

PROCEDURE 13

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[AU1]
[AU2]
[AU3]
[AU4]

Osteochondral Allograft Transplantation

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s0010 INDICATIONS

- u0010 • Localized, unipolar symptomatic chondral lesions of the femoral condyle, tibia, trochlea, or patella. Bipolar lesions of the patellofemoral joint can be addressed as well but are more controversial.
- u0015 • The patient is typically less than 40 years old and places relatively high physical demand on the knee.
- u0020 • Common lesions include osteochondritis dissecans, avascular necrosis, and post-traumatic osteochondral defects.
- u0025 • Lesion diameter typically ranges from 15 mm to 35 mm.

s0015 Examination/Imaging

- u0075 • Radiographs/magnetic resonance imaging studies
- u0080 • These are used to diagnose and size the lesion (Fig. 13.1).
- u0085 • Precise radiographic matching between the donor and recipient is essential to ensure success of the implantation. Radiographs are corrected for magnification and matched for the medial or lateral condyle. In addition, tibial width measured 1 cm below the articular surface is used to correlate the donor tissue with the host dimensions.
- u0090 • Long cassette view standing radiographs are taken if malalignment is suspected.
- u0095 • Previous operative records and arthroscopic images should be reviewed.
- u0100 • Other concomitant issues such as ligament instability and meniscal deficiencies are evaluated and addressed at or prior to allograft implantation.

CONTROVERSIES

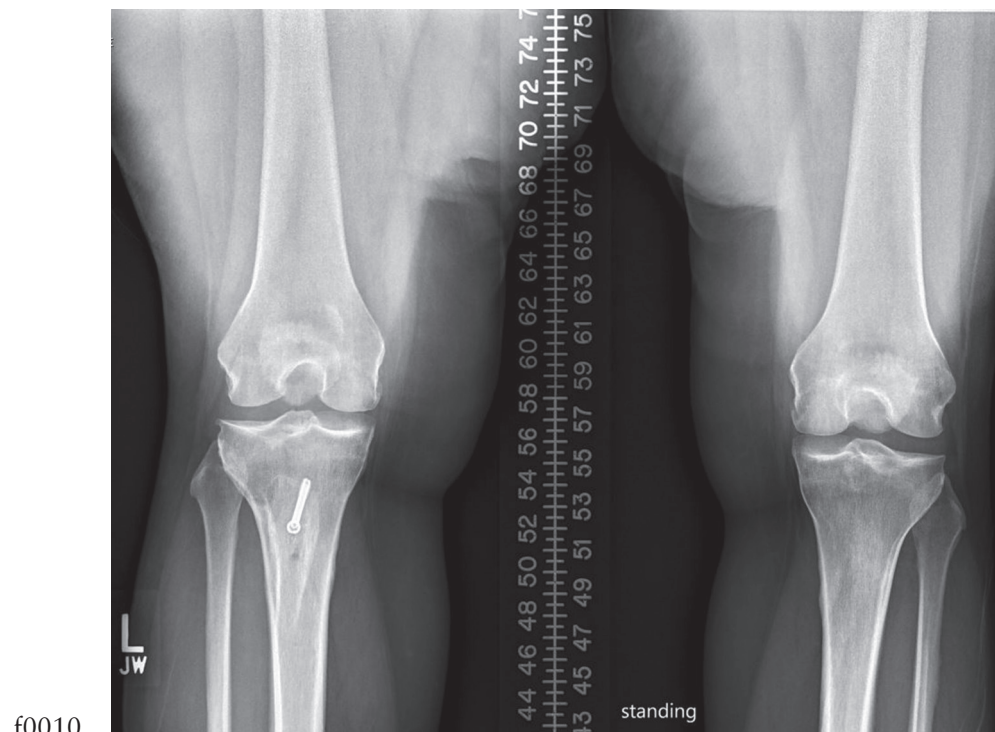
- Patients with inflammatory arthritis
- Patients with bipolar disease
- Morbid obesity
- Patients over the age of 40
- Medical problems that may interfere with the incorporation of the allograft into the host tissue

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INDICATION PITFALLS

- Freezing of allograft tissue leads to chondrocyte death.
- Failure to recognize bipolar tibiofemoral disease.
- Failure to recognize concomitant ipsilateral meniscal deficiency or ligamentous instability.
- Contemporary tissue banking procedures generally do not allow graft implantation beyond 28 days of cold preservation.

