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Osteochondritis Dissecans of the Knee: Experiences at The Children's Hospital of Philadelphia and a Review of Literature

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Abstract: Osteochondritis dissecans is a condition primarily found in the knee, elbow, and ankle, which affects subchondral bone and potentially the overlying articular cartilage. Although the etiology is not certain, possible causative factors include repetitive microtrauma, ischemia, genetic and endocrine factors, and anomalies of ossification. The etiology, presentation, and management is age-dependent, as osteochondral lesions have a much greater potential to heal when those affected are skeletally immature. The first line of treatment is to remove stress from the involved area by immobilization and activity modification. However, if non-operative measures are unsuccessful or if loose bodies are present, then surgical approaches may be used, some of which include: fixation with pins or screws, subchondral drilling, abrasion or drilling arthroplasty, and autologous chondrocyte implantation. This article discusses the etiology, clinical findings, diagnostic imaging, treatment options, rehabilitation, and considerations for future management based on current literature and our experiences at the Children's Hospital of Philadelphia.

Introduction

Osteochondritis dissecans (OCD) is a condition that affects the subchondral bone, and potentially the articular cartilage, and can lead to separation of an articular fragment from the underlying bone. Konig coined the term *osteochondritis dissecans* in 1888, describing it as an inflammation of the bone-cartilage interface. Other terms have been associated with OCD in the literature, including osteochondral fracture, osteonecrosis, accessory ossification center, osteochondrosis, and hereditary epiphyseal dysplasia [32].

OCD must be given sufficient medical attention in young patients because it impacts a child's present and future activity levels and can contribute to degenerative joint disease later in life. The prognosis of OCD often depends on the status of the growth plate. The juvenile form of the disease occurs in children with open growth plates, usually between the ages 5 and 15 years. The adult form, which occurs in those who have reached skeletal maturity, is most commonly found in patients of ages 16 to 50 years [4]. The skeletally mature patients are more likely to fail non-operative treatment and typically have an overall worse prognosis. In an evaluation of 76 knee joints at an average follow-up of 33 years, Linden did not report significant complications in patients with a history of juvenile OCD who had been treated before skeletal maturity [23]. In contrast, symptoms and gonarthrosis had an incidence approaching 100% with time in patients with a history of the adult form of OCD. In another study, Twyman et al. followed patients who had OCD as adolescents and found a 32% incidence rate of moderate to severe osteoarthritis after an average of 34 years [37].

OCD occurs more commonly in males than females with a ratio between 2:1 and 3:1 [11,25]. The knee is the most commonly involved joint, as the ratio of knee lesions to all other areas combined, including the talus, capitellum, and wrist, is 3:1 [11]. The lateral aspect of the medial femoral condyle is the most common site of involvement in the knee, accounting for 73% to 85% of all OCD lesions [1,22]. Patients with bilateral involvement, or those with more than one joint affected and associated short stature, may have endocrine anomalies. Further medical work-up is warranted in these patients.

Possible causative factors for OCD include repetitive microtrauma, ischemia, genetic and endocrine factors, and anomalies of ossification [14,15,18,21,35]. Although the name *osteochondritis dissecans* implies an inflammatory condition, the lack of inflammatory cells in histological examination suggests that there is a more likely cause. We theorize that repetitive microtrauma, which leads to microfractures, may cause subsequent focal ischemia or alteration of growth. As a result, the subchondral bone offers reduced support, the articular cartilage softens, and fragment separation may lead to cartilage injury and later crater formation. Mature articular cartilage, which has no blood supply, lymphatic drainage, or neural elements, does not heal once injured.

Clinical Presentation

Patients with OCD complain of activity-related pain that develops gradually. Subjective complaints usually consist of mechanical symptoms, including pain, swelling, catching, locking, and "giving way."

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Physical examination typically reveals an effusion, tenderness, and crepitus. The tenderness may be diffuse initially but often changes to well-defined focal tenderness as the lesion progresses. Acute osteochondral fracture has a similar presentation, but is usually associated with a fatty hemarthrosis. Although there is no significant pathologic gait or characteristic alignment abnormality associated with OCD, the patient may walk with the involved leg externally rotated in an attempt to avoid tibial spine impingement on the lateral aspect of the medial femoral condyle [32].

