32 Osteochondral Allograft Transplantation

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32.1 Introduction

Articular cartilage injury and osteochondral damage in the knee can be debilitating conditions that lead to significant patient pain, dysfunction, and decreased activity. Restoration of the joint surface is critical to restoring overall joint mechanics and biology in order to allow patients to return to previous levels of function and prevent potential progression of osteoarthritis [1–3]. Fresh osteochondral allograft transplantation (OCA) utilizes the transfer of allograft subchondral bone and articular cartilage to a chondral or osteochondral defect. An OCA is sized matched to the patient and transfers viable chondrocytes, resulting in type II hyaline cartilage that matches the patient's native articular joint surface. With the transfer of both underlying bone and mature hyaline cartilage, OCAs offer distinct advantages over other cartilage repair techniques such as debridement, microfracture/marrow stimulation, and surface cell-based repair (i.e., autologous chondrocyte implantation (ACI)), particularly for uncontained or deep chondral or osteochondral defects [4–9]. Debridement, microfracture, and osteochondral autograft transplantation (OAT) are either impractical (OAT) or have poor long-term outcomes (debridement, microfracture) for defects >2 cm^2 [10–14]. ACI results in acceptable outcomes in larger defects but requires two separate, staged procedures and can be difficult in the setting of subchondral bone loss, failed marrow stimulation or cell-based repair, or with unshouldered defects. OCA transplantation provides a single-stage procedure for the treatment of osteochondral defects and has been shown to result in excellent mid- to long-term outcomes, with high rates of return to activity and return to sport [15–25].

Historically, issues with graft storage, chondrocyte viability, and size matching have made the availability of appropriate OCAs difficult. Novel storage methods have increased the duration of time grafts retain viable chondrocytes, and studies have shown non-orthotopic grafts (i.e., a lateral femoral graft to a native medial femoral condyle defect) to have to have excellent clinical results [26–30]. The combination of these things has greatly increased graft availability. For large defects, the procedure has historically been very technically surgical demanding, sometimes requiring multiple grafts to be stacked onto each other in a "snowman" configuration. Advances in surgical cutting guides, making

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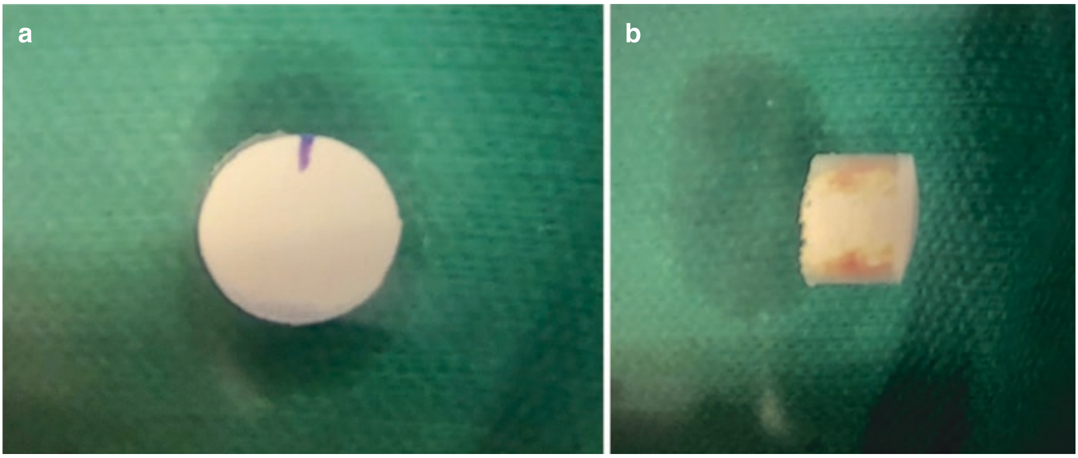

Fig. 32.1 (**a**) Intraoperative image of a fresh, precut, osteochondral allograft (OCA) core, viewing the articular cartilage with the 12 o'clock position marked on the graft. (**b**) Fresh, precut osteochondral allograft core viewed from the side, with the depth of the subchondral bone visualized

them more size specific and well contoured, have greatly decreased the technical demands.

One factor which has been cited as potential downside to OCAs is the possibility of an immune response to the graft. Articular cartilage elicits no humoral immune response, however, and studies have shown no histologic evidence of rejection, with the hyaline cartilage acting as immune privileged tissue [31–34]. The subchondral bone and, more specifically, bone marrow elements of the graft can elicit an immune response. This potential effect can be mitigated by a thorough lavage of all marrow elements prior to transplantation. This technique, combined with meticulous graft implantation, results in minimal risk of an immune response.

The combination of all the above factors previously made OCA transplantation a salvage procedure only for many surgeons, but currently it may be indicated as a first-line treatment as part of the standard joint restoration treatment algorithm.

32.2 Indications and Contraindications

The primary indications for sized matched OCA transplantation in the knee are large (>2 cm^2), symptomatic, full thickness chondral or osteochondral defects, as a salvage for previous failed cartilage restoration procedures, or in cases of significant subchondral bone loss or bony abnormality (osteonecrosis, post-traumatic). Conditions such as osteochondritis dissecans, avascular necrosis, or post-traumatic degeneration are also conditions that frequently result in large lesions that may be amenable to OCA transplantation. For smaller defects where osteochondral autograft may not be easily performed or a surgeon wishes to avoid autograft morbidity, OCA may also be performed. Fresh, pre-cut allograft cores are a viable option for isolated 10–16 mm in diameter defects [35] (Fig. 32.1). These grafts do not require size matching and thus are more readily available. In addition, they can be performed in a single stage procedure without the need for a prior staging arthroscopy.

Other indications for OCA include very large defects requiring resurfacing of a hemi-condyle or an entire condyle, as may be seen in a post-traumatic degenerative knee or a patient who has undergone tumor resection, unshouldered lesions that would not be amenable to a cell-based procedure or multifocal defects.

Primary contraindications to OCA transplantation include patients unwilling to accept allograft tissue and patients unwilling to comply with postoperative rehabilitation restrictions, inflammatory arthropathy, and diffuse degenerative arthrosis. Historically, patellofemoral defects, particularly bipolar "kissing lesions," resulted in poor outcomes with allograft transplantation [36–38]. While bipolar lesions, either within the patellofemoral or tibiofemoral compartments, still result in decreased outcomes vs. focal, solitary lesions, advanced instrumentation and fixation techniques have improved overall outcomes in these patient populations. In particular, physiologically young and active patients that require complete resurfacing of the patella or trochlea, an OCA is an excellent consideration. There are no absolute age limitations, but inferior outcomes have been reported in patients >50 years old [36, 37].