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FIG. 13.1

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TREATMENT OPTIONS

Nonoperative Treatment Options

- Nonsteroidal anti-inflammatory drugs.
- Cortisone injections.
- Viscosupplementation.
- Unloader brace.
- Assistive devices (canes, walkers).

Operative Treatment Options

- Consider osteotomy in all patients with malalignment.
- Lesions less than 2 cm² to 3 cm²
 - For low-physical-demand patients and low-level symptoms: debridement, microfracture.
 - For high-physical-demand patients and high-level symptoms: debridement, microfracture, osteochondral autograft.
- If the above fail: osteochondral allograft, autologous chondrocyte implantation.
- Lesions greater than 2 cm² to 3 cm²
 - For low-physical-demand patients and low-level symptoms: debridement, microfracture, osteochondral allograft, autologous chondrocyte implantation.
 - For high-physical-demand patients and high-level symptoms: osteochondral allograft, autologous chondrocyte implantation.
 - If the above fail: osteochondral allograft, autologous chondrocyte implantation, arthroplasty.
- Consider in the setting of a failed cell-based or marrow stimulation procedure.

- Osteochondral allografts are harvested by a local organ procurement organization within 24 hours of asystole and then aseptically processed by regional tissue banks. The tissue is then refrigerated at 4° C for up to 28 days. No tissue matching is required between the donor and recipient.

POSITIONING

- The patient can be positioned in the supine position or the limb may be placed in a standard leg holder. Our preference is to place the patient supine with the foot in a standard leg positioner, which provides a stable, assistant-free knee flexion angle.
- A tourniquet is applied and used throughout the case and deflated at the end of the case prior to closure to achieve hemostasis.

Portals/Exposure

- This procedure is generally done through a small ipsilateral arthrotomy. On the medial side, a vastus-sparing approach is used. On the lateral side, a lateral retinacular release is used which can largely be left open at the conclusion of the case.
- The arthrotomy can be extended proximally or distally to improve exposure.
- A Z-retractor or Hohmann retractor is placed in the notch to retract the patella and extensor mechanism, and another Z-retractor or large rake is used on the other side of the lesion to retract the soft tissue. The knee is flexed to a point that exposes the lesion fully (Fig. 13.2).
- For the remainder of the procedure, the flexion angle is kept the same using the leg positioner.

PROCEDURE

Step 1: Exposure

- Prior to administering anesthesia, physical confirmation of the appropriate graft is performed.
- Arthroscopy is only necessary if insufficient information regarding the defect is available or comorbidities are suspected. In this instance, a brief diagnostic arthroscopy confirms that the lesion is amenable to the allograft implantation.
- The tourniquet is inflated and the small arthrotomy is performed in the standard fashion. The lesion is exposed (Fig. 13.3).
- The allograft is opened (Fig. 13.4) and soaked in cold saline. Sudden changes in temperature may be harmful to the chondrocytes and should be avoided.

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STEP 1 PEARLS

- Keeping the sizer perpendicular to the lesion will achieve the most symmetric measurements.
- Avoiding patella eversion and violation of the VMO are key steps in assuring an excellent and expeditious recovery.
- Changing the knee flexion angle can help expose the lesion and allow easier access to it.

[AU5]

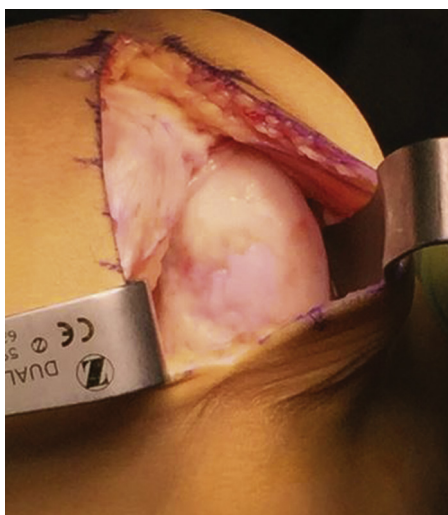


FIG. 13.2

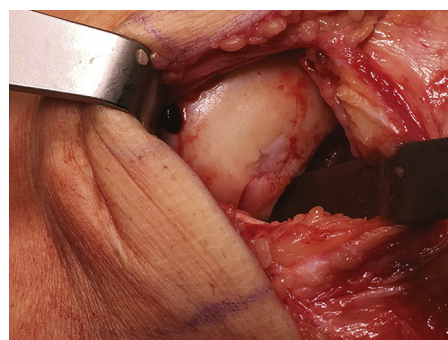


FIG. 13.3



FIG. 13.4

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s0040 **Step 2: Preparation of the Cartilage Lesion**