A special test known as the “Wilson sign” has been described to locate OCD lesions of the femoral condyle [39]. The test is performed by slowly extending the knee from 90 degrees while maintaining internal rotation. Pain reported at 30 degrees of flexion and relief with tibial external rotation is a positive result.

The possibility of microtrauma contributing to OCD underscores the importance of evaluating biomechanical forces at the knee during the physical examination. The treating physician should be certain to include an evaluation of the alignment and rotation of all major joints in the involved extremity. Extrinsic and intrinsic abnormalities of the joint, including joint laxity, should also be considered.

Diagnostic Imaging

Plain radiographs show lucency of the ossification front, representing growth inhibition, in young patients. In older adolescents, the OCD lesion frequently appears as a well-circumscribed area of sclerotic subchondral bone with a radiolucent line between the defect and the epiphysis. OCD lesions of the medial femoral condyle are best visualized with a notch or tunnel posteroanterior radiograph. The apparent size of the lesion depends on its location on the condyle and on the amount of knee flexion used. By viewing the lateral radiograph, Harding described a method to identify the most common site of an OCD lesion (Fig. 1) [17]. Cahill and Berg described a method to record the location of OCD based on radiographs by plotting the lesion with coordinates; the letters A–C are used for the lateral view, and the numbers 1–5 are used for the anteroposterior view (Fig. 1) [8,9].

We have found that the presentation of OCD may vary with age. Children between the ages of 8 and 11 may present with inhibition of the ossification front, which creates the appearance of a defect (Fig. 2) [7]. A patient with a more mature epiphysis and a more advanced lesion will show a fracture line initially through the region of the subchondral plate (Fig. 3A), and eventually through the articular cartilage. Severe lesions may show lysis of the developed epiphysis, similar to the radiographic findings in avascular necrosis (Fig. 4A). Patients close to skeletal maturity may present in later stages with a well-circumscribed ossicle on plain radiographs. In patients found to have multiple lesions, the treating physician should also consider multiple epiphyseal dysplasia, and a skeletal survey may be required.

Magnetic resonance imaging (MRI) is useful for staging OCD lesions, evaluating the integrity of the joint surface, and distinguishing normal variants from OCD by showing bone and cartilage edema in the area of the irregularity. MRI provides information regarding features of the articular cartilage and underlying subchondral bone, including edema, fractures, fluid interfaces, articular surface integrity, and fragment displacement [12,13]. High signal at the fragment interface is seen in active lesions, which we consider to be potentially unstable or to have current or recent microfractures (Fig. 5). MRI and arthroscopy have been reported to have a close correlation, while MRI and plain radiographs have been shown to have a poorer correlation [13].

We have evaluated MRI exams for patients with OCD lesions in the knee to determine whether a particular distal femoral OCD will fail non-operative treatment. We feel that four critical MRI criteria of instability exist: a line of high signal intensity at least 5 mm in length between the OCD and underlying bone, an area of homogeneous signal at least 5 mm in diameter beneath the lesion, a focal defect in the articular surface, and a high signal line traversing the subchondral plate into the lesion (fracture of subchondral bone) (Fig. 5).

Technetium bone scintigraphy has been used to monitor the progress of treatment. It can detect osteoblastic activity, regional blood flow, and the amount of osseous uptake, which seem to be correlated to the potential amount of healing possible in the osteochondral fragment [10]. Periodically repeating the technetium bone scan can help to plan a course of treatment. We have found that a cold lesion does

