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Fresh Osteochondral Allograft

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Current Procedural Terminology Codes	
27415	Osteochondral allograft, knee, open
29867	Arthroscopy, knee, surgical; osteochondral allograft (eg, mosaicplasty)

Observation of focal chondral pathology in the knee is common during knee arthroscopy.[1] A wide spectrum of chondral disease exists, ranging from superficial articular cartilage injuries to large full-thickness osteochondral lesions. Defects may progress to osteoarthritis based on several patient-, limb-, knee-, and defect-specific factors.[2] The ideal candidate for cartilage restoration surgery is the symptomatic, young or middle-aged motivated individual with either normal or correctable comorbidities (meniscoligamentous status and alignment). However, patients who meet these criteria comprise only 5% of those with articular cartilage injury in the knee.[3] The challenge in identification of symptomatic chondral pathology warrants caution in proceeding with surgical techniques used to treat them. Thus, "treat the patient and not the MRI" (magnetic resonance imaging).

The exact mechanism of symptom initiation and progression with isolated chondral lesions is not completely known. Nonetheless, it is recognized that they may cause significant pain and limitation of function.[4] In symptomatic patients who have failed conservative treatment, there are several viable surgical treatment options. While many procedures are simple and inexpensive arthroscopic procedures (eg, debridement, drilling, microfracture), others require considerable financial and time investments (eg, cell-based therapies (autologous chondrocyte implantation [ACI]) or allograft transplants [osteochondral, meniscal]). Further, comorbidities are addressed either simultaneously or sequentially: (1) meniscal repair or transplantation, (2) high tibial valgus-producing osteotomy (for varus) or distal femoral varus-producing osteotomy (for valgus), (3) tibial tubercle osteotomy (for patellofemoral compartment), and (4) ligament reconstruction as indicated. Therefore, it is the responsibility of the surgeon to understand the advantages and disadvantages of all potential options and educate the patient for the best treatment option for "the here and now." Prophylactic surgery for incidental lesion identification is not recommended.

In the setting of symptomatic, large lesions with subchondral bone loss, treatments such as microfracture, osteochondral autograft, ACI, and other cell-based therapies are insufficient to address underlying osseous deficiency. Thus, fresh osteochondral graft is advantageous with viable hyaline cartilage and structural subchondral bone transplanted as a one-stage procedure. Grafts traditionally were frozen or cryopreserved (inferior chondrocyte viability, matrix

Cole BJ, Harris JD, eds.
Biologic Knee Reconstruction: A Surgeon's Guide (pp 125-131).

Preoperative Patient Education Material

- Cartilage defects in the knee are a common source of pain, swelling, and clicking or locking.
- Nonsurgical treatments include rest, activity modification, ice cryotherapy, bracing (if bow-legged or knock-kneed), supplements (glucosamine and chondroitin), medications (oral anti-inflammatories like ibuprofen, Aleve [naproxen], Celebrex [celecoxib]), aspirations (draining the fluid off the knee), and/or injections (cortisone, hyaluronic acid viscosupplementation).
- Surgical treatments include arthroscopy, chondroplasty, microfracture, drilling, autologous chondrocyte implantation (cell transplant), osteochondral autograft (your tissue), osteochondral allograft (cadaver tissue).
- Osteochondral allograft is a surgery that treats knee cartilage lesions with a transplant of cadaver bone and cartilage, usually with one incision in the front of the knee.
- Osteochondral allograft is outpatient surgery that may take 45 minutes to 2 hours, depending on the size, location, and number of lesions being treated.
- Most patients require pain medication for 1 to 2 weeks following surgery.
- Most patients start physical therapy the week of surgery.
- Most patients use a continuous passive motion (CPM) machine for 6 to 8 hours/day for 6 weeks.
- Most patients use crutches and are nonweight bearing for the first 6 weeks following surgery, and gradually return to full weight bearing over 8 to 12 weeks.
- Return to sports activities is typically discouraged until 9 to 12 months following surgery.

preservation, and clinical outcomes vs fresh grafts), whereas now they are aseptically processed and stored fresh at 4°C.[5] Although chondrocyte viability is significantly decreased beyond 14 days after allograft harvest, this is a necessary step to allow for disease testing.[5] Modern tissue banks have created guidelines to ensure safety of implanted grafts. Most banks recommend transplantation by 28, to a maximum of 35, days post-harvest.

