using standard statistical software (StatView, Abacus Concepts, Berkeley, CA).

RESULTS

The results of five patients were classified as clinical failures. Two knees had revision allografting, two knees had TKAs, and one knee had an arthrodesis. The remaining 15 knees (13 patients) were classified as having successful results.

For the subgroup of knees classified as having successful results, the average 18-point score increased significantly from 11.7 points (range, 7–15 points) preoperatively to 16.3 points (range, 12–18 points) at the latest followup ($p = 0.001$). There were four excellent results,

TABLE 2. Radiographic Results of Fresh Osteochondral Allografting of the Patellofemoral Joint

Patient Number	Radiographic Followup (months)	Patellofemoral Arthrosis	Allograft-Host Interface	Radiodensity versus Host	Subchondral Lysis	Sclerosis
5	51	Grade 0	Not visible	Unchanged	No	No
6	120	Grade III	Not visible	Unchanged	No	Yes
8	49	Grade I	Not visible	Unchanged	No	No
9	38	Grade I	Not visible	Unchanged	Yes	No
10	80	Grade 0	Visible	Unchanged	No	No
11	183	Grade I	Visible	Unchanged	Yes	No
13	38	Grade I	Not visible	Unchanged	No	No
14	68	Grade I	Not visible	Unchanged	Yes	Yes
15	18	Grade 0	Visible	Increased	Yes	Yes
16	39	Grade 0	Not visible	Increased	No	Yes
17	51	Grade I	Not visible	Increased	No	No
19	99	Grade II	Not visible	Increased	No	No

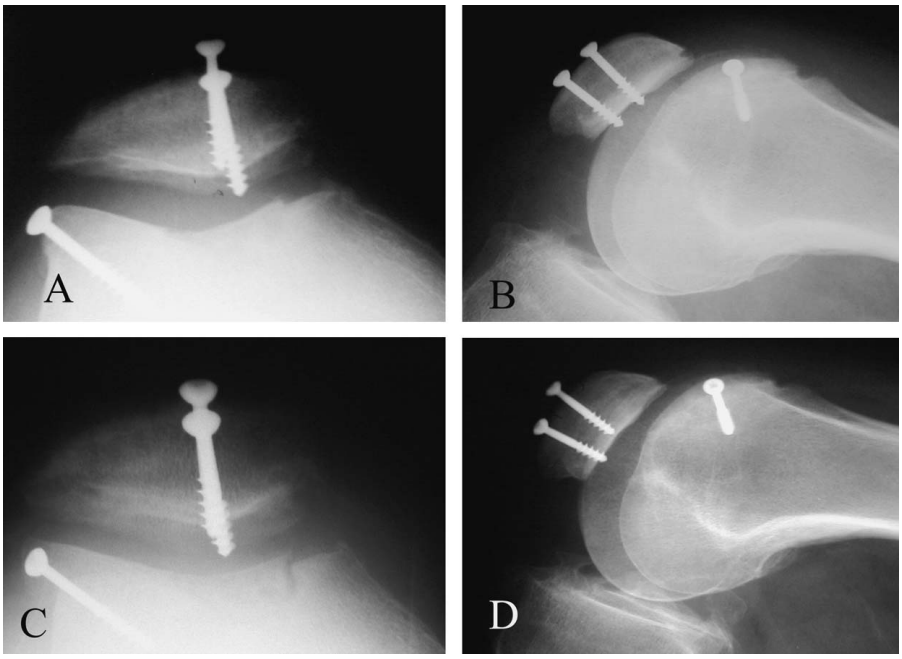

Fig 3A–D. A 64-year-old patient with patellar and trochlear defects was treated with osteochondral allografting of both lesions. Early postoperative (A) Merchant and (B) lateral radiographs show the patellar and trochlear grafts. At 4 years postoperatively the (C) Merchant and (D) lateral radiographs indicate excellent incorporation at the host-graft interface, absence of sclerosis, lucency, fracture, and lack of progression of patellofemoral arthrosis.

eight good results, and three fair results. The overall rate of excellent or good results was 60% (12 of 20 patients). Kaplan-Meier analysis revealed that the probability of allograft survival at 10 years with a 95% confidence interval was 67% ± 25%.

