Management of the Failed OCD

Crystal A. Perkins¹ · S. Clifton Willimon¹

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Abstract

Purpose of the Review Osteochondritis dissecans (OCD) is a pathologic condition of subchondral bone most frequently occurring in the medial femoral condyle of the knee in children and adolescents. Salvage techniques are necessary when either nonoperative or typical operative treatments fail, or the OCD presents in an unsalvageable state. The purpose of this review is to describe the evaluation and management of failed OCDs.

Recent Findings Thorough preoperative planning is essential to the treatment of failed OCDs. Radiographs and advanced imaging such as MRI and CT allow for a detailed assessment of subchondral bone and cartilage. Long-leg alignment radiographs are critical to assess for malalignment which may increase the contact forces on the affected condyle. Malalignment can be corrected with hemiepiphysiodesis or an osteotomy depending on the skeletal maturity of the patient. Osteochondral allografts and autologous chondrocyte implantation treat the defect in both bone and cartilage or solely cartilage and have good short to moderate term outcomes, particularly as compared to the inferior outcomes of microfracture of larger OCDs.

Summary Osteochondritis dissecans of the knee that fails to heal with initial operative measures can result in a large defect of bone and cartilage in the knee of adolescents. Treatment of the bone and cartilage defect can be accomplished with either osteochondral allograft transplantation or matrix-assisted autologous chondrocyte implantation can be performed with good outcomes. Assessment and correction of lower extremity malalignment is a critical component of treatment. Durable long-term solutions are necessary for the treatment of these difficult lesions.

Keywords Osteochondritis dissecans · Cartilage · Osteochondral allograft · Autologous chondrocyte implantation

Introduction

Osteochondritis dissecans (OCD) of the knee, most commonly affecting the lateral aspect of the medial femoral condyle, is a pathologic condition of subchondral bone [1, 2]. The incidence of OCD of the knee is 9 to 29 cases per 100,000 populations, occurring more frequently in boys than girls at a rate of 4:1 [1]. The ultimate goal of treatment of OCD is to preserve native cartilage and bone. In skeletally immature children, nonoperative treatment with limited weight-bearing, immobilization, and activity restrictions can be successful in 50–67% of cases [3, 4]. The standard treatment of OCD of the knee with intact cartilage that has

either failed nonoperative treatment or has risk factors for failure is drilling, with or without fixation [5]. This can be performed in trans-articular or retro-articular fashion. In a systematic review of twelve studies, including 205 OCD lesions, both retro-articular drilling and trans-articular drilling were associated with favorable healing rates, 86 and 91%, respectively [6]. Internal fixation of the OCD with a large progeny fragment can be added to drilling, with highly variable success rates reported in the literature, ranging from 67–100% [7–12]. Multiple fixation methods, ranging from metal screws to bioabsorbable implants have been described. A systematic review of 13 small studies showed no significant differences in outcomes between fixation types [13].

Salvage techniques are necessary when an OCD lesion fails to heal with appropriate treatment (Fig. 1) or that presents in an unsalvageable state with fragmentation of the progeny fragment, a loose body, or with extensive cartilage deterioration. Salvage techniques include debridement, microfracture, osteochondral grafting, or autologous chondrocyte implantation.

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✉ S. Clifton Willimon
Cliff.willimon@choa.org

¹ Children's Healthcare of Atlanta, Atlanta, GA, USA

Fig. 1 15-year-old male with OCD of the lateral femoral condyle (**a**) initially treated with curettage, grafting, and fixation. He had incomplete healing on MRI, radiographs (**b**) and arthroscopy at 5 months post-op. He later underwent osteochondral allograft transplantation as a salvage surgery 6 months after his initial surgery (**c**)