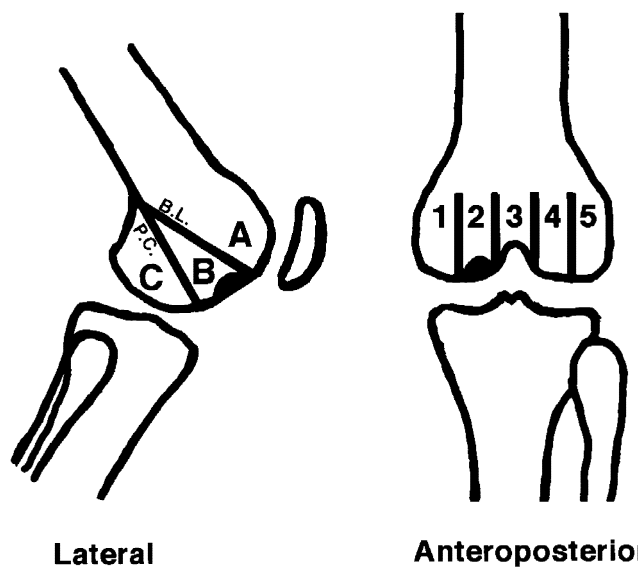

Fig. 1. Schematic drawing of a lateral and anteroposterior radiograph illustrating the most common location of an OCD according to Harding [17]. The subchondral bone located between two lines, one along the posterior femoral cortex (P.C.), and another along the density caused by the roof of the intercondylar notch (the Blumensaat line, B.L.), is the most common area of an OCD, as shown above in area **B**. Cahill and Berg also used the anteroposterior view to describe the location of OCD by plotting the lesion [8,9]. On the anteroposterior view, both condyles are divided into two equal halves while the area over the intercondylar notch is given its own number. This lesion would be considered a “B2 lesion.”

not heal unless stimulated. While we recognize the merits of using repeat bone scintigraphy, we have found clinical, plain radiographic, and if needed, MR criteria to be sufficient for decision making.

Treatment

Because treatment of OCD varies based on patient age, severity of the lesion, and personal bias of the treating surgeon, the list of suggested methods is long. Non-operative management may include activity modification, protected weight bearing (partial or non-weight bearing), and immobilization. The goal of non-operative intervention is to promote healing in the subchondral bone and potentially prevent chondral collapse, subsequent fracture, and crater formation [34].

A variety of surgical options exist for the treatment of persistently symptomatic, intact, partially detached, and completely detached OCD lesions. The principles of treatment are to enhance the healing potential of subchondral bone, fix unstable fragments while maintaining joint congruity, and to replace the damaged bone and cartilage with implant tissues or cells that can replace bone and grow cartilage [34].

Fig. 2. The minimal change at the distal femoral condyle (arrow) is consistent with a developing ossification front or early, mild OCD lesion. This patient presented with clinical symptoms and was therefore treated non-operatively. Clinical and radiographic resolution was noted after three months.

It has been widely believed that all patients with open physes heal without surgery, but some skeletally immature patients fail to heal with non-operative measures. Likewise, some lesions in mature patients become asymptomatic. Therefore, operative treatment is recommended if one or more of the following conditions are met: persistently symptomatic juvenile lesions, the presence of symptomatic loose bodies, predicted physeal closure within one year, or fragment detachment (“non-union”) [8].

Intact lesions

If non-operative measures are unsuccessful in healing intact lesions, drilling may be considered to stimulate healing of the subchondral bone. Arthroscopic drilling may be performed by using an antegrade approach through the articular cartilage, or by using a retrograde approach, which is intended to avoid penetration of the articular cartilage (Fig. 6). Bradley reported successful results at one-year follow-up with antegrade drilling with K-wires in 9 out of 11 patients with the juvenile form of OCD [5]. Anderson also reported excellent results with antegrade drilling at an average follow-up of five years (range of 2–9 years) in 18 of 20 skeletally immature patients who had failed prior conservative programs [2]. When performing retrograde drilling, it sometimes can be more difficult to avoid the physis, find the exact location of the lesion, and reach the calcified tidemark without penetrating the cartilage.

Hinged lesions

Pins and screws can be used to secure flap lesions. Pain relief is usually rapid (within days after operation), suggesting that the pain may be caused by increased pressure at the line of separation between the fragment and the epiphysis [5,20,36]. Options for securing hinged lesions include bone pegs, metallic pins and screws, as well as bioresorbable screws and pins.