There were no infections directly related to the index operation in this series. Eight of the 15 knees (seven patients) with successful results had additional surgeries. The surgeries included seven diagnostic arthroscopies, two arthroscopic chondroplasties, two hardware removal operations, and one arthrotomy and fat pad debridement.

Of the 12 knees evaluated radiographically, four had no evidence of patellofemoral arthrosis and six had mild arthrosis (Table 2). The allograft-host interface was not visible radiographically in nine patients and was identifiable in three patients. The radiodensity of the grafts was identical to the host in eight patients and was increased in four patients. Four grafts had subchondral lysis, three of which still had good or excellent clinical scores.

Fourteen of 16 patients said they would have the operation again. In addition, 14 of 16 patients said they had less pain. Eight patients were extremely satisfied, six were satisfied, and two were dissatisfied with the operation. Thirteen patients had better function as a result of the surgery. Nine patients reported substantial improvement, four reported that they were somewhat improved, two reported no change, and one was substantially worse.

DISCUSSION

In our series, good or excellent results were achieved in 60% of patients at a mean followup of 94 months. Additionally, in patients whose results were not considered clinical failures based on revision, arthroplasty, or arthrodesis, there was a significant improvement in the Merle D'Aubigné-Postel[29] scores. However, five patients ultimately required some form of major surgery on the knee. Of the 15 knees with successful results, eight required additional surgery; most were minor procedures. The radiographic analysis suggests that if there is healing of the allograft-host interface, the progression of arthrosis potentially can be halted. Of the 12 patients evaluated radiographically, 10 patients had minimal to no evidence of radiographic patellofemoral arthrosis. The majority of the grafts achieved an invisible interface of radiographically similar radiodensity to the host and did not have subchondral lysis.

Our results are disappointing relative to previously published data from our institution involving all compartments of the knee. In a report on 55 knees from our database, 82% of patients achieved good or excellent results at a mean followup of 75 months.[5] The mean age of the patients was 39 years, slightly younger than our cohort.[5] Five patients had resurfacing of the patellofemoral joint in that series with no failures.[5] Eight-five percent of a series of 126 fresh osteochondral allografts of the knee were successful at a mean followup of 7.5 years.[13] However, only two patients from that series had resurfacing of the patellofemoral joint. In a series of fresh allografts for failed tibial plateau fractures there was a 10-year Kaplan-Meier survivorship of 80%, slightly greater than our series.[41]

Different surgical treatments have been proposed for articular disease of the patellofemoral joint (Table 3). The

TABLE 3. Treatment Options and Results of Surgical Procedures for Treatment of Patellofemoral Arthritis

Authors	Procedure	Implant	Age at Surgery (years)	Followup (years)	Number of Knees Available at Followup	Comments
Fulkerson et al[12]	Anteromedialization of tibial tubercle	N/A	28 (15–56)	2.9 (2.2–4.2)	30	89% success by objective questionnaire evaluation; 75% of patients with advanced arthrosis had good results (no excellent results)
Morshuis et al[32]	Anteromedialization of tibial tubercle	N/A	36 (18–66)	2.5 (1.8–3.2)	20	84% good/excellent early results at mean 1 year followup; 70% good/excellent results at study end point; patients with radiographic arthritis or lateral subluxation had 60% successful results versus 100% in patients with no arthritis and normal tracking
Pidoriano et al[37]	Anteromedialization of tibial tubercle	N/A	29 (16–54)	3.9 (1–8)	37	Good/excellent results: distal patella (nine of 10 knees), lateral facet (11 of 13 knees), medial facet (five of nine knees), proximal or diffuse (one of five knees); distal and lateral lesions had a statistically higher success rate than medial, proximal, or diffuse lesions; patellar chondromalacia grade not associated with any difference in outcome
Jenny et al[18]	Maquet tibial tubercle elevation	N/A	43 (17–64)	11 (8–15)	65	Grade IV chondromalacia lesions associated with a significant improvement at mean 4 years followup, but no significant difference at 11 years followup; no effect from duration of symptoms, age, gender, body weight, preoperative pain, or joint space narrowing; 62% success rate at 4-year and at 11-year followups
Radin and Pan[38]	Maquet tibial tubercle elevation	N/A	31 (16–49)	6.1 (3–9.8)	42	79% good/excellent subjective results; nine of 42 knees were failures (21%): social/psychological reasons (n = 6), unrecognized tibiofemoral arthritis (n = 2), unexplained (n = 1); 7% major complication rate: nonunion (n = 2), osteomyelitis and skin slough (n = 1); nine of 42 distal fractures of tibial shingle
Schmid[39]	Maquet tibial tubercle elevation	N/A	34 (20–66)	16 (1–20)	35	80% very good/good results; 20% unsatisfactory results attributed to surgical error or inaccurate diagnosis; four failures from tibiofemoral arthritis or lateral subluxation; other complications: osteomyelitis (n = 2), irritation at site of prominent tibial tubercle (n = 2)
Ackroyd and Polyzoides[1]	Patellectomy	N/A	60 (34–77)	6.5 (2–22)	87	53% good results, 26% fair results, 21% poor results (patient/surgeon VAS); minimal preoperative tibiofemoral arthritis was only factor indicating a good long-term prognosis