Indications and Contraindications

The indications for osteochondral allograft transplantation include symptomatic chondral or osteochondral defects of the knee that have failed conservative treatment and/or prior cartilage repair techniques, and previously untreated primary chondral or osteochondral lesions greater than 1 to 2 cm^2 on the femoral condyles, trochlea, or patella. The surgical technique varies based on lesion location. Exposure typically involves a medial or lateral parapatellar mini-arthrotomy. Defect preparation involves recipient site sizing and ensuring sufficient surrounding osteochondral walls to support the donor plug. Preoperative sizing images match the recipient and donor sites. Once the recipient site is reamed to a healthy subchondral bone bed (typically between 6 and 9 mm), a surface area- and depth-matched donor plug is press-fit with gentle manual pressure. It is imperative to ensure flush placement of the donor plug, as proud or recessed graft placement significantly increases contact pressure and subsequent degeneration.[6] If graft fixation security is in doubt, a recessed bioabsorbable screw may be placed in the center of the graft.

Surgical Technique

1. Ensure accurate and precise preoperative radiographs and MRI for lesion characterization and sizing. This requires magnification markers and condyle-specific matching.
2. Ensure use of a qualified tissue bank, with the graft refrigerated at 4°C and used between 14 to 28 days.
3. Prior to general anesthesia, ensure the graft is available and in the room.
4. Place patient in the supine position with a standard leg holder and thigh tourniquet inflated for case duration and deflated prior to end to ensure hemostasis.
5. Utilize an ipsilateral parapatellar mini-arthrotomy for lesion exposure.
6. Place the knee in varying degrees of flexion for complete lesion visualization with Z-retractors used in the notch and gutter for retractors.
7. Once lesion is deemed appropriate for osteochondral allograft, open the graft and soak in cold saline to avoid sudden dramatic temperature changes, which are potentially chondrotoxic.

Pearls and Pitfalls

PEARLS	PITFALLS
• Thorough preoperative planning (symptomatic defect, good sizing x-rays, and staged/simultaneous comorbidity correction) • Use of a certified tissue bank with fresh storage and appropriate dating (14 to 28 days) • Perpendicularity of sizing tube to lesion surface to ensure flush graft on implantation • Complete visualization of lesion with stable retractors for exposure of sizing tube, bore, and graft • Cold irrigation during all steps of the procedure involving drilling or boring to avoid thermal necrosis	• Poor patient selection and preoperative planning • Inaccurate measuring with sizing tube, especially undersizing the defect • Leaving graft proud or recessed in the recipient site • Failing to address comorbidities (alignment, meniscus, cruciate ligaments) • Failing to pulse lavage the graft to remove marrow elements (immunogenicity) • Not achieving stable graft fixation in operating room (either press-fit or with screw fixation) • Poor rehabilitation (motion/stiffness, too early weight bearing, too early return to vigorous high-impact sports activity)

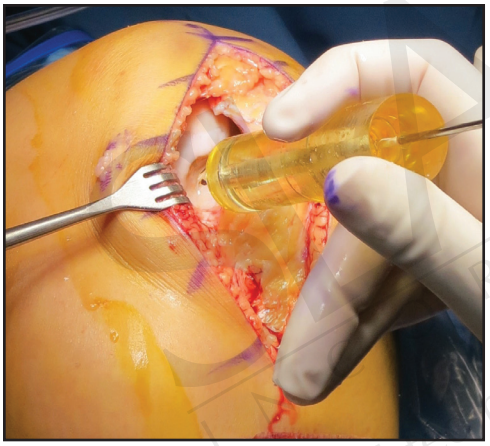

Figure 17-1. Left knee medial femoral condyle chondral defect visualized via medial parapatellar mini-arthrotomy with sizing tube and guide pin placed through tube, perpendicular to articular surface.