Full thickness lesions

A variety of options exist for treating full thickness lesions. The concept of recruiting pluripotential cells from the marrow elements via arthrotomy drilling (1959, Pridie) and arthroscopic drilling arthroplasty (1981, Sprague) came well after the first surgical debridement of an OCD lesion in 1946 by Magnusson. Three methods commonly used for full thickness lesions include arthroscopic drilling, abrasion with a high-speed burr, and microfracturing using a pick (Rodrigo, 1994). The advantages for these techniques include technical simplicity, low morbidity, and cost effectiveness. The recruited cells differentiate mostly into fibrocartilage, which is principally type I collagen and rarely types II, VI, and IX (hyaline types). While small lesions can be effectively resurfaced, the repair tissue typically has less strength than normal hyaline articular cartilage and must be protected from high impact loading for 6 to 12 months. The results for large lesions usually diminish over time due to the decreased resilience, stiffness, and poor wear characteristics of the fibrocartilage [24].

Both periosteum and perichondrium can remain viable and produce a cartilagenous extracellular matrix after transplantation, and have been used for complete resurfacing of smaller joints such as the elbow. The graft is transplanted with the cambium layer facing down and placed deep into the defect to avoid excessive shear forces in the early phase of healing [32]. Niedermann et al. reported successful results one year after periosteal transplantation for knee OCD lesions in all four of his patients [26]. A report by Homminga et al. revealed that 28 of 30 OCD lesions filled with cartilage-like tissue on repeat arthroscopy after perichondrial grafting from the ribs [19]. However, Vachon et al., in a more recent study, showed that chondrogenesis occurs to a greater extent with periosteal grafts than with perichondrial grafts [38]. Moreover, periosteal grafting has less associated morbidity than perichondrial grafting, since periosteum exists in large quantities immediately adjacent to the knee and

Fig. 3. A 13-year-old male runner presented with persistent knee pain, swelling, and "giving way." Plain radiographs (**A**, tunnel view) and MR imaging (**B**, T1 weighted image) revealed an OCD lesion of the medial femoral condyle. Due to persistent symptoms and because the patient was approaching skeletal maturity, surgery was performed. (**C**) A probe shows articular cartilage softening immediately before arthroscopic drilling. (**D**) A repeat plain tunnel radiograph taken three months post-operatively reveals a well-healed lesion.

does not require a second incision on the chest wall [27]. Despite good results one year after periosteal transplantation, the long-term outcome of these treatments has recently been challenged by Angermann et al., who reported disappointing results at the 6 to 9 year follow-up in 14 patients with severe adult OCD of the femoral condyle [3].

In attempts to address the weaker structural properties of the reparative fibrocartilage, new techniques have been designed to fill the defect with tissue that more closely simulates normal hyaline articular cartilage. One such technique is autologous chondrocyte implantation (ACI), which is particularly useful for large, isolated femoral defects in younger patients with no lower extremity malalignment. In this technique, chondrocytes are extracted arthroscopically from healthy articular surface and grown in vitro. The chondrocytes are then injected into the defect that has been covered by a periosteal patch, which is taken usually from the medial proximal tibia by open arthrotomy. Brittberg et al. reported good-to-excellent results for reducing pain, swelling, and locking after ACI in 14 of 16 patients with knee OCD (age range of 14–48 years, mean follow-up of 39 months) [6]. Peterson et al. recently found similar results with ACI at a follow-up interval of 2 to 9 years in 94 patients with chondral lesions of the knee [29]. Sixteen of the 18 (89%) patients in their study with adult OCD improved, from a poor rating to a very good rating, on the Noyes overall clinical rating, and arthroscopic examination revealed good repair tissue hardness, adherence, and fill within the defects.

Unfortunately, little literature currently exists for ACI in young patients. We have used ACI at our institution for skeletally immature patients with massive femoral defects who met the International Cartilage Repair Registry criteria. The physician knee evaluation scores and the modified Cincinnati knee scores were improved more in this group of patients at two years than in older patients reported in the cartilage repair registry. Additional long-term evaluations of ACI are needed.