- u0250 • Although a number of companies manufacture allograft implantation sets, we prefer the Mega-OATS osteochondral allograft system (Arthrex, Inc., Naples, FL, USA). The allograft set allows allograft implants of the following sizes: 15, 18, 20, 25, 30, and 35 mm.
- u0255 • Different cannulated sizers are placed over the lesion to estimate the appropriate allograft diameter (Fig. 13.5). It is better to oversize the lesion than leave marginal-quality tissue on its perimeter.
- u0260 • Once the appropriate size is chosen, the cannulated sizer is placed in the center of the lesion so that the sizer completely covers the lesion.
- u0265 • Cold irrigation is used during all mechanical steps to prevent thermal necrosis to the surrounding cartilage and underlying bone.
- u0270 • The chosen sizer is now placed over the allograft condyle to make sure a similar-sized plug can be harvested with comparable topographic anatomy (Fig. 13.6). A marking pen is used to mark its location along with the 12 o'clock position.
- u0275 • The cannulated sizer is then placed over the recipient lesion and a 2.4-mm guide pin is advanced to a depth of at least 3 cm (Fig. 13.7).
- u0280 • The sizer is removed, leaving the guide pin, and a cannulated recipient harvester of the same size is placed over the guide pin. The harvester is used to score the peripheral cartilage and a portion of the subchondral bone (Fig. 13.8).
- u0285 • A cannulated counterbore of the same size is placed over the guide pin and used to create a cylindrical defect in the recipient bone of a depth of 6 mm to 8 mm (Fig. 13.9). The counterbore and guidewires are both removed.
- u0290 • The 12 o'clock position is marked with a pen.
- u0295 • Precise measurements are taken of the four quadrants on the recipient lesion (12, 3, 6, and 9 o'clock) (Fig. 13.10). This is done with a cut down ruler on a hemostat. Ideally, the quadrant measurements should be fairly similar.
- u0300 • A fresh #15 blade is used to remove any loose or frayed cartilage on the perimeter of the lesion and pulsatile irrigation is used.
- u0305 • A calibrated allograft dilator is inserted into the recipient socket and gently tapped to achieve an additional 0.5-mm dilation (Fig. 13.11).
- u0310 • A Kirschner wire (K-wire) is used to make multiple small drill holes in the bed of the socket to induce further bleeding (Fig. 13.12).

s0045 **Step 3: Allograft Preparation**

- u0325 • If a full hemicondyle is received, it may need to be trimmed slightly with an oscillating saw to allow it to fit on the allograft workstation (Fig. 13.13).
- u0330 • The donor condyle is secured in the workstation using the four screws (Fig. 13.14).
- u0335 • The bushing of the same size is placed over the graft.
- u0340 • The bushing is adjusted three-dimensionally so that a sizer placed into the bushing fits directly over the marked spot on the graft. The bushing is secured (Fig. 13.15).

STEP 2 PEARLS

- The bushing should be adjusted so that the graft is harvested in a perpendicular fashion similar to how the defect was prepared.
- It is better to oversize the lesion than leave marginal-quality tissue on its perimeter.