TABLE 3. Treatment Options and Results of Surgical Procedures for Treatment of Patellofemoral Arthritis (*Continued*)

Authors	Procedure	Implant	Age at Surgery (years)	Followup (years)	Number of Knees Available at Followup	Comments
Arciero and Toomey[3]	Patellofemoral arthroplasty	14-Richards Type II (Smith & Nephew, Memphis, TN) 11-CFS Wright (Wright Medical, Arlington, TN)	62 (33–86)	5.3 (3–9)	25	15 of 17 (72%) excellent/good results; seven failures: tibiofemoral arthritis (n = 3), component malposition (n = 2), persistent patellofemoral malalignment (n = 1), persistent anterior knee pain (n = 1)
Argenson et al[4]	Patellofemoral arthroplasty	Autocentric (Medinov, Roanne, France)	57 (19–82)	5.5 (2–10)	66	10 revisions: arthrofibrosis (n = 4), sepsis (n = 3), tibiofemoral arthritis (n = 3); greater revision rate in patients with primary osteoarthritis compared with patients with patellar subluxation or patellofemoral dysplasia
de Winter et al[6]	Patellofemoral arthroplasty	Richards Type II	59 (22–90)	11 (1–20)	26	Five failures: revised to patellectomy (pain or malalignment) (n = 3), TKA for tibiofemoral degeneration or malalignment (n = 2); 21 nonrevised knees: Knee Society score: 90 (range, 65–100)
Krajca-Radcliffe and Coker[22]	Patellofemoral arthroplasty	Bechtol I and II (Smith & Nephew, Memphis, TN)	64 (42–84)	5.8	16	14 of 16 (88%) excellent/good results; one revision at 18 months for malalignment and subluxation
Tauro et al[42]	Patellofemoral arthroplasty	Lubinus (Waldemar Link, Hamburg, Germany)	65.5 (50–87)	7.5 (5–10)	62	Satisfactory results 45%; 21 of 76 (28%) revised; revision indications: persistent patellofemoral maltracking (n = 15), tibiofemoral arthritis (n = 5), periprosthetic fracture (n = 1)
Parvizi et al[35]	Total knee arthroplasty	Press-Fit Condylar (Johnson & Johnson, Raynham, MA), Genesis (Smith & Nephew, Memphis, TN), Total Condylar (Howmedica, Rutherford, NJ)	70 (47–85)	5.2 (2–12)	31	21 knees required lateral retinacular release at time of arthroplasty; there were three reoperations including manipulation for poor motion (n = 1), revision of a loose patellar component (n = 1), and extensor mechanism realignment (n = 1)
Current study	Fresh osteochondral allografts	N/A	42 (19–64)	7.8 (2–18)	20	Rate of major reoperation including total knee replacement, arthrodesis, revision allografting (five of 20); of the remaining 15 knees, 18-point scores increased from a mean of 11.7 to 16.3; Kaplan-Meier 10 year survival with 95% confidence intervals: 67% ± 25%