When implanting cells, some investigators have preferred to use undifferentiated pluripotential cells, such as bone

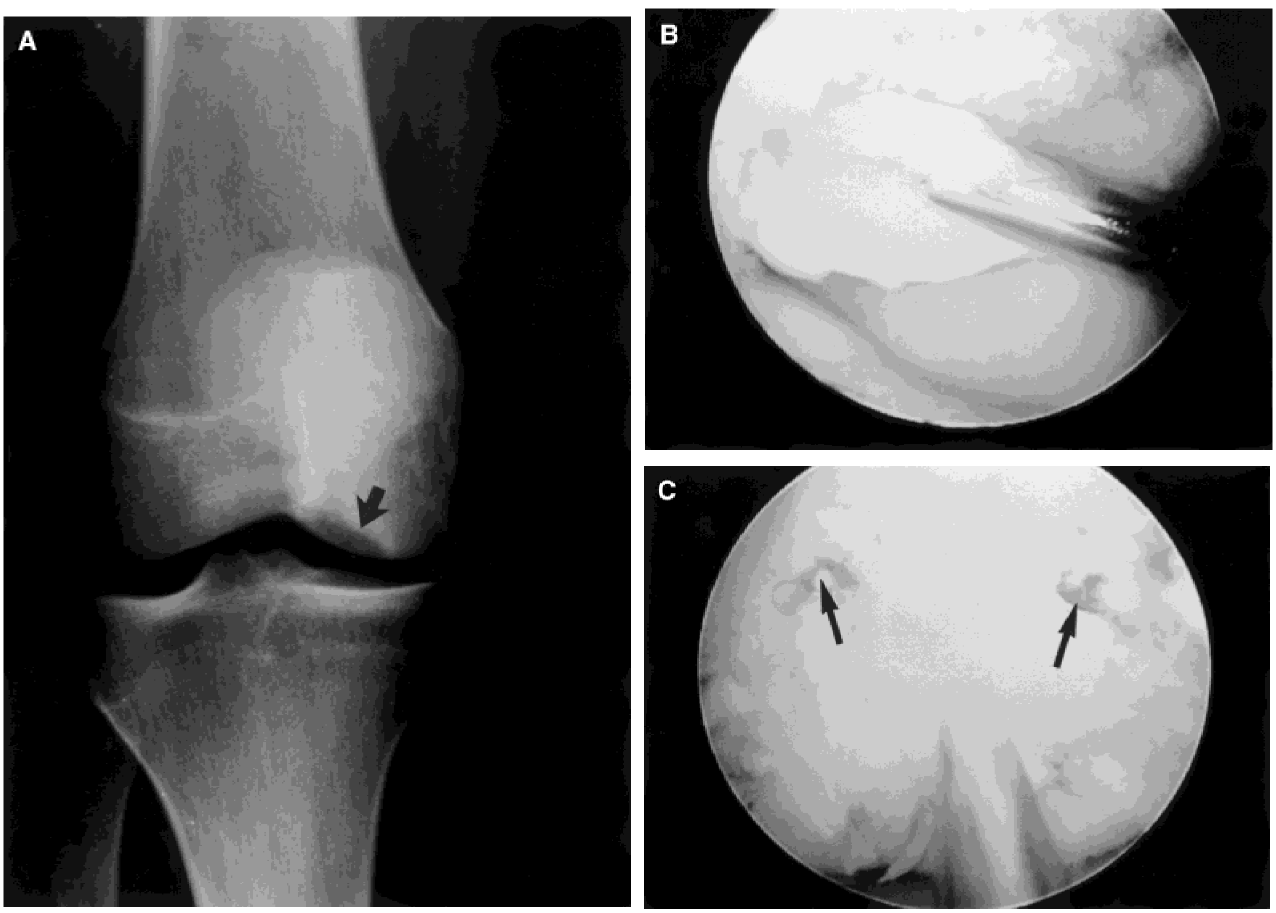

Fig. 4. A 13-year-old female, who did not participate in any regular exercise program, presented to our emergency department with immediate knee pain and swelling after performing resistance exercise on a leg press machine. She could not ambulate without discomfort, and the knee was locked in flexion. On physical examination, she had marked effusion and anteromedial joint line tenderness. Stress testing revealed no pathologic laxity, but the Wilson test elicited pain in the area of the medial joint line. Full painless range of motion was present in her hips and uninvolved knee with no tenderness and normal strength throughout. (**A**) Plain radiographs revealed an OCD lesion of the medial femoral condyle and closed physes. Based on her skeletal maturity and severity of symptoms, surgery was performed. (**B**) Multiple loose bodies were removed, and (**C**) antegrade drilling was performed in an attempt to fill in the defect with reparative cartilage. Recruitment of pluripotential cells from the marrow is demonstrated by the bleeding (arrows). Three months after the operation, the patient was able to perform her activities of daily living symptom-free.