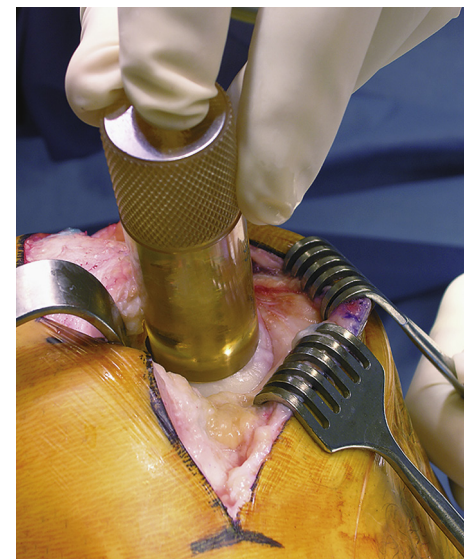


FIG. 13.5

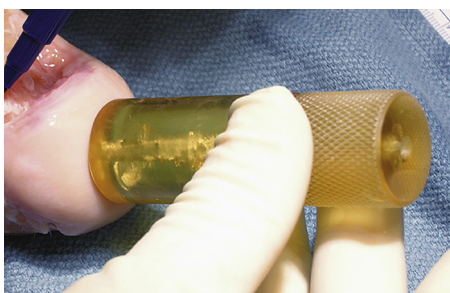


FIG. 13.6

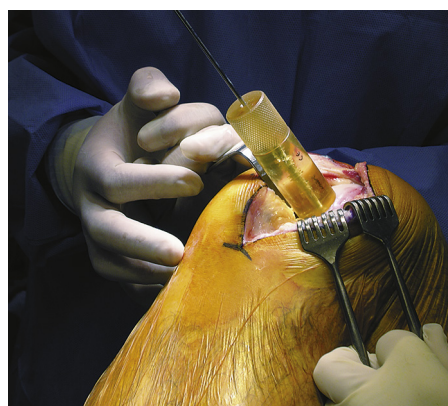


FIG. 13.7

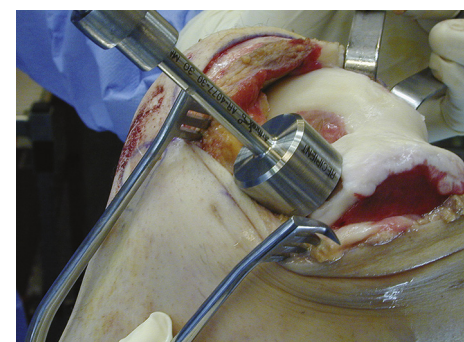


FIG. 13.8

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FIG. 13.9

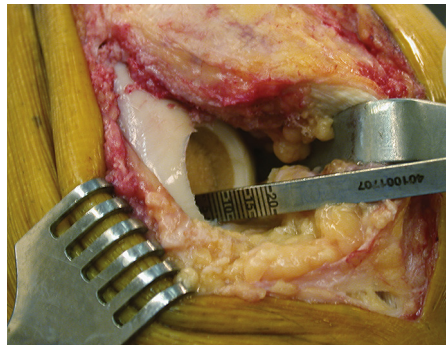
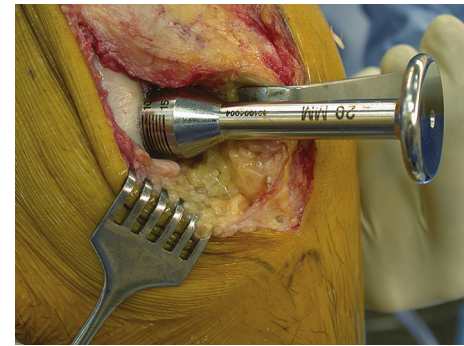


FIG. 13.10



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FIG. 13.11



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FIG. 13.12

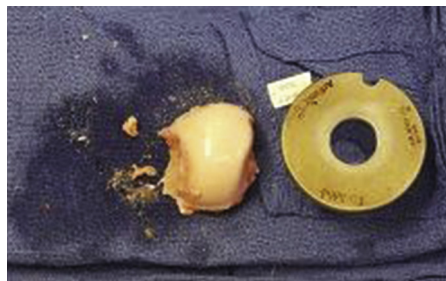
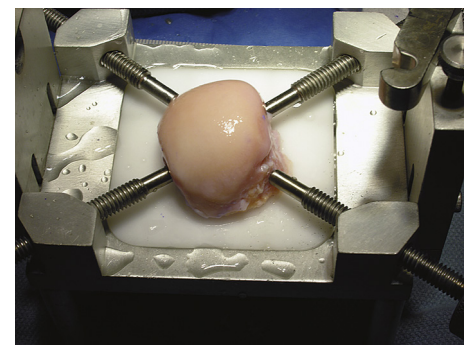
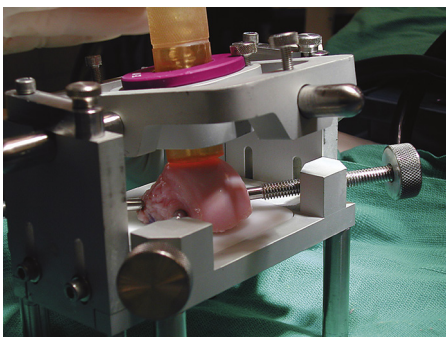


FIG. 13.13



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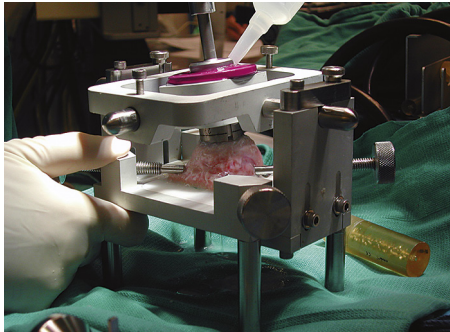
FIG. 13.14