32.3 Concomitant Procedures

OCA transplantation has been shown to have excellent results when performed with concomitant procedures, such as ligament reconstruction or repair, meniscus transplantation, or limb realignment [39–43]. Thorough identification and management of each of these potential pathologies, either concurrently with OCA transplantation or in a staged fashion, is vital to the long-term success of an OCA procedure. Joint stability (stable ligaments), joint congruity and shock absorption (stable meniscus and articular cartilage surfaces), and neutral or near neutral limb alignment are important components to successful long-term outcomes. Limb malalignment is especially crucial to correct with a realignment osteotomy in order to decrease load on the graft(s). Various types of osteotomies have been described, but typically an opening wedge high tibial osteotomy is used to correct limb varus malalignment, and an opening wedge distal femoral osteotomy is used to correct limb valgus malalignment. For the patellofemoral joint, a tibial tubercle osteotomy may be necessary to decrease load from a patellofemoral graft(s) and/or correct patellar maltracking [42, 43]. A list of concomitant pathologies and subsequent procedures is listed in Table 32.1.

Table 32.1 Concomitant procedures that accompany osteochondral allograft transplantation

Procedure	Indication
Ligament reconstruction	ACL, PCL, PLC, PMC, MPFL insufficiency
Meniscus transplantation	Meniscus insufficiency
Valgus producing tibial osteotomy	Asymmetric genu varum ≥3° with medial compartment pathology
Varus producing femoral osteotomy	Asymmetric genu valgum ≥3° with lateral compartment pathology
Tibial tubercle osteotomy	Patella defect with abnormal TT-TG, abnormal Caton-Deschamps ratio
Lateral lengthening	Patella defect with fixed patella tilt with lateral retinacular tightness

ACL anterior cruciate ligament, *PCL* posterior cruciate ligament, *PLC* posterolateral corner, *PMC* posteromedial corner, *MPFL* medial patellofemoral ligament

32.4 OCA Transplantation Surgical Technique: Small Defects

The patient is placed supine on the operative table, and general anesthesia is induced after application of a regional nerve block. No tourniquet is necessary. A lateral post and foot rest or leg holder can be helpful to stabilize the leg and hold the knee in flexion when addressing condylar defects. If no prior staging arthroscopy was performed, a diagnostic arthroscopy is performed to address any concomitant pathology. For larger defects, an open standard midline skin incision is made from the superior pole of the patella to the joint line, followed by either a medial or lateral parapatellar arthrotomy to expose the affected compartment. For multifocal or multiple compartment defects, a larger skin incision and arthrotomy may be made.

For small, solitary osteochondral defects, an arthroscopic or mini-open technique may be employed to perform the OCA transplantation. Defects which are well circumscribed in easily accessible areas of the knee (mid-femoral condyle, mid-trochlea, mid-patella) are best suited for these types of approaches. After the defect size is fully assessed, recipient site preparation may begin. First, a guide pin is drilled perpendicularly in the center of the lesion. A reamer equal to the diameter of the defect is then selected, and the recipient site is reamed to a depth of 6–8 mm. The depth of the reamed socket is then measured at the 3, 6, 9, and 12 o'clock positions. An oscillating shaver is utilized to remove any remaining debris within the socket or any loose cartilage at the periphery to ensure easy graft seating during implantation. If there is sclerotic or cystic bone at the base of the defect, this is then drilled with a 2.0 mm drill bit to create multiple, small marrow stimulation tunnels.

The OCA graft is then opened on the back table. If a fresh pre-cut core is utilized, as in the case example shown in Fig. 32.2, the 12 o'clock position is marked on the graft for orientation. A ruler and marking pen are then used to mark the length of the graft at the corresponding clock positions to match previously measured depths of the recipient socket. An oscillating saw and a small rongeur are then used to precisely remove excess bone until the graft length is appropriate. The deep osseous edges of the graft may be beveled with a rasp for ease of insertion. Pulsatile lavage is then used for a minimum of 2 min to lavage any donor marrow elements out of the subchondral bone portion of the graft. Multiple small drill tunnels may be created on the backside (bony) portion of the graft to allow improved native marrow inflow and integration. The graft is then soaked in bone marrow aspirate concentrate or platelet-rich plasma on the back table.

The recipient site is debrided again to ensure smooth graft implantation. When performed arthroscopically, a hollow tube with an inner diameter equivalent to, or just slightly larger than the graft diameter, may be utilized to deliver the graft into the knee to the recipient site. Using manual pressure with a small tamp, the graft is pushed through the tube and press-fit into the recipient site. Small taps on the tamp around the edges of the graft may be utilized to ensure the graft is completely flush, with smooth transitions, but care should be taken not to exert too much force on the graft itself. If the graft does not fit flush, it may be removed, and the recipient site may be dilated with a slightly oversized tamp, or the edges of the grafts can be gently beveled with a rasp prior to re-insertion. The final position of the graft should be flush with the surrounding articular surface. It may be receded 1 mm but should not be proud relative to the surrounding cartilage.

32.5 Surgical Technique: Large Condyle Defects

The preferred surgical management for large, focal condylar defects is also a press-fit technique. For cylindrical defects, a cylindrical coring reaming system of matching size, like that described for the small defect, may be utilized to match to recipient sites ranging from 10–35 mm in diameter. Many condylar defects match the shape of the condyle, however, resulting in an oblong defect. In these cases, the Bio-Uni specialized cutting guides and preparatory system may be utilized. The steps of this cutting guide system and OCA placement are demonstrated in Fig. 32.3.