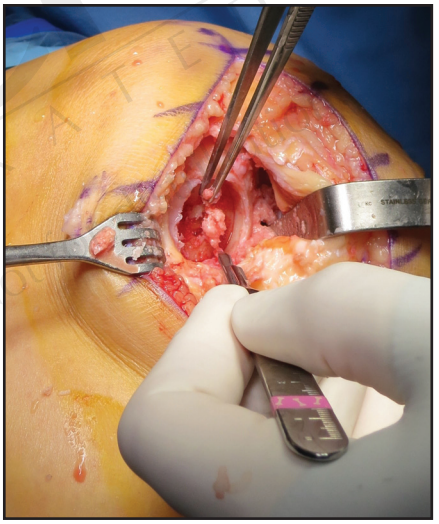

Figure 17-2. After recipient site is reamed, all loose unstable peripheral cartilage is removed with a scalpel. The recipient site bed is prepared by removing all bony or cartilaginous debris that may preclude flush donor graft placement.

8. Prepare the lesion and identify normal peripheral articular cartilage and pathologic defect cartilage.
9. The surgeon's choice of sizing system is used for defect sizing. It is important to avoid undersizing, as this will leave abnormal cartilage peripherally. The authors prefer Arthrex's Osteochondral Autograft Transfer System (OATS), which has circular cannulated sizing blocs of 15, 18, 20, 25, 30, and 35 mm (Figure 17-1).
10. After the correct sizing tube has been selected, ensure that this tube is appropriate for the allograft on the back table. Mark the 12 o'clock position on the allograft with a sterile surgical marker.
11. Place the sizing tube on the recipient site and place a 2.4-mm guide pin through the defect's center (see Figure 17-1). Ensure the pin is perpendicular to the lesion surface.
12. Remove the sizing tube and place the cannulated recipient site harvester and bore over the wire to remove the overlying remnant defect cartilage and subchondral bone to a depth of approximately 7 mm. Then remove the bore and pin.
13. Use a new no. 15 blade scalpel to remove any loose unstable peripheral cartilage (Figure 17-2).

Postoperative Rehabilitation				
	WEIGHT-BEARING STATUS	**BRACE USE**	**RANGE OF MOTION**	**THERAPEUTIC EXERCISES**
Phase I 0 to 6 weeks	Non-weight bearing	Locked in extension (< 1 week) Unlock in 20-degree increments until full quad control without extensor lag	CPM 6 hours/day, begin 0 to 40 degrees, increase 5 to 10 degrees/day as tolerated, goal 100 degrees by week 6	PROM, AAROM, patella mobilization, quad, glute, hamstring, straight leg raise, hip strengthening
Phase II 6 to 8 weeks	25% partial weight bearing	None	Goal 130 degrees	Stationary bike, quad, hip, hamstring, core
Phase III 8 to 12 weeks	Gradual return to full weight bearing	None	Full, symmetric, pain free	Gait, closed-chain (wall-sits, shuttle, mini-squats, toe raises)
Phase IV 12 to 26 weeks	As tolerated, with normal gait	None	Full, symmetric, pain free	Advance all phase III

AAROM, active assisted range of motion; CPM, continuous passive motion; PROM, passive range of motion.

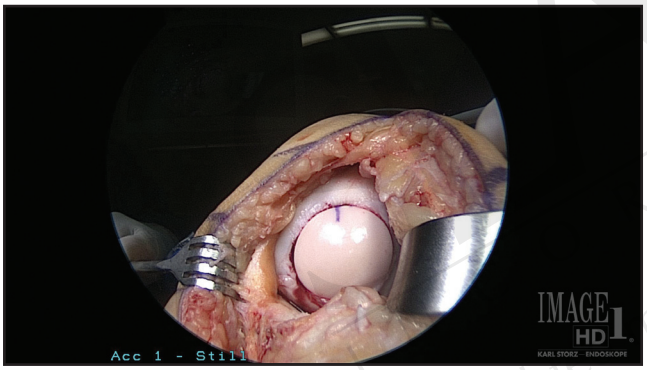

Figure 17-3. Graft placed flush into recipient site. Note importance of flush placement, avoiding proud (elevated) graft placement above surrounding articular surface or recessed placement below surrounding articular surface.