Fig. 5. An MRI of the medial femoral condyle reveals high signal intensity at the fragment interface and traversing the subchondral plate. This suggests an active, unstable OCD lesion.

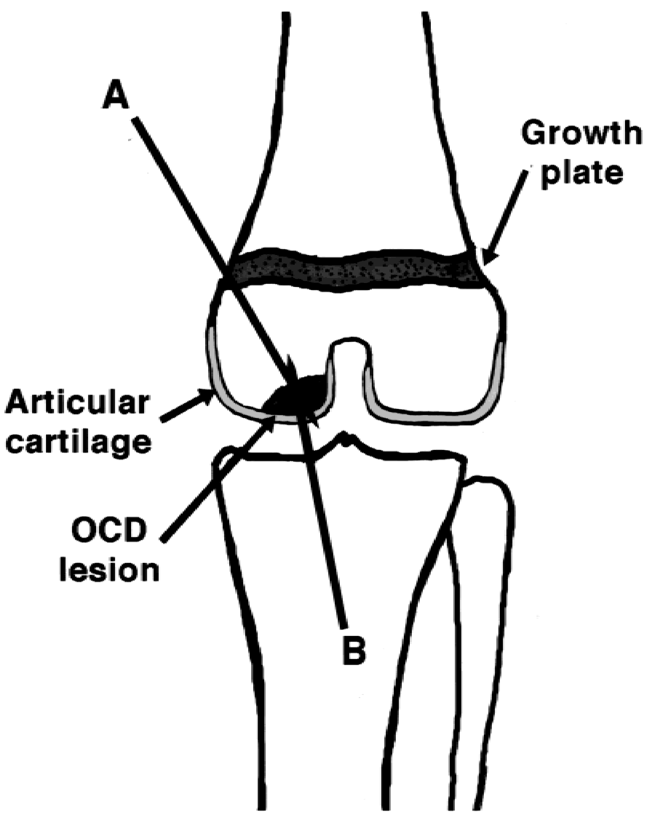

Fig. 6. Schematic drawing illustrating two drilling techniques for OCD lesions. (**A**) Retrograde drilling theoretically avoids the articular cartilage. It is technically more challenging to avoid the distal femoral physis and avoid penetrating the articular cartilage while reaching the calcified tidemark using this technique. (**B**) Antegrade drilling, which we prefer, is more technically simple and has allowed us to obtain consistent healing of intact lesions while permitting a perpendicular approach to lesions in the most classic locations and a direct visualization of the drilling site.

marrow or periosteal cells, as opposed to chondrocytes. The transplanted cells or tissue must be capable of forming bone and cartilage to repair OCD lesions. Periosteal and bone marrow stem cells have demonstrated the ability to regenerate both the cartilage and the underlying subchondral bone [27].