First, an appropriately sized curved (matching the condyle contour) template guide is used to cover the defect in its entirety. This guide is then placed on the graft on the back table to ensure the contour and size matches prior to any bone cuts being made. If it matches well, the graft preparation begins. A scoring guide of the exact same medial-lateral and superior-inferior lengths to the curved template guide is placed at the appropriate location on the graft. A Kirschner wire is drilled through a hole on the top over the guide (superior to the cutting portion) into the bone to hold the guide into place. A mallet is then utilized to make the oval cut into the graft osteochondral surface. Once the appropriate depth is achieved, the cutting guide block is left in place, but the handle from the cutting guide is removed and a flat saw cutting jig is assembled to it. A sagittal saw is then used to make a flat cut through the subchondral bone. This results in a smooth, flat surface of bone on the posterior bony surface of the graft. The articular cartilage joint surface still matches that of the native condyle. The oblong cut graft is then removed from the surrounding graft tissue

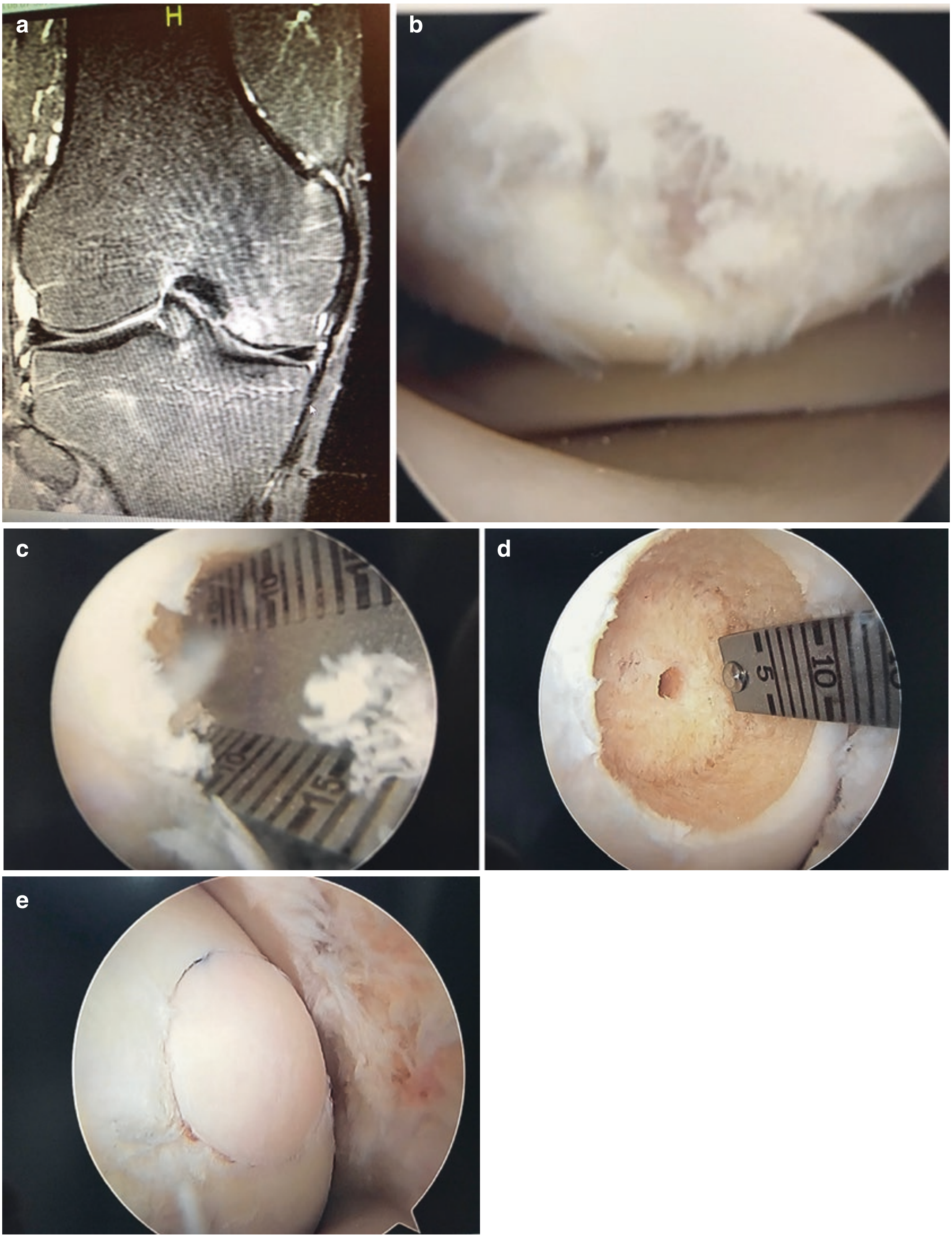

Fig. 32.2 Intraoperative images demonstrating an osteochondral allograft (OCA) transplantation single plug technique. (**a**) Coronal T2-weighted magnetic resonance image of the knee demonstrating an osteochondral defect of the medial femoral condyle. Intraoperative images of the recipient medial femoral condyle defect before (**b**) and during (**c**) reaming. The lesion is reamed to the appropriate depth of 6–10 mm and measured (**d**). The final intraoperative arthroscopic photograph (**e**) demonstrates the donor OCA after it has been press-fit into the reamed recipient defect