14. Mark the 12 o'clock position with a sterile surgical marker. Measure the recipient site at the 12, 3, 6, and 9 o'clock positions twice. Although ideally similar, often they differ by 1 to 2 mm.
15. A small Kirschner wire may be used to make multiple nonconfluent drill holes in the lesion bed to induce further bleeding for osseous healing.
16. Secure the allograft hemicondyle in the 4 screws of the osteochondral allograft back table workstation.
17. Place the workstation bushing of the appropriate graft size over the graft at the exact location that matches the previously marked 12 o'clock position. Secure the bushing.
18. Use the donor harvester to drill out an osteochondral core through the condyle and then extract the plug.
19. Mark the previously measured 12, 3, 6, and 9 o'clock positions on the plug.
20. Use the graft holding clamp to secure the graft while using an oscillating saw to remove the excess bone. Use a rongeur to smooth sharp edges or make fine adjustments in graft fit and fill.
21. Pulse lavage the donor graft with sterile saline to remove all possibly immunogenic bone marrow elements. Pulse lavage the recipient site to remove any residual bony debris in the lesion.
22. Line up the 12 o'clock positions of the recipient and donor sites and gently thumb press-fit the graft into the lesion until flush (Figure 17-3). Ensure the graft is not proud (if cannot thumb press-fit, then gently use tamp). If a tight press-fit is not achieved, then stable fixation may be obtained with recessed bioabsorbable or metallic headless screws.
23. Deflate the thigh tourniquet, achieve hemostasis, close the knee in layers, apply sterile dressing and hinged knee brace locked in extension.
24. Begin physical therapy, including home continuous passive motion (CPM), soon after surgery (within 1 week).

Clinical Outcomes

High-quality evidence using reliable and validated patient-reported outcomes is currently lacking for cartilage repair in the knee.[7] However, new meta-analyses have indicated significant recent improvements in quality.[7] For focal and diffuse single compartment chondral or osteochondral lesions, osteochondral allograft predictably and significantly improves patient-reported outcomes, and results in high patient satisfaction.[8] At short-, mid-, and long-term follow-up, nearly half (46%) of patients undergo concomitant or staged osteotomy or meniscal surgery.[8] At 5 years' follow-up, overall satisfaction approaches 90%, and 65% of patients have little or no radiographic osteoarthritis.[8] Short-term complications are infrequent (< 3%). Failures, although variably defined (repeat surgery, revision cartilage surgery, osteotomy, or conversion to arthroplasty), are uncommon (< 18%). Survival rates decline with time: 91% to 95% at 5 years,[9,10] 76% to 85% at 10 years,[9,10] and 74% to 76% at 15 years.[9,10] Prognostic factors that may negatively influence clinical outcomes include diagnosis of spontaneous osteonecrosis of the knee, bipolar lesions, age greater than 50 years, patellofemoral lesions, workers' compensation status, preoperative duration of symptoms greater than 12 months, and failure to address malalignment or meniscal deficiency.[10-15] The boxes on pages 130 and 131 list recent clinical outcome studies in subjects undergoing fresh osteochondral allograft for focal chondral or osteochondral defects in the knee.