Preoperative Planning

Preoperative planning requires a complete imaging portfolio for each patient. AP, lateral, tunnel, and sunrise view radiographs should routinely be obtained in all patients with a known OCD. Lesions located in the femoral condyle are more posterior and typically seen better on the tunnel view than the AP view (Fig. 2). Full-length lower extremity alignment radiographs are used to assess standing limb alignment. Genu valgum in the setting of a lateral femoral condyle OCD or genu varum in the setting of a medial femoral condyle OCD should be identified and treated. MRI is most commonly utilized at the time of OCD diagnosis but is also beneficial for monitoring OCD healing and/or progression. This modality allows for a detailed assessment of both cartilage and subchondral bone. Although MRI has nearly

100% diagnostic sensitivity for OCD [14], one limitation of this imaging modality is its low specificity for diagnosing fragment instability [15, 16]. New techniques, such as T1rho sequences, have been described to detect early changes in cartilage integrity in osteoarthritis models and may have future applications in OCD [17, 18]. Lastly, computerized tomography (CT) can be selectively used for quantifying healing after initial surgery. This may be particularly beneficial in patients with prior fixation, in whom the utility of MRI may be limited secondary to artifact created by indwelling implants such as headless compression screws. In patients who have had prior surgery, surgeons must consider factors which may have contributed to failed initial treatment, which may include coronal malalignment, unrecognized fragment instability, or patient noncompliance with activity restrictions.

Fig. 2 AP, lateral, and notch radiographs of the right knee of a 15-year-old male with a lateral femoral condyle OCD

Treatment Algorithm

Coronal Alignment

In children and adolescents with open physes and growth remaining, guided growth of the distal femur and/or proximal tibia can be performed to obtain gradual correction. A careful assessment of bone age, using the Greulich and Pyle Atlas [19] or shorthand bone age assessment [20] is performed to ensure the patient has adequate growth remaining to enable successful deformity correction. Correction of 0.5–1 degree per month [21] or 5 degrees per remaining year in the tibia and 7 degrees per remaining year in the femur [22] can be anticipated.

Guided growth, described with physeal stapling by Blount in 1949 [23], is more commonly now performed with hemiepiphysal screws [24–26] or plates [27]. The Heuter and Volkmann principles of mechanical manipulation of bone explain the mechanics of guided growth, with increased and asymmetric pressure parallel to the axis of the epiphysis resulting in asymmetrical growth [28]. Multiple studies have assessed the effectiveness of hemiepiphysal screws and plates and found no to small differences in the rate of correction [29] or clinical outcomes [30••].

In skeletally mature adolescents with coronal malalignment and an OCD requiring salvage treatment, alignment correction can be corrected with a distal femoral or proximal tibial osteotomy, with the goal of unloading the affected compartment and protecting the salvage surgery. The authors' ideal correction of the mechanical alignment is to the base of the medial tibial spine for a lateral femoral condyle OCD (Fig. 3) and to the base of the lateral tibial spine for a medial femoral condyle OCD. This corresponds to the Fujisawa point, which is 62.5% of the medial-lateral width of the knee, which effectively unloads the affected compartment [31]. Osteotomy is typically performed at the time of final articular cartilage restoration such as osteochondral allograft transplantation or

autologous chondrocyte implantation to limit the patient to one instead of two periods of prolonged altered weight-bearing.

Debridement and Microfracture

Debridement alone is associated with poor long-term outcomes with degenerative radiographic changes and inferior outcome scores although early follow-up shows improvement in 1–2 years but gradual deterioration and increasing symptoms in mid-term follow-up and beyond [32–34]. Marrow stimulation, in the form of microfracture produces fibrocartilage. The decreased durability of fibrocartilage is likely secondary to the relative deficiency of type 2 collagen which predominates in hyaline cartilage. In a prospective randomized controlled trial of debridement and microfracture versus osteochondral autograft for juvenile OCD, similar clinical outcomes were present at 1 year, but microfracture outcomes were far inferior at 4 years, with 41% failure [35]. Recent studies suggest improved outcomes associated with biologic augmentation of microfracture with injectable or scaffold adjuvants [36], but larger long-term outcome studies among pediatric patients are necessary to determine if improved outcomes are sustainable. Although debridement and microfracture may be appropriate for very small OCDs or to address small articular cartilage defects in an OCD which has otherwise healed throughout, we do not recommend this as a standard treatment for the failed OCD.