Maquet osteotomy, a technique to advance the tibial tuberosity anteriorly, has been advocated to improve the lever arm of the quadriceps and to decrease compressive loads on the patellofemoral joint.[25] Long-term results of this procedure with various outcome measures have shown success rates of 62%–80% at 6–11 years mean followups.[16,18,38,39] Fulkerson advocated anteromedialization of the tibial tubercle in patients with refractory patellofemoral pain combined with subluxation.[11] In a series of 30 patients with a minimum 2-year followup, good results were achieved in 75% of patients in the subgroup with advanced patellar arthrosis.[12] However, no patients

achieved an excellent result.[12] A decline in results was seen using this osteotomy 12–38 months postoperatively, particularly in patients with arthrosis.[32] There was a 60% rate of satisfactory results 5 years postoperatively.[32] The results of anteromedialization of the tibial tubercle have been shown to be suboptimal in patients with global patellar arthrosis and central trochlear lesions.[37] Patellofemoral arthroplasty has been associated with 50–90% success rates for patients at short-term followup.[3,4,6,22,42] However, the average patient age in most series is 55 years or older, substantially older than our patients.[3,4,6,22,42] In one series using the Lubinus prosthesis (Waldemar Link, Hamburg, Germany), 65% of patients had maltracking, and survival at 6 years with revision and moderate pain as end points was 48%.[42] Total knee arthroplasty for isolated patellofemoral arthritis has achieved clinical success with substantial improvements in pain and function.[31,35] However, this procedure should be considered a salvage procedure, particularly in young, active patients because of complications such as aseptic loosening, infection, and persistent knee pain. There are no reports of the results of this procedure in this patient population. Patellectomy is another surgical option for severe patellofemoral arthritis. However, knees that have had patellectomy require a 15%–30% increase in muscular force to achieve full extension.[20] Long-term studies of patellectomies have found satisfactory results in slightly more than 50% of patients, with a progressive decline in function[1,20] and permanent quadriceps weakness and pain.[36]

Our study has some important limitations. The size of the cohort is small (20 knees). Details of the surgical procedure were unavailable for some of the patients because of missing operative notes or insufficient data in the available notes. The modified Merle D'Aubigné-Postel 18-point scale provides limited information regarding pain, ROM, stair climbing ability, and general function.[29] It does not address knee instability or symptoms of patellofemoral disease such as pain with squatting or extended sitting, location of the pain, and general health measures. Although this scale or its modifications are used commonly in the orthopaedic literature, it has not been validated statistically. Our study also lacks an appropriate control group. This is a common limitation of reports dealing with the merits of a given surgical procedure. Results of alternative procedures such as mosaicplasty, autologous chondrocyte implantation, and the Fulkerson[11] osteotomy were not available in the literature at the time of our study. There was no histologic analysis of the fresh osteochondral allografts at long-term followup. However, previous studies of fresh allografts consistently had improved chondrocyte viability compared with preserved and frozen allografts[7,24,26,34] and a greater percentage of hyaline cartilage than other cartilage replacement procedures.[15,17,33] Radiographic data were available for only 12 of the 20 knees. Radiographic results were limited because of excluding failed knees and three knees that were lost to radiographic followup.

Patellofemoral alignment is critical to the treatment of articular cartilage disease of the patellofemoral joint. A lateral release was done in nine of the knees. This was based on surgical assessment of lateral retinacular tightness. We favor preoperative assessment of patellofemoral tilt and subluxation based on clinical examination, Merchant view radiographs, and computed tomography. If there is evidence of subluxation or asymmetric loading of the lateral patellar facet, we recommend combining the fresh osteochondral allograft with a patellofemoral realignment procedure such as anteromedialization of the tibial tubercle. This is analogous to unloading of tibiofemoral joint allografts using osteotomies as advocated by Gross et al.[14] The role of lateral release in unloading of the patellofemoral joint in the dynamic state is controversial.