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Recent Osteochondral Allograft Clinical Outcomes for Focal Chondral and Osteochondral Lesions in the Knee

Authors	Number of Participants	Mean Participant Age (Years)	Defect Size (cm^2)	Defect Location	Length of Follow-up (Years)	Method Preservation (Days to Implant)	Primary Outcomes
Lyon et al (2013)[16]	13	15	5.1	11 FC, 2 PF	2.0	Fresh (14 to 21)	• Merle d'Aubigne-Postel 12.7 to 16.3 at final follow-up • All patients returned to unrestricted sports at 9 to 12 months
Shaha et al (2013)[17]	38	30	4.9	25 MFC 13 LFC	4.1	Fresh (14 to 21)	• Significant ($P < .05$) improvements in KOOS pain, ADL, sport recreation, quality of life • Overall return to full military duty 29%; return to limited duty with restrictions 29% • Overall return to preinjury level of sport 5.3%
Giorgini et al (2013)[18]	11	34	10.3	7 FC, 4 TP	2.2	Fresh (14 - 21)	• Subjective IKDC 27 to 59 ($P < .001$) • Defect size < 8 cm^2 IKDC improved 38 vs defect size > 8 cm^2 IKDC improved 23 ($P = .01$) • One failure (conversion to unicompartmental arthroplasty)
Haudenschild et al (2012)[19]	1	48	10.2	Trochlea, FC	3.0	Fresh (12)	• Gene expression, proliferation rate, chondrogenic potential of graft/host • No chondrocyte chimerism, shorter doubling times in host • Retained XX host and XY donor (FISH)
Krych et al[13] (2012)	43	33	7.3	80% FC	2.5	Fresh (7 to 30)	• Preinjury level return to sport in 34/43 (79%), 9.6 months • Age > 25 years ($P = .04$) and preoperative duration symptoms ($P = .003$) decreased RTS • Improved ($P \leq .01$) in IKDC subjective, KOOS ADL, and Marx activity score

(continued)

Recent Osteochondral Allograft Clinical Outcomes for Focal Chondral and Osteochondral Lesions in the Knee (continued)

AUTHORS	NUMBER OF PARTICIPANTS	MEAN PARTICIPANT AGE (YEARS)	DEFECT SIZE (CM^2)	DEFECT LOCATION	LENGTH OF FOLLOW-UP (YEARS)	METHOD PRESER-VATION (DAYS TO IMPLANT)	PRIMARY OUTCOMES
Scully et al (2011)[20]	18	27	2.2	100% FC	3.4	Fresh	• One soldier returned to previous military position • 10 soldiers to Medical Evaluation Board for discharge (23 months) • 7 soldiers still active duty, but with permanent running/athletic restrictions
Gortz et al (2010)[21]	22	24	10.8	100% FC	5.5	Fresh (5 to 21)	• 89% graft survival rate (avoided reoperation) • Knee Society Score improved 60 to 86 ($P=.005$) • Merle d'Aubigne-Postel 11.3 to 15.8 ($P<.001$) • IKDC pain 7.1 to 2.0 ($P<.001$) and IKDC function 3.5 to 8.3 ($P=.002$)
LaPrade et al (2009)[22]	23	31	4.8	100% FC	3	Fresh (15 to 28)	• IKDC subjective 52 to 68.5 ($P<.03$) • Modified Cincinnati score increased 27.3 to 36.5 ($P<.01$) • 0 failures
Pascual-Garrido et al (2009)[23]	16	34	4.5	100% FC	4	Fresh	• Tegner 0 to 6 ($P<.001$); Lysholm 25 to 37 ($P=.015$); IKDC subjective 31 to 45 ($P=.004$) • KOOS: Pain 52-74 ($P=.002$); Sport 32-46 ($P=.037$) • Lower ($P<.03$) increase in KOOS Sport and Quality of Life scores vs ARIF and LBR
Gross et al (2008)[24]	35	53	n/a	n/a	21	Fresh	• At retrieval study, long-term graft survival shows viable chondrocytes, functional matrix, complete replacement of graft bone with host bone at 1 to 25 years postoperatively

ADL, activities of daily living; ARIF, arthroscopic reduction and internal fixation; FC, femoral condyle; FISH, fluorescence in situ hybridization; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; L, lateral; LBR, loose body removal; ; M, medial; PF, patellofemoral; RTS, return to sport; TP, tibial plateau.