Osteochondral Transplantation

Osteochondral grafts address both bone and cartilage deficiency in a single graft, which make them attractive for the treatment of osteochondritis dissecans. Autograft transfer

Fig. 3 16-year-old male with unsalvageable lateral femoral condyle OCD and genu valgum treated with osteochondral allograft transplantation and distal femoral osteotomy

using multiple small grafts in a mosaic technique has been described with good outcomes [35]. The noncritical areas available for autograft are limited, therefore, limiting their utility in large OCDs. Additionally, the mosaic technique depends on fibrocartilage fill between plugs, potentially limiting their durability and creating an incongruent articular surface. The use of osteochondral autografts on OCDs of 6 cm² or larger is associated with poor outcomes [37, 38]. The authors do not utilize more than a single 10 mm osteochondral autograft given the availability and outcomes of osteochondral allograft transplantation and autologous chondrocyte implantation techniques.

Osteochondral allograft transplantation allows for the transfer of larger cores of bone and cartilage from a matching portion of the donor knee, therefore, resulting in a congruent articular surface. These fresh allografts contain viable hyaline cartilage and bone. Ultimately, the donor bone is replaced with host bone through creeping substitution, and the donor chondrocytes remain viable [39]. Unlike solid organ transplants, bone and cartilage transplants are immunoprivileged, requiring no blood or leukocyte antigen matching and producing no host immune response [40]. The grafts are recovered within 24 h of donor expiration, held for 14 days for testing, and then released for implantation, once screening tests are

confirmed as negative, no later than 28 days following procurement [41].

Donor grafts are matched based on radiographic, CT, or MRI measurements depending upon the graft supplier. Figure 3 demonstrates a donor hemicondyle that has been matched to the recipient for osteochondral allograft transplantation. An arthrotomy is performed, and the OCD visualized and the appropriately sized allograft are determined. A guide pin is placed perpendicular to the recipient articular surface, the cartilage margin is scored using a size matched tool, and then a reamer is used to debride the selected area of bone and cartilage. Reaming is performed to a depth of bleeding subchondral bone, with ideal bone thickness of 6–9 mm. Donor plug bone thickness less than 5 mm has been associated with an increased odds ratio of cystic changes, while thickness greater than 9 mm is associated with residual osseous clefts, assign of incomplete osseous incorporation [42••]. Next, the donor hemicondyle is assessed to select the area which most closely matches the contour, and a plug of corresponding size is harvested, again ensuring the dowel is reamed perpendicular to the articular surface. Recipient site depths are measured in each quadrant, and the donor graft is likewise marked with these same dimensions and trimmed to appropriate depth. Pulse lavage of the donor dowel has classically been described as a means of removing residual donor marrow elements, although the most recent evidence suggests this is no more effective than no lavage [43••]. The donor graft is then inserted into the recipient site with matching orientation and a press fit. Great care should be taken to dilate the recipient site as forceful insertion of the graft may decrease chondrocyte viability. A moist sponge applied over the graft if light impaction is needed helps dissipate forces on the graft. In large OCDs, additional grafts may be added in a “snowman technique” of interdigitating grafts (Fig. 4) [44].

The results of osteochondral allograft transplantation for post-traumatic osteochondral defects have been generally favorable [45, 46]. At a mean of 6 years, 135 patients 12–55 years of age with a mean allograft size of 7 cm² had a survivorship of 95% at 5 years and 93% at 10 years. Ninety-five percent of patients reported being satisfied with the outcome of their procedure [46]. Outcomes specific to pediatric and adolescent patients were published by Bugbee et al. on 2014 [47]. Thirty-nine patients with a mean age of 16.4 years were treated with an osteochondral allograft (mean size 8.5 cm²) for OCD (61%), avascular necrosis (16%), and traumatic chondral injury (14%). Graft survivorship at 10 years was 90%, and of the surviving knees, 89% rated their knees as extremely satisfied or satisfied [47].