Fresh osteochondral allografting of the patellofemoral joint is a salvage operation aimed at young, active patients with isolated patellofemoral articular cartilage disease in whom previous procedures have failed. The patients in our series had articular cartilage damage treated by a common method. Our study is the largest reported series of fresh osteochondral allografts limited to the patellofemoral joint. Although the study is retrospective, it does provide prospectively obtained information in the form of the 18-point scale on all knees at a minimum of 24 months postoperatively. This procedure is the only available technique for resurfacing the entire patellofemoral joint with viable hyaline articular cartilage. In allografting of the patellofemoral joint, much like allografting of the tibiofemoral joint, critical factors for success are initial stability at the host-graft junction, minimization of immune response to the grafts, and optimization of chondrocyte viability.

References

1. Ackroyd CE, Polyzoides AJ: Patellectomy for osteoarthritis: A study of eighty-one patients followed from two to twenty-two years. J Bone Joint Surg 60B:353–357, 1978.
2. Ählback S: Osteoarthrosis of the knee: A radiographic investigation. Acta Radiol Diagn (Stockh) 277(Suppl):7–72, 1968.
3. Arciero RA, Toomey HE: Patellofemoral arthroplasty: A three- to nine-year follow-up study. Clin Orthop 236:60–71, 1988.
4. Argenson JN, Guillaume JM, Aubaniac JM: Is there a place for patellofemoral arthroplasty? Clin Orthop 331:162–167, 1995.
5. Chu CR, Convery FR, Akeson WH, Meyers M, Amiel D: Articular cartilage transplantation: Clinical results in the knee. Clin Orthop 360:159–168, 1999.
6. de Winter WE, Feith R, van Loon CJ: The Richards type II patellofemoral arthroplasty: 26 cases followed for 1–20 years. Acta Orthop Scand 72:487–490, 2001.
7. Desjardins MR, Hurtig MB, Palmer NC: Incorporation of fresh and cryopreserved bone in osteochondral autografts in the horse. Vet Surg 20:446–452, 1991.
8. Fairbank T: Knee joint changes after meniscectomy. J Bone Joint Surg 30B:664–670, 1948.