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FIG. 13.15

- A corresponding donor harvester is used to drill through the entire donor condyle. The graft is then gently extracted (Fig. 13.16). u0345
- The depth measurements previously made in the recipient socket are now marked on the donor plug (Fig. 13.17). u0350
- The allograft is secured to the holding clamp at the marked positions and trimmed with an oscillating saw. Marking the 12 o'clock position is important to remember graft orientation. (Fig. 13.18). u0355
- A rongeur or a saw can be used to slightly round off the corners of the bone to facilitate the insertion of the donor plug into the recipient socket (Fig. 13.19). u0360



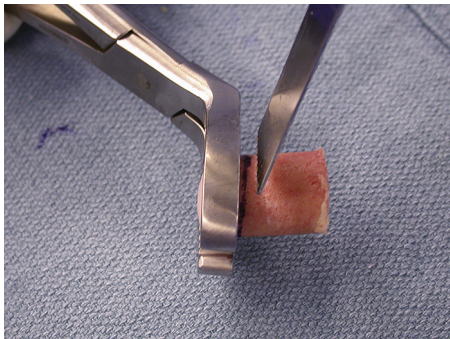
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FIG. 13.16



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FIG. 13.17



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FIG. 13.18



FIG. 13.19

s0050 **Step 4: Graft Implantation**

- u0365 • The graft is pulse lavaged thoroughly with saline to remove all marrow elements.
- u0370 • The graft is gently press-fit into the socket, lining up the two 12 o'clock positions on the donor and recipient sides (Fig. 13.20A and B).
- u0375 • If the graft cannot be flush-fit by hand, a tamp can be used to gently tap the graft in place.

s0055 **Step 5: Graft Fixation**

- u0410 • In cases in which a tight press-fit cannot be achieved, additional fixation may be necessary. Options for graft fixation include metallic headless screws, bioabsorbable screws and pins.
- u0415 • Metallic headless screws (Acutrak 2 miniscrews; Acumed, Hillsboro, OR, USA) (see [AU] Procedure 14)
- u0420 • Useful for large and uncontained plugs (Fig. 13.21).
- u0425 • Bioabsorbable screws (Bio-Compression screws; Arthrex, Inc., Naples, FL, USA) [AU8] (see Procedure 14)
- u0430 • Useful for large and uncontained plugs (Fig. 13.22).
- u0435 • Orthosorb Pins (Depuy, Inc., Warsaw, IN, USA)
- u0440 • Made of PDS (absorbable) [AU9]
- u0445 • Available in 1.3- and 2.0-mm diameters.
- u0450 • Useful for small plugs (under 20 mm in diameter).

STEP 4 PEARLS

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- If the graft is too proud, it should be removed and sized appropriately. A small Freer elevator can be used to lever the plug out of the socket. Alternatively, a graft retriever is available with the allograft set and can be used to extract the plug. Some of the potential causes of a mismatch are:
 - Inaccurate measurement: trim the donor bone.
 - Bone debris in the base of the socket: thoroughly clean the base using a curette.
- If the graft is too recessed, it should also be removed. Allograft bone can be crushed and placed in the base of the socket to build it up.
- If the graft is too tight, the dilator can be used again to dilate the socket.
- If the graft is too loose, bone grafting may be performed on the periphery of the plug. Augmented fixation may also be necessary.