Another method used to promote normal articular cartilage replacement is the technique of transplanting autologous osteochondral plugs, which can be done arthroscopically. The plugs are taken from a relatively “non-weight-bearing region” of the knee, such as the area just above the intercondylar notch or the edge of the patellar groove, and inserted in the defect. Outerbridge et al. reported good clinical results with plugs taken from the lateral facet of the patella when treating 10 patients with large femoral OCD lesions [28]. Limitations of this procedure include donor site morbidity, plug damage from percussive forces during insertion, and the technical challenge of placing the plug edges flush with the adjacent articular cartilage.

Fresh osteoarticular allografts have also been used for the treatment of OCD defects. In a study of 126 patients with knee OCD, Ghazavi et al. reported an 85% success rate at an average of 7.5 years after osteochondral allograft transplantation [16]. This procedure may be a viable option when other treatments have failed and symptoms persist.

The above procedures are most successful in patients with isolated, symptomatic lesions with no malalignment. If malalignment exists, an osteotomy may be indicated to reduce joint surface pressure. More recent techniques are promising, but prospective clinical trials are needed using randomized, control groups to compare the long-term effects of current treatments for juvenile OCD.

Our Experiences at the Children’s Hospital of Philadelphia

Non-operative treatment

Candidates for non-operative treatment include those who are skeletally immature with an intact lesion and no loose bodies (Fig. 7). Patients and their families are first counseled so that they have a basic understanding of OCD. We explain that the condition differs from “wear and tear” degenerative arthritis, which is primarily an articular surface problem. Instead, OCD is a problem of the underlying subchondral bone, which may secondarily affect the cartilage.

Patients with OCD of the knee are immobilized for 4–6 weeks in a cylinder cast in extension to remove shear stress from the involved area. Patients with special considerations and concerns of skin breakdown may be treated in a knee immobilizer. Patients immobilized are permitted to ambulate with weightbearing as tolerated. The reason for favoring a cast is to ensure compliance and to eliminate shearing forces on the region of the osteochondral lesion while permitting compression to stimulate healing and chondrocyte nutrition.

If the plain radiographs taken three months after the start of non-operative therapy reveal that the radiolucency has resolved and the lesion has healed, then a gradual return to activities is instituted. Patients with some component of healing demonstrated by increased radiodensity in the subchondral region, or those patients whose lesions are unchanged, are candidates to repeat the above described three-month protocol until healing is noted.

Operative treatment

We consider surgical intervention in patients who fail three months of non-operative management, in patients approaching skeletal maturity, and in patients with persistently symptomatic lesions. Surgery is also indicated in patients with significant progression (as detected by markedly increased radiolucency in the subchondral bone), in those with a fracture of subchondral bone (as detected by MRI), and in those who have an intra-articular loose body (Fig. 7). In patients treated surgically, an evaluation under anesthesia and diagnostic arthroscopy are performed to ensure that no other ligamentous, meniscal, or chondral pathology exists. Standard medial and lateral parapatellar portals may be used for both the diagnostic arthroscopy and the arthroscopic treatment.

Intact lesions

For intact lesions, a probe is used to determine the extent of softening at the location of the lesion (Fig. 3). For lesions of the lateral aspect of the medial femoral condyle, the medial portal is used as the viewing portal and the lateral portal is initially used as the working portal. A 0.62-mm smooth K-wire is passed through the other portal after the knee is flexed or extended to ensure that the K-wire is perpendicular to the articular surface. Accessory portals may be placed such that the K-wire remains perpendicular (or nearly so) to the articular surface to avoid undermining the remainder of the lesion. Drill holes should be placed several millimeters apart and the K-wire should penetrate into the subchondral bone.

Hinged lesions

In patients with large flap lesions, the underlying fibrous tissue between the fragment and the subchondral plate should be removed without removing a significant amount of the underlying cancellous bone. The chondral flap should be removed also if it does not have subchondral bone attached. If the size of the fragment is significantly smaller than the size of the defect, fixation can lead to worse results than fragment excision and salvage procedures. In patients with unstable lesions that have subchondral bone attached and an appropriate defect-fragment match, compression screw fixation with or without bone grafting may be performed. We perform arthroscopic fixation with a cortical screw followed by immobilization with a