9. Fitzpatrick PL, Morgan DA: Fresh osteochondral allografts: A 6-10-year review. Aust N Z J Surg 68:573–579, 1998.
10. Frisbie DD, Trotter GW, Powers BE, et al: Arthroscopic subchondral bone plate microfracture technique augments healing of large chondral defects in the radial carpal bone and medial femoral condyle of horses. Vet Surg 28:242–255, 1999.
11. Fulkerson JP: Anteromedialization of the tibial tuberosity for patellofemoral malalignment. Clin Orthop 177:176–181, 1983.
12. Fulkerson JP, Becker GJ, Meaney JA, Miranda M, Folcik MA: Anteromedial tibial tubercle transfer without bone graft. Am J Sports Med 18:490–496, 1990.
13. Ghazavi MT, Pritzker KP, Davis AM, Gross AE: Fresh osteochondral allografts for post-traumatic osteochondral defects of the knee. J Bone Joint Surg 79B:1008–1013, 1997.
14. Gross AE, Aubin P, Cheah HK, Davis AM, Ghazavi MT: A fresh osteochondral allograft alternative. J Arthroplasty 17(4 Suppl 1):50–53, 2002.
15. Hangody L, Feczko P, Bartha L, Bodo G, Kish G: Mosaicplasty for the treatment of articular defects of the knee and ankle. Clin Orthop 391(Suppl):S328–S336, 2001.
16. Heatley FW, Allen PR, Patrick JH: Tibial tubercle advancement for anterior knee pain: A temporary or permanent solution. Clin Orthop 208:215–224, 1986.
17. Horas U, Pelinkovic D, Herr G, Aigner T, Schnettler R: Autologous chondrocyte implantation and osteochondral cylinder transplantation in cartilage repair of the knee joint: A prospective, comparative trial. J Bone Joint Surg 85A:185–192, 2003.
18. Jenny JY, Sader Z, Henry A, Jenny G, Jaeger JH: Elevation of the tibial tubercle for patellofemoral pain syndrome: An 8- to 15-year follow-up. Knee Surg Sports Traumatol Arthrosc 4:92–96, 1996.
19. Kaplan E, Meier P: Non-parametric estimation from incomplete observations. J Am Stat Assoc 53:457–461, 1958.
20. Kaufer H: Mechanical function of the patella. J Bone Joint Surg 53A:1551–1560, 1971.
21. Knutsen G, Engebretsen L, Ludvigsen TC, et al: Autologous chondrocyte implantation compared with microfracture in the knee: A randomized trial. J Bone Joint Surg 86A:455–464, 2004.
22. Krajca-Radcliffe JB, Coker TP: Patellofemoral arthroplasty: A 2- to 18-year followup study. Clin Orthop 330:143–151, 1996.
23. Lundberg M, Messner K: Long-term prognosis of isolated partial medial collateral ligament ruptures: A ten-year clinical and radiographic evaluation of a prospectively observed group of patients. Am J Sports Med 24:160–163, 1996.
24. Malinin TI, Wagner JL, Pita JC, Lo H: Hypothermic storage and cryopreservation of cartilage: An experimental study. Clin Orthop 197:15–26, 1985.
25. Maquet P: Advancement of the tibial tuberosity. Clin Orthop 115:225–230, 1976.
26. Marco F, Leon C, Lopez-Oliva F, et al: Intact articular cartilage cryopreservation: In vivo evaluation. Clin Orthop 283:11–20, 1992.
27. Mensch JS, Amstutz HC: Knee morphology as a guide to knee replacement. Clin Orthop 112:231–241, 1975.
28. Merchant AC, Mercer RL, Jacobsen RH, Cool CR: Roentgenographic analysis of patellofemoral congruence. J Bone Joint Surg 56A:1391–1396, 1974.
29. Merle d'Aubigné R, Postel M: Functional results of hip arthroplasty with acrylic prosthesis. J Bone Joint Surg 36A:451–475, 1954.
30. Minas T: Autologous chondrocyte implantation for focal chondral defects of the knee. Clin Orthop 391(Suppl):S349–S361, 2001.
31. Mont MA, Haas S, Mullick T, Hungerford DS: Total knee arthroplasty for patellofemoral arthritis. J Bone Joint Surg 84A:1977–1981, 2002.
32. Morshuis WJ, Pavlov PW, de Rooy KP: Anteromedialization of the tibial tuberosity in the treatment of patellofemoral pain and malalignment. Clin Orthop 252:242–250, 1990.
33. Nehrer S, Spector M, Minas T: Histologic analysis of tissue after failed cartilage repair procedures. Clin Orthop 365:149–162, 1999.
34. Ohlendorf C, Tomford WW, Mankin HJ: Chondrocyte survival in cryopreserved osteochondral articular cartilage. J Orthop Res 14:413–416, 1996.
35. Parvizi J, Stuart MJ, Pagnano MW, Hanssen AD: Total knee arthroplasty in patients with isolated patellofemoral arthritis. Clin Orthop 392:147–152, 2001.
36. Pickett JC, Stoll DA: Patellaplasty or patellectomy? Clin Orthop 144:103–106, 1979.
37. Pidoriano AJ, Weinstein RN, Buuck DA, Fulkerson JP: Correlation of patellar articular lesions with results from anteromedial tibial tubercle transfer. Am J Sports Med 25:533–537, 1997.
38. Radin EL, Pan HQ: Long-term follow-up study on the Maquet procedure with special reference to the causes of failure. Clin Orthop 290:253–258, 1993.
39. Schmid F: The Maquet procedure in the treatment of patellofemoral osteoarthrosis: Long-term results. Clin Orthop 294:254–258, 1993.
40. Schonholtz GJ, Ling B: Arthroscopic chondroplasty of the patella. Arthroscopy 1:92–96, 1985.
41. Shasha N, Krywulak S, Backstein D, Pressman A, Gross AE: Long-term follow-up of fresh tibial osteochondral allografts for failed tibial plateau fractures. J Bone Joint Surg 85A(Suppl 2):33–39, 2003.
42. Tauro B, Ackroyd CE, Newman JH, Shah NA: The Lubinus patellofemoral arthroplasty: A five- to ten-year prospective study. J Bone Joint Surg 83B:696–701, 2001.