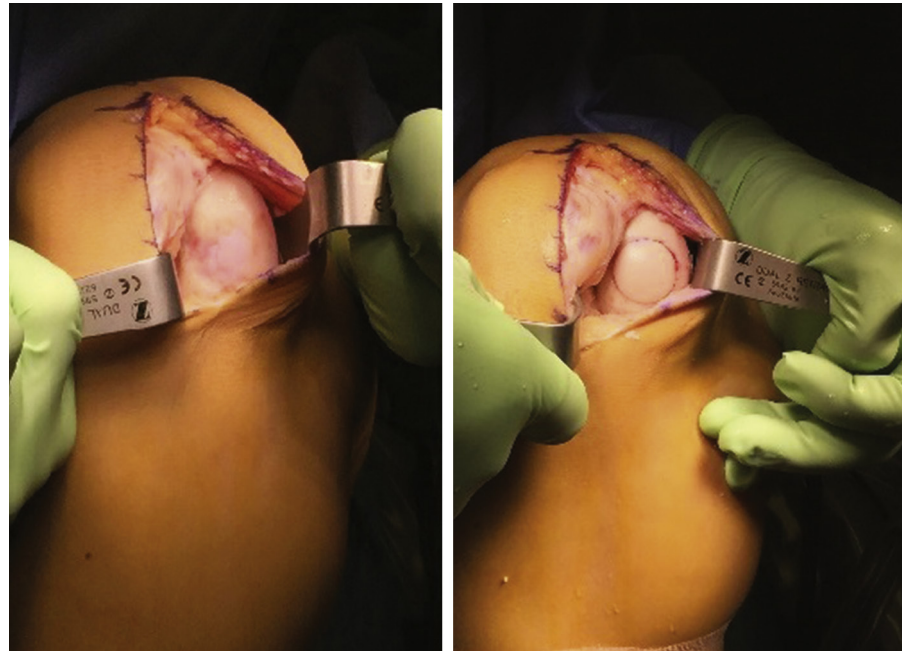


FIG. 13.20

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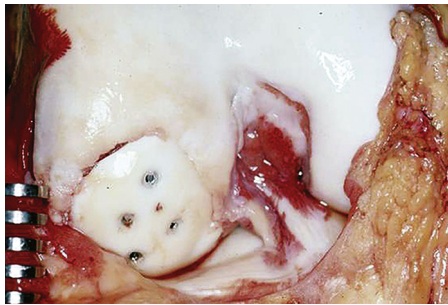


FIG. 13.21

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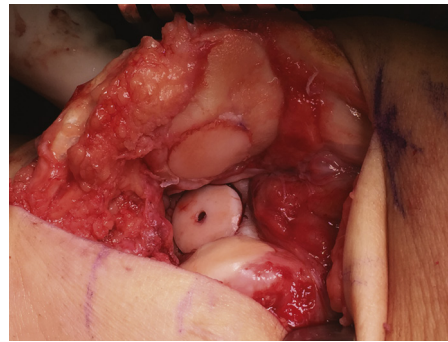


FIG. 13.22

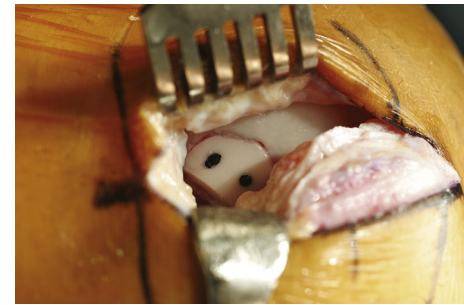


FIG. 13.23

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- Technique: u0455
- The appropriate K-wire from the kit is placed through the center of the plug into the bone. u0460
- The K-wire is removed and the Orthosorb pin is advanced over a cannulated inserter into the bone. u0465
- The pin is trimmed to be flush with the bone. u0470
- If more than one pin is used, they should be placed in a divergent fashion (Fig. 13.23). u0475

POTENTIAL COMPLICATIONS

- Infection
- Arthrofibrosis
- Failure of graft incorporation
- Graft collapse
- Progressive joint space narrowing

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Step 6: Closure

- The tourniquet is deflated and hemostasis is achieved. s0060
- The knee is irrigated with saline, and the arthrotomy is closed in layers. u0480
- The lateral release portion of the arthrotomy can be left open. u0485
- A knee brace locked in full extension is applied and is taken off for therapy and continuous passive motion (CPM). u0490
- A knee brace locked in full extension is applied and is taken off for therapy and continuous passive motion (CPM). u0495

POSTOPERATIVE CARE AND EXPECTED OUTCOMES

- Phase I (0–6 weeks) s0065
- Patients are started on a CPM machine immediately. The CPM is used for about 6 hours per day for 6 weeks. u0525
- The brace is unlocked after 2 weeks and is discontinued when the patient is able to perform a straight leg raise without an extension lag. u0530
- The brace is unlocked after 2 weeks and is discontinued when the patient is able to perform a straight leg raise without an extension lag. u0535

- u0540 • Depending on the quality of fixation, weight bearing may range initially from complete nonweight bearing to touch down weight bearing.
- u0545 • Physical therapy mainly works on passive range of motion (ROM) and active-assisted ROM.
- u0550 • Phase II (6–8 weeks)
- u0555 • Partial weight bearing is allowed.
- u0560 • 130° of flexion and full extension should be achieved.
- u0565 • Physical therapy includes quad and hamstring strengthening exercises and a stationary bike for ROM.
- u0570 • Phase III (8–12 weeks)
- u0575 • Full weight bearing is allowed.
- u0580 • Full ROM should be achieved.
- u0585 • Physical therapy begins closed-chain exercises and works on gait training.
- u0590 • Phase IV (12 weeks to 6 months)
- u0595 • Advanced strengthening with minimal restrictions.
- u0600 • Return to vigorous activities is discouraged for at least 12 months.

s0070 EVIDENCE

Aubin PP, Cheah HK, Davis AM, Gross AE: Long-term follow-up of fresh osteochondral allografts for posttraumatic knee defects, *Clin Orthop* 391:S318–S327, 2001.