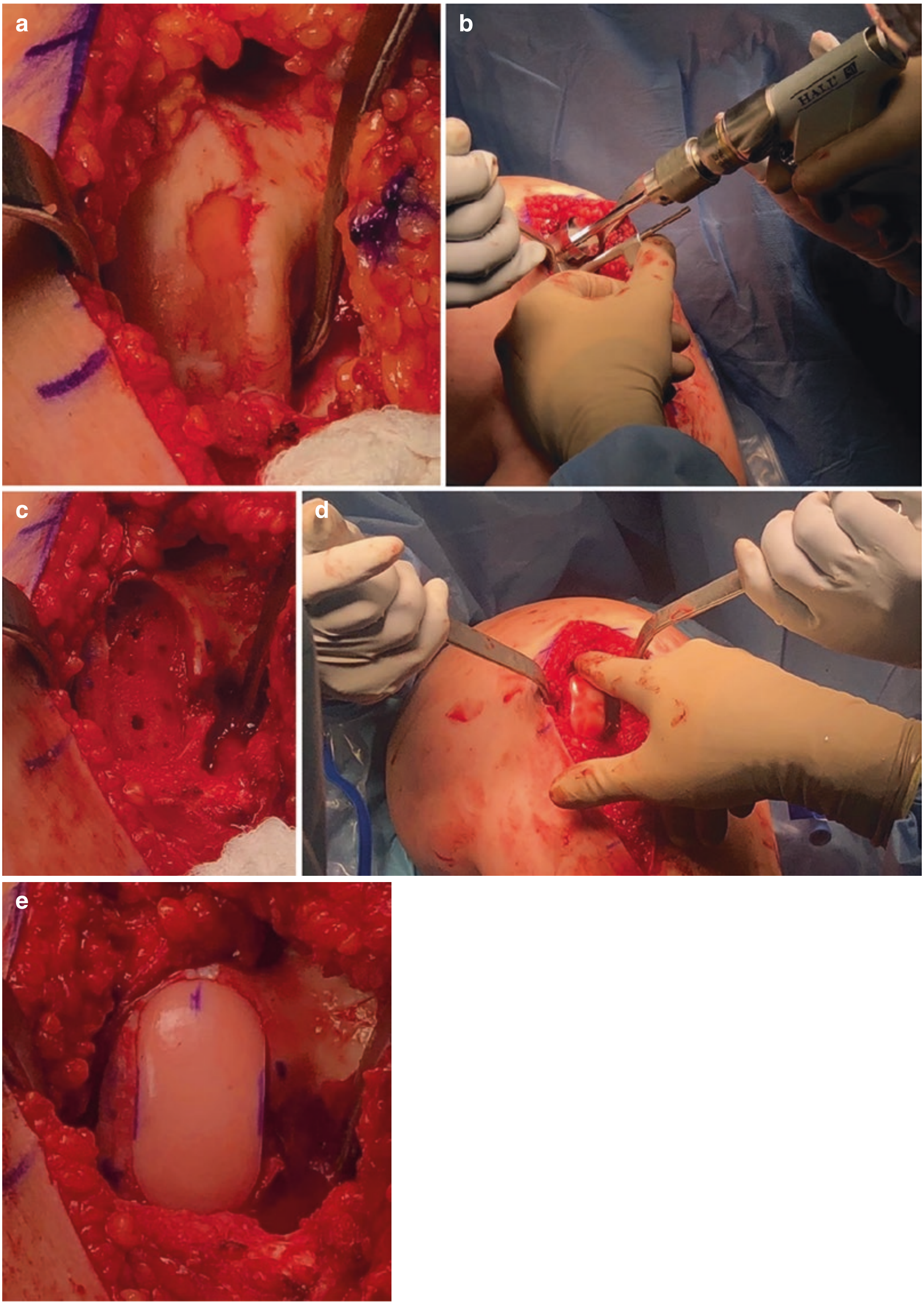

Fig. 32.3 Intraoperative images demonstrating an osteochondral allograft (OCA) large condylar defect transplantation technique in a left knee. (**a**) Native full thickness osteochondral medial femoral condyle defect. (**b**) Intraoperative image demonstrating the reamer utilized to ream the base of the recipient site. (**c**) Image demonstrating the base of the recipient after reaming and after drilling with a small drill bit to create marrow stimulation channels in the subchondral bone. (**d**) Utilizing a press-fit technique to implant the osteochondral allograft into the recipient defect site. (**e**) The final image of a large OCA in place after transplantation

and placed in a depth measuring device. If the graft is not flush around all the edges, a small rasp can be used to file down any of the proud portions. If a portion of the grafts is slightly receded, a smaller reamer is selected to ream the native recipient site. Multiple small drill tunnels are created on the backside (bony) portion of the graft to allow improved native marrow inflow and integration. The graft is then thoroughly washed with pulsatile lavage to remove blood and marrow cells to decrease the risk of a host immune response. The graft is then soaked on the back table in either bone marrow aspirate concentrate or platelet-rich plasma. The recipient defect preparation then begins.

The curved guide is placed again over the native defect, and two central guide pins are drilled perpendicular to the condyle through the guide. The curved guide is removed; a reamer depth stop guide is placed over the inferior pin. Based on the previous depth guide measurements, an appropriate reamer depth is selected. The reamer depth stop may be set at 0, or +1 or −1 mm. The reamer is then utilized to ream the superior aspect of the recipient site fully. The depth stop guide is placed over the superior guide pin, and the reamer is utilized to ream the inferior aspect of the defect recipient site in similar fashion. The depth guide is removed, and a box cutter is placed over the wires and malleted into place to remove any remaining bony debris along the edges or in the base of the defect. The recipient site is thoroughly irrigated, and the base of the defect is then drilled with a 2.0 mm drill bit to create multiple, small marrow stimulation tunnels approximately 3 mm apart. Finally, the OCA graft is brought from the back table and transplanted to the recipient site using a press-fit technique. An oblong tamp may be utilized to ensure the graft edges are flush with the native articular cartilage.

For large condyle defects that are not amenable to an oblong graft, more than one press-fit OCA graft may be required. This “snowman technique” allows coverage of a larger surface area of the condyle using a second plug. In this technique, the first graft is placed as previously described. The subchondral portion of the graft is then pinned with a K-wire in an oblique trajectory away from the articular cartilage or held in place with a small biocompression screw to prevent dislodgement during preparation and placement of the second graft. Preparation of the remaining recipient site is undertaken as before, with the reamer overlapping the previously placed graft but ensuring definitive coverage of the remaining entirety of the recipient defect site. Overlapping the grafts is preferred to leaving spaces between the grafts, as any gaps between the grafts could lead to formation of fibrocartilage or poor articular congruity. Once the second graft has been placed using the press-fit technique, stability is re-assessed. Typically, once the second graft is placed, the entire snowman construct has excellent stability, but if there is any remaining instability present, further biocompression screws may again be added to the subchondral portion of the graft to enhance stability (Fig. 32.4).

32.6 Surgical Technique: Trochlea

An OCA for the trochlea may be performed in one of two ways: using the circular reaming technique (similar to the patella or condyle) or a shell technique. For the reaming technique, the medial and lateral depths of the reamed defect will be much deeper than the proximal and distal depths. It is imperative to have enough depth proximally and distally for a press-fit graft, but not too deep to delay graft incorporation. An example of the steps of trochlear reaming is shown in Fig. 32.5.

For salvage-type procedures that result in lesions that involve an entire condyle or the entire trochlea, or that are uncontained, with very minimal shoulder of cartilage and bone, the shell technique may be employed (Fig. 32.6). For this technique an entire condyle or, in many cases, an entire distal femur is obtained. The recipient bone is cut flush with a free hand, flat cut at depth of 6–10 mm from any remaining adjacent cartilage. Creation of a basic shape at the recipient site (i.e., a trapezoid or rectangle), eases the ability to match the sizing and shape of the OCA graft. The graft is then prepped on the back table.

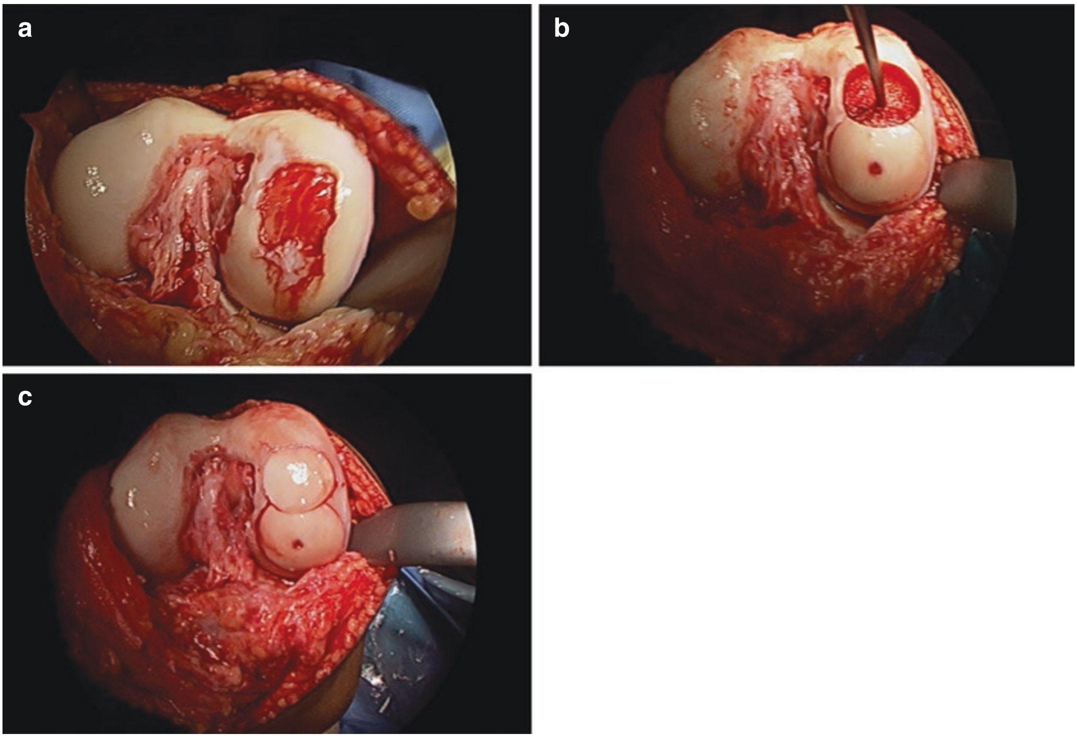

Fig. 32.4 (**a**) Intraoperative photograph of a medial femoral condyle defect. (**b**) Photograph demonstrating the reaming of the snowman technique that overlaps the previously placed inferior graft to ensure the final construct can cover the entire recipient defect site. (**c**) Final construct of the snowman technique using the press-fit technique to position the graft ensuring coverage of the entire medial femoral condyle defect

The graft is measured around all four edges and then stabilized in a cutting jig. The posterior aspect of the graft is then cut with a microsagittal saw to the appropriate depths so as to match recipient site exactly. When initially cutting the graft, it is best to error on oversizing the graft at first, as it can then be trimmed down to size as necessary. The donor shell graft may then be sculpted to create the best fit and then secured to the recipient site with multiple bioabsorbable or metal screws placed in oblique trajectories away from the articular cartilage.

32.7 Surgical Technique: Patella

For smaller lesions that are largely central or are well shouldered along the edges, the same cylindrical reaming and press-fit technique for the circular condyle defects is utilized for the patella as well (Fig. 32.7). For defects involving most of the patella or that result in a poor shoulder around the edges, a shell technique of the entire patellar articular surface may be employed. In this technique, a sagittal saw is utilized to make a flat cut across the entirety of the articular side of the patella. The donor allograft is the cut flush on its posterior aspect as well. It is imperative not to remove too much bone either from the native patella or the donor allograft so that each portion will be able to hold screw fixation. The depth of the native bone removed from the recipient site should be measured, and the donor graft should be cut at nearly the same depth. It is critical that the graft not be larger than the removed recipient portion, or else it will overstuff the patellofemoral joint and increase contact forces on the graft. The donor graft is then placed bone

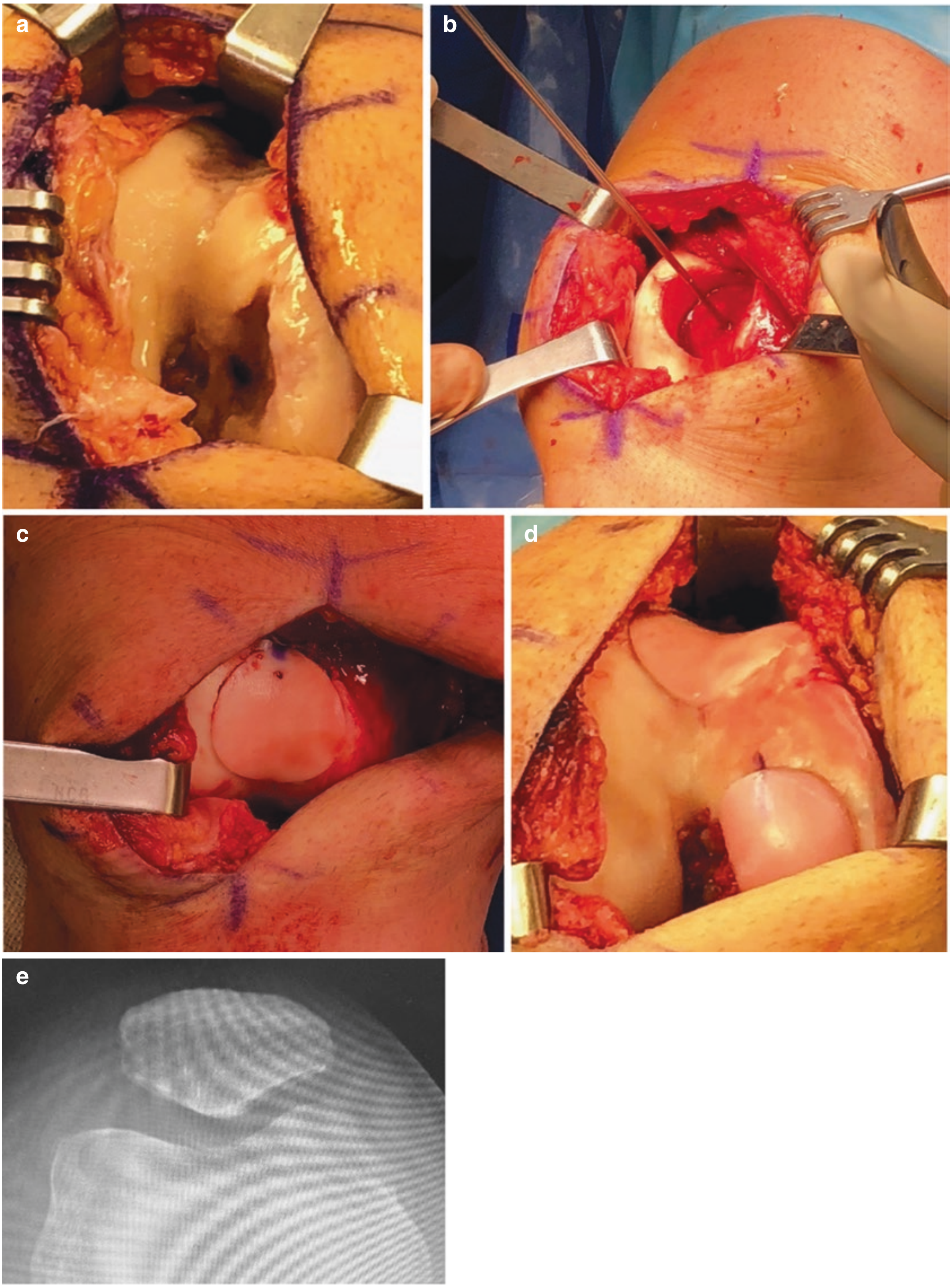

Fig. 32.5 (**a**) Intraoperative image of a right knee demonstrating multifocal but unipolar osteochondral defects of the medial femoral condyle and the trochlea. (**b**) Image demonstrating a central guide and the trochlea after circumferential reaming. (**c**) Image demonstrating the contour of the trochlear graft after placement in the knee. (**d**) Image demonstrating the final trochlea and medial femoral condyle grafts in place in the right knee. (**e**) Postoperative sunrise x-ray view of the trochlea OCA

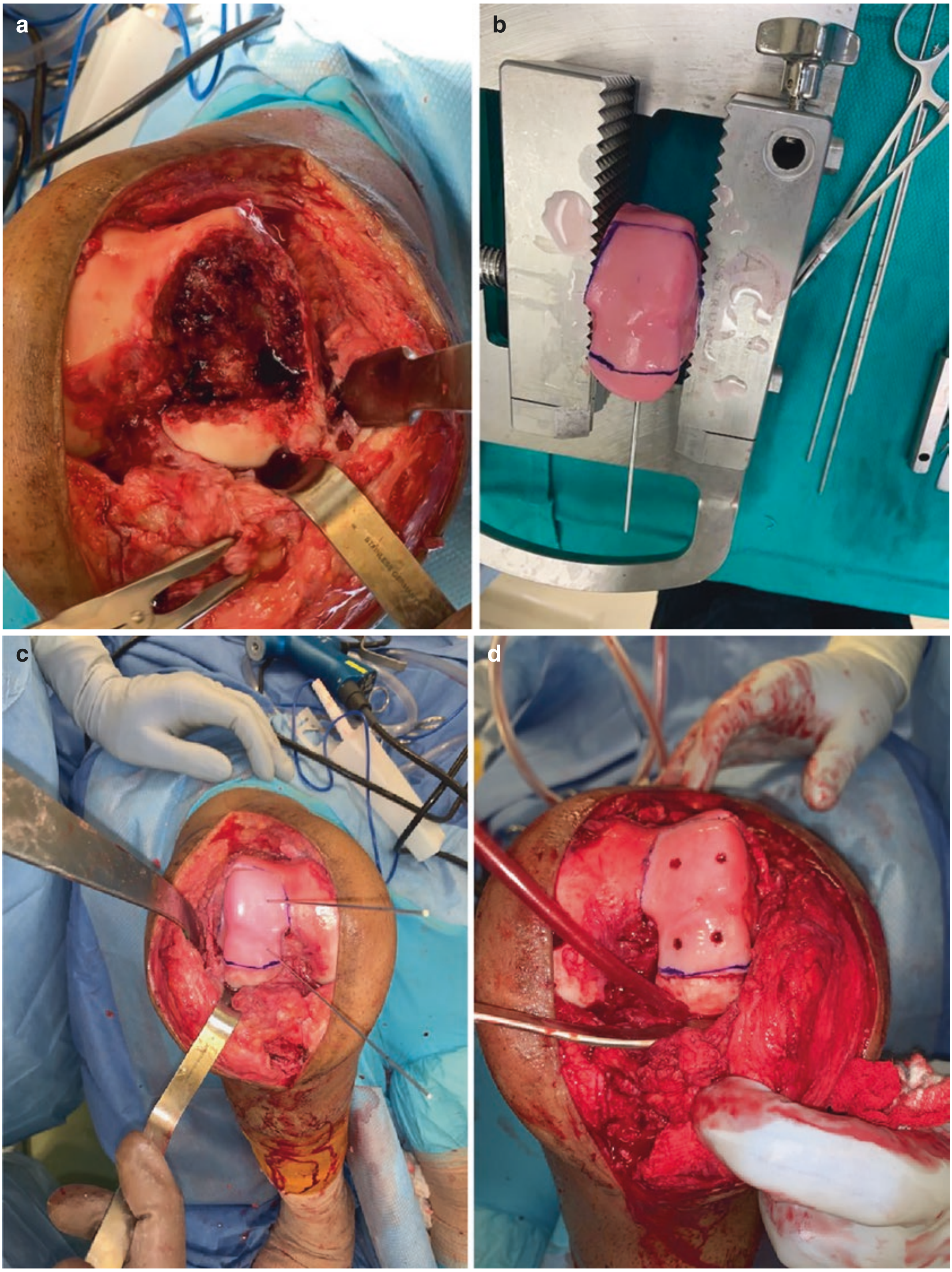

Fig. 32.6 (**a**) Intraoperative image of a trochlea and lateral femoral condyle defect after a gunshot wound to the left knee. (**b**) Image showing the preparation of a trochlea and lateral femoral condyle osteochondral allograft (OCA) transplantation shell while stabilized in a cutting jig. (**c**) Image demonstrating the OCA transplantation shell that has been sized to match the recipient site and is initially stabilized with Kirshner wires. (**d**) Final construct of the OCA shell technique fixated with headless metallic screws placed in oblique trajectories away from the articular cartilage

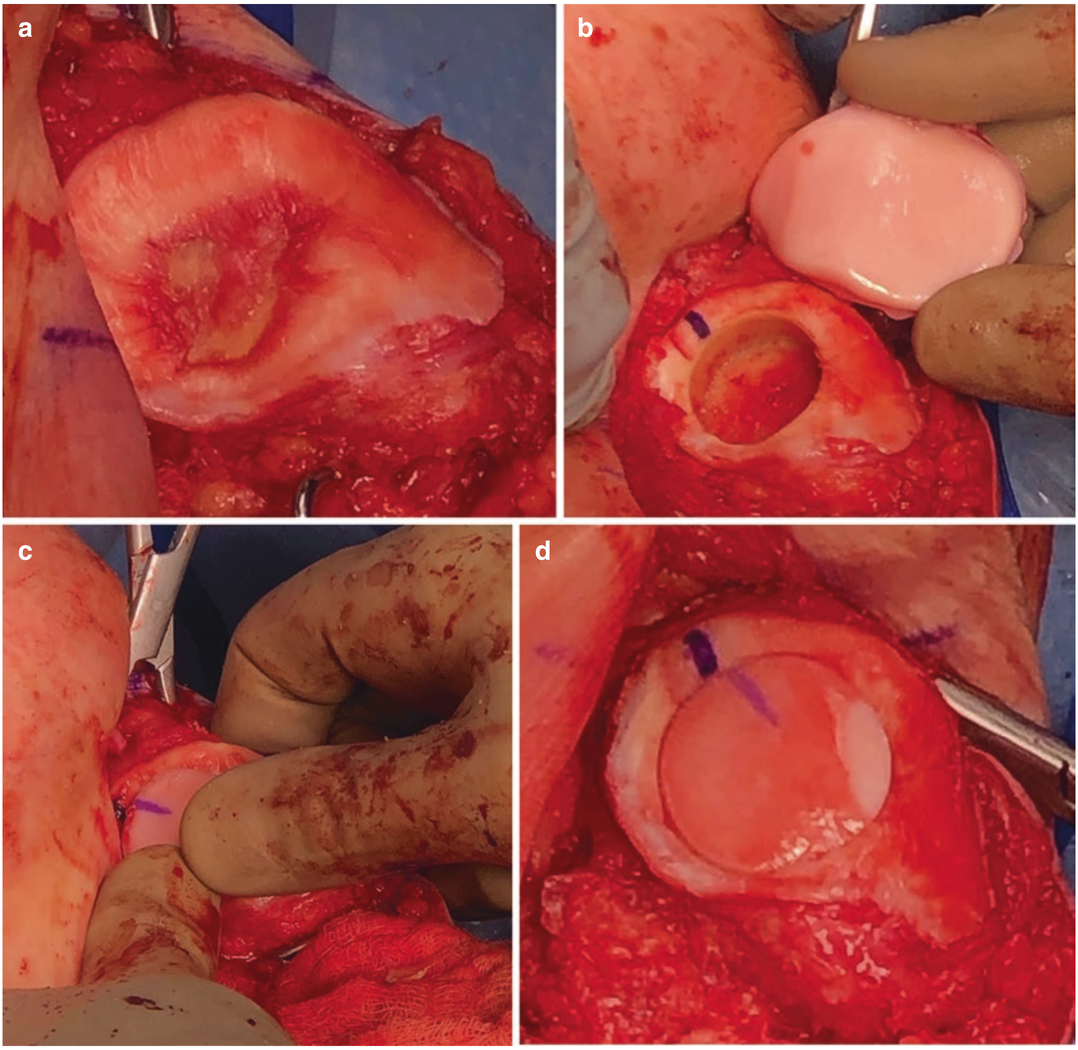

Fig. 32.7 Intraoperative images demonstrating an osteochondral allograft (OCA) transplantation to the patella technique. (**a**) Recipient site osteochondral defect. (**b**) Allograft patella demonstrated adjacent to the native patella after reaming of the base of the defect. (**c**) Image demonstrating a press-fit insertion of the patella OCA to the recipient site. (**d**) Final image after patella OCA transplantation with the lines at the 12 o'clock position of the recipient site and the graft matched up

to bone to the recipient patella and secured with either bioabsorbable or metal screws. Typically, two to three screws are utilized to ensure adequate rotational stability of the graft, and the screws are placed from anterior to posterior. Care should be taken to ensure the screws do not violate the chondral articular surface but are deep enough to have adequate fixation in the subchondral bone.

32.8 Postoperative Rehabilitation

Postoperative rehabilitation after OCA transplantation proceeds in phases, with different weight bearing restrictions for different lesions locations but with the initial phase focusing on graft protection for 0–6 weeks. The goal is to avoid excessive compressive or shear forces on the transplanted graft.

For lesions of the patellofemoral joint, weight bearing as tolerated with the knee locked in full extension in a brace is typically utilized after wound healing. Some authors recommend graduated knee flexion for the first 4–6 weeks for patellar or trochlear transplants to limit excessive pressure across the graft. For femoral condyle or tibial plateau grafts, patients are restricted to Foot Flat <10% WB until postoperative radiographs demonstrate early signs of graft incorporation. For small, well-shouldered lesions, advancement or a partial progressive weight bearing protocol may begin as soon as 4 weeks. For large lesions or poorly contained/shouldered lesions, longer weight bearing restrictions should be instituted (6 weeks or more). In general, patients may perform range of motion as tolerate for condyle lesions. Weight bearing and range of motion restrictions may also be altered based on the concomitant procedures performed (i.e., ligament reconstruction, meniscus transplantation, osteotomy). In patients with the need for prolonged period of protection, consideration can be made for the use of blood flow restriction therapy to reduce risk of muscular atrophy.

Regardless of weight bearing status, early range of motion is paramount after OCA transplantation. Early motion both supports articular cartilage viability and prevents arthrofibrosis. Use of a continuous passive motion (CPM) device can be helpful in the immediate postoperative period, particularly if weight bearing is restricted. Typical settings for CPM use would be 6 h/day, beginning at 0–40°, advanced 5–10° daily as tolerated. Gravity-assisted ROM is also encouraged.

The primary goal of the second phase of rehabilitation (6–12 weeks) is normalization of daily life activities and slow and steady strength training. Any braces utilized are discontinued with adequate quadriceps muscle control, and strength has been achieved. Some authors have advocated for use of an unloader brace to unload the affected compartment, but this has not been shown to alter long-term outcomes or graft survival rates [43, 44]. Regardless, the goal is for patients to progress to full ROM, normalized gait, and improved strength. Low-impact activities are performed in this phase (i.e., swim, bike, elliptical).

The final phase of postoperative rehabilitation (>12 weeks) is patient specific based on individual goals and expectations. In general, this phase focuses on increased strength, endurance, and a return to functional and occupational activities. In relatively sedentary patients, a transition to a home exercise program and activities of daily living may be implemented. In athletes, advanced proprioceptive and sport-specific activities may begin. Athletes should be cautioned, however, that high impact activities should be avoided for 9–12 months after surgery. Athletes should have radiographic (ideally magnetic resonance imaging) evidence of full graft incorporation, no effusion or significant pain, full knee ROM, ligamentous stability, and complete dynamic strength and endurance before return to play may be entertained. Full return to play should be evaluated on a case-by-case basis with the individual athlete and surgeon.

32.9 Potential Complications

The inherent risks of surgery (infection, arthrofibrosis) may occur and are typically prevented using standard precautions. Use of small arthrotomy (or an arthroscopic technique) and early range of motion help avoid arthrofibrosis. Allograft-related complications, such as disease transmission or immunogenic reaction, are exceedingly rare but have been documented [50, 51]. Delayed or nonunion of the graft and graft fragmentation and/or collapse may occur, especially in patients with poor bone quality. This may result from incomplete graft incorporation to the native bone due to limited revascularization. Performing marrow stimulation of the recipient site and drilling channels in the subchondral bone of the donor graft can aid in the revascularization process. Finally, using careful, line to line, press-fit technique helps avoid graft collapse and/or eventual fragmentation and failure. Finally, other underlying diseases processes (avascular necrosis, osteoarthritis) may result in persistent symptoms regardless of graft healing or incorporation status.

32.10 Summary

Fresh osteochondral allograft transplantation is an excellent treatment option for large, full thickness articular cartilage defects, with or without bony involvement, in the knee. It may be indicated as a first-line treatment for large defects, for defects with extensive subchondral involvement, and is an excellent salvage procedure for previously failed microfracture or other cartilage restoration procedures. OCA transplantation provides viable, mature hyaline cartilage with underlying subchondral bone to the defect area, resulting in excellent graft strength and overall joint restoration. Management of concomitant meniscus deficiency, ligament instability, and limb malalignment is vital to the success of an OCA transplant. Postoperative rehabilitation follows the general principles of cartilage restoration procedures and is modified based on concomitant pathologies and patient-specific goals. Improvements in graft storage capability, use of non-orthotopic grafts, and specialized cutting guides have greatly improved graft availability and surgical technique demands. Overall, mid- to long-term studies of OCA transplantation show good to excellent outcomes and graft survival in large series (Table 32.2). Future basic science and clinical studies continue to refine indications, graft healing and incorporation, and surgical techniques.

Table 32.2 Osteochondral allograft transplantation outcomes

Study	Lesion site	Diagnosis	Mean follow-up (years)
McCulloch et al. [8]	Multiple site	Trauma, OA, OCD, AVN	2.9
Raz et al. [15]	Femoral condyle	Trauma, OCD	22
Abrams et al. [39]	Femoral condyle	Isolated ICRS grade 3 or 4 defect of the femoral condyle	4.4
Wang et al. [45]	Femoral condyle	Previous failed cartilage repair	3.5
McCarthy et al. [19]	Femoral condyle	Idiopathic, trauma, OCD lesions >2 cm	5.9
Meric et al. [36]	Bipolar, patellofemoral	Degenerative, traumatic, OA, failed OCA, OCD, chronic	7.0
Levy et al. [9]	Femoral condyle	OCD lesions >2 cm, trauma, osteonecrosis, OA	13.5
Krych et al. [46]	Femoral condyle, trochlea, multiple locations	Trauma, nontrauma, OCD	2.5
Gracitelli et al. [37]	Patella	Idiopathic, OCD, traumatic, degenerative	9.7
Sadr et al. [47]	Femoral condyle, trochlea, multiple site	OCD	6.3
Briggs et al. [48]	Multiple sites	OCD, AVN, OA, trauma	7.6
Cameron et al. [49]	Trochlea	OCD, OA, trauma	7.0

No. of knees	Failure rate (%)	Graft survival (%)	Outcomes scores postoperative (preoperative)
25	N/A	4	Lysholm: 67 (39) IKDC total: 58 (29) SF-12: 40 (36)
58	22	91% (10 years), 84% (15 years), 69% (20 years), 59% (25 years)	Modified HSS: 87
48	46	64% (5 years), 39% (10 years)	IKDC function: 7 (3.4) IKDC pain: 4.7 (7.5) KS-F: 84 (71) Modified d'Aubigne´-Postel: 16 (12)

(continued)

Table 32.2 (continued)

32	25	N/A	Lysholm: 64 (42) IKDC: 55 (33) IKDC: 63 (43) SF-12: 47 (44)
43	9	91	SF-36: 84 (61) IKDC: 69 (46) Cincinnati: 6.5 (4.6) Marx: 6.0 (4.4) OCAM-RISS: 10.1
13	0	100	Lysholm: 64 (41) IKDC: 63 (38) Tegner: 4.5 Marx: 5.7 SF-12: 44(35) Return to sport: 77%
129	24	82% (10); 74% (15); 66% (20)	Merle d'Aubigne and Postel: 16 ± 2.2 (12.1 ± 12.1) IKDC pain: 3.8 ± 2.9 (7 ± 1.9) IKDC function: 7.2 ± 2 (3.4 ± 1.3) Knee Society function: 82.5 (65.6)
43	0	100	Limited return to sport, 88%; return to sport at preinjury level, 79% IKDC: 79.29 ± 15 (46.27 ± 14.86) KOOS ADL: 82.82 ± 14 (62 ± 15.96) Marx activity: 8.35 ± 5.9 (5.49 ± 6.35)
28	29	78 (5,10 years), 56 (15)	IKDC: 67 (37) KS-F: 81 (65) Modified d'Aubigne´-Postel: 15 (12)
149	8	95% (5), 93% (10 years)	Modified d'Aubigne´-Postel: 82(44) KS-F: 96(72)
61	18	89% (5 years), 75% (10 years)	Modified d'Aubigne´-Postel: 16.5 (12.6) IKDC: 80 (37) KS-F: 90 (67) KOOS symptoms: 85 (59)
29	21	100% (5 years) 91.7% (10 years)	Modified d'Aubigne´-Postel: 16 (13) IKDC: 72 (39) KS-F: 85 (66) UCLA: 7.9

OA osteoarthritis, *OCD* osteochondritis dissecans, *AVN* avascular necrosis

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