Autologous Chondrocyte Implantation

The indication for autologous chondrocyte implantation (ACI) has been contained, irreparable lesions 2–16 cm² from

Fig. 4 Donor hemicondyle and recipient following osteochondral allograft transplantation to the lateral femoral condyle using a “snowman” technique to interdigitate allograft dowels

osteochondritis dissecans or osteochondral injury. ACI requires two surgeries; the first of requires harvesting of a cartilage biopsy, and the second being implantation. ACI is approved for treatment of cartilage defects with bone loss of 6 mm or less. If the OCD is associated with bone loss greater than 6 mm, then bone grafting of the defect is performed in the first stage. Similar to osteochondral transplantation, an arthrotomy is performed, and the OCD is visualized. Debridement of the lesion of all nonviable cartilage and bone is completed, with careful attention to create vertical walls. Classically, ACI required that the chondrocytes be implanted free-floating deep to a periosteal patch which was sewn to the bordering intact articular cartilage. More recently, this technique has evolved to autologous cultured chondrocytes impregnated into a porcine collagen membrane (MACI), simplifying the implantation process. A template of the defect is created, the MACI implant is then trimmed using the created template, a thin layer of fibrin glue is placed in the base of the defect, the MACI implant is applied with the cell-side facing down, and then an additional layer of fibrin glue is applied. It is critical with MACI technique that the chondrocyte laden membrane fits within the defect in contrast to ACI technique in which the patch is sewn flush with the intact cartilage border.

A prospective randomized study of ACI versus MACI found similar clinical, arthroscopic, and histological outcomes [48]. The results of MACI as compared to microfracture are far superior in the treatment of symptomatic isolated chondral defects 3–10 cm² in size with respect to Tegner, Lysholm, KOOS, and ICRS scores [49, 50••]. Further research, including long-term outcomes and studies specific to the pediatric and adolescent population treated with MACI for OCD of the knee, will be necessary.

Rehabilitation

Both osteochondral allograft transplantation and autologous chondrocyte implantation require protected weight-bearing for a total of 8 weeks. Protective knee bracing is also utilized the first 6 weeks. Range of motion is advanced as tolerated for osteochondral grafts, while ROM is restricted to 0–90 degrees for the first weeks following MACI. Serial radiographs are used to monitor incorporation of osteochondral allografts. Postoperative CT or MRI are not routinely obtained, but reserved for patients whose radiographs do not show complete healing or those with persistent pain or effusion. Full return to regular activities is approximately 6 months.

Conclusions

Osteochondritis dissecans of the knee that fails to heal with initial operative measures can result in a large defect of bone and cartilage in the knee of adolescents. Durable long-term solutions are necessary for the treatment of these difficult lesions. Thoughtful preoperative planning with the assessment of coronal alignment and bone and cartilage deficiency are necessary. Correction of coronal alignment, by means of guided growth or osteotomy, should be an essential component of the treatment. Treatment of the combined bone and cartilage defect can be accomplished with either osteochondral allograft transplantation or matrix-assisted autologous chondrocyte implantation with good outcomes.

Compliance with Ethical Standards

Conflict of Interest Crystal A. Perkins declares that she has no conflict of interest pertaining to this chapter.

S. Clifton Willimon declares that he has no conflict of interest pertaining to this chapter.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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50. Brittberg M, et al. Matrix-Applied Characterized Autologous Cultured Chondrocytes Versus Microfracture: Five-Year Follow-up of a Prospective Randomized Trial. *Am J Sports Med*. 2018;46(6):1343–51 **Symptomatic cartilage defects of 3cm or larger in the knee have clinically improved outcomes at 5 years with MACI as compared to microfracture. Large chondral injuries should not be treated with microfracture alone.**

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