Osteochondral allografts were used to treat 60 patients with articular defects in the distal femur.

The average patient age was 27 years. Mean follow-up was 10 years. Twenty percent of the patients had failures and 84% of the patients were rated as good or excellent.

Briggs DT, Sadr KN, Pulido PA, Bugbee WD: The use of osteochondral allograft transplantation for primary treatment of cartilage lesions in the knee, *Cartilage* 203–207, 2015.

Fifty-five patients (61 knees total) received osteochondral allografts, with an average patient age of 32.9 years. The mean follow-up was 7.6 years. 18 knees (29.5%) had further surgery with 11 of those 18 surgeries being considered OCA failures. 86% of the patients were “satisfied” or “extremely satisfied” with the results of their surgery and OCA survivorship at 10 years was 74.7%.

[AU10]

Cameron JI, Pulido PA, McCauley JC, Bugbee WD: Osteochondral allograft transplantation of the femoral trochlea, *Am J Sports Med* 44:633–638, 2016.

This cohort of 28 patients (29 knees) received a fresh OCA transplant to the femoral trochlea. The average follow-up was 7 years. One patient was converted to total knee arthroplasty after 7.6 years, and graft survivorship at 10 years was 91.7%. 89% of patients were “satisfied” or “extremely satisfied with their outcomes”.

Chahal J, Gross AE, Gross C, Mall N, Dwyer T, Chahal A, Whelan DB, Cole BJ: Outcomes of osteochondral allograft transplantation in the knee, *Arthroscopy* 575–588, 2013.

This comprehensive review of 19 studies evaluated a total of 644 knees that received osteochondral allografts, with an average follow-up of 58 months. The overall percent of satisfaction was 86% and 65% of patients had little to no arthritis at follow-up.

Chu CR, Convery FR, Akeson WH, Meyers M, Amiel D: Articular cartilage transplantation—clinical results in the knee, *Clin Orthop* 360:159–168, 1999.

Fifty-five patients with a mean age of 35 years underwent osteochondral allografts. The average follow-up was 75 months. Overall, 76% of the knees were rated as good or excellent. In the unipolar transplant category, 84% of the patients regained full use of their affected knee. Conversely, only 50% of bipolar lesions were rated as good or excellent.

Garrett JC: Fresh osteochondral allografts for treatment of articular defects in osteochondritis dissecans of the lateral femoral condyle in adults, *Clin Orthop* 303:33–37, 1994.

Seventeen patients with osteochondritis dissecans lesion were treated with allografts and followed for an average of 3.5 years. The mean age was 20. Herbert screws were used to augment the fixation of the allografts. At follow-up, 94% of the patients had successful outcomes.

Ghazavi MT, Pritker KP, Davis AM, Gross AE: Fresh osteochondral allografts for posttraumatic osteochondral defects of the knee, *J Bone Joint Surg Br* 79:1008–1013, 1997.

This is a review of 126 knees with posttraumatic osteochondral defects that were treated with osteochondral allografts. The mean age was 35 years and the mean follow-up was 7.5 years. The authors demonstrated 95% survival at 5 years, 71% at 10 years, and 66% at 20 years.

Gracitelli GC, Meric G, Pulido PA, Gortz S, De Young AJ, Bugbee WD: Fresh osteochondral allograft transplantation for isolated patellar cartilage injury, *Am J Sports Med* 879–884, 2015.

Twenty-seven patients (28 knees) underwent OCA transplantation of the patella. 60.7% of the knees had further surgery, with 28.6% being considered “failures” where the OCA graft was removed. The average follow up was 9.7 years and 89% of patients were satisfied with the results of their surgery.

Gracitelli GC, Meric G, Pulido PA, McCauley JC, Bugbee WD: Osteochondral Allograft Transplantation for knee lesions after failure of cartilage repair surgery, *Cartilage* 98–105, 2015.

One-hundred and sixty-four knees received an OCA as a salvage procedure, with all patients receiving subchondral marrow stimulation, osteochondral autograft transplantation, or autologous chondrocyte implantation previously. Survivorship of the allograft was 82% at 10 years follow-up and 74.9% at 15 years.

Horton MT, Pulido PA, McCauley JC, Bugbee WD: Revision osteochondral allograft transplantations: do they work? *Am J Sports Med* 2507–2511, 2013.

This cohort of 33 patients received a revision osteochondral allograft. At 10 year follow-up, 61% had surviving revisions, while 39% had failed.

Jamali AA, Emmerson BC, Chung C, Convery RF, Bugbee WD: Fresh osteochondral allografts, *Clin Orthop* 437:176–185, 2005.

Twenty knees were treated with osteochondral allografts in the patellofemoral joint. There were five failures (25%). The knee scores improved from 11.7 to 16.3. Of the 10 knees evaluated radiographically, four knees had no patellofemoral arthrosis and six had mild arthrosis.

Krych AJ, Robertson CM, Williams 3rd RJ: Return to athletic activity after osteochondral allograft transplantation in the knee, *Am J Sports Med* 1053–1059, 2012.

Forty-three athletes who received an osteochondral were evaluated at an average of 2.5 years. Limited return to sport was possible in 88% of athletes, with 79% able to return to their preinjury level of activity.



[AU11]

Levy YD, Görtz S, Pulido PA, McCauley JC, Bugbee WD: Do fresh osteochondral allografts successfully treat femoral condyle lesions? *Clin Orthop Relat Res* 231–237, 2013.

One-hundred and twenty-nine knees were treated with an osteochondral allograft transplantation to the femoral condyle. Survivorship was 82% at 10 years and fell to 66% at 20 years. Thirty-one knees failed at an average of 7.2 years.

McCulloch PC, Kang RW, Sobhy MH, Hayden JK, Cole BJ: Prospective evaluation of prolonged fresh osteochondral allograft transplantation of the femoral condyle, *Am J Sports Med* 35:411–420, 2007.

Twenty-five patients received osteochondral allografts for isolated defects. Two patients had a history of avascular necrosis and 24 had previous surgery. The average age was 35 years and the average follow-up was 35 months. Nineteen patients received one plug and six patients received two plugs. At follow-up, 88% of the grafts were fully incorporated. General satisfaction averaged 84%.

Meric G, Gracitelli GC, Görtz S, De Young AJ, Bugbee WD: Fresh osteochondral allograft transplantation for bipolar reciprocal osteochondral lesions of the knee, *Am J Sports Med* 709–714, 2015.

Forty-six patients (48 knees) received bipolar osteochondral allografts as treatment for their cartilage defects. Twenty-two knees were considered failures (revision, arthroplasty, or patellectomy). Mean follow-up was 7 years for patients that still had their grafts in place and all clinical outcomes scores saw improvement.

Meyers MH, Akeson W, Convery R: Resurfacing of the knee with fresh osteochondral allograft, *J Bone Joint Surg Am* 71:704–713, 1989.

The authors reported their results on 39 patients who received osteochondral allografts who were followed for an average of 3.6 years. The patients had an average age of 38 years; 77.5% successful results were documented. In patients with traumatic unicompartmental arthritis, the success rate was only 30%.

Murphy RT, Pennock AT, Bugbee WD: Osteochondral allograft transplantation of the knee in the pediatric and adolescent population, *Am J Sports Med* 635–640, 2014.

Osteochondral allografts were used to treat 43 pediatric and adolescent knees (mean age of 16.4 years). Graft survivorship was 90% at 10 years, with five knees experiencing failed grafts at an average of 2.7 years. Four of those failures were salvaged with a revision OCA.

Raz G, Safir OA, Backstein DJ, Lee PT, Gross AE: Distal femoral fresh osteochondral allografts: follow-up at a mean of twenty-two years, *J Bone Joint Surg Am* 1101–1107, 2014.

Sixty-three patients who received an osteochondral allograft were followed for an average of 22 years. Graft survival was 91% at 10 years and 59% at 25 years.

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 Am* 85(Suppl 2):33–39, 2003.

Sixty-five patients with failed tibial plateau fractures were treated with fresh osteochondral allografts. The patients were followed for an average of 12 years. Overall, 67.7% had intact grafts and the remainder were converted to total knee replacements. Kaplan-Meier survivorship analysis showed the rate to be 95% at 5 years, 80% at 10 years, 65% at 15 years, and 46% at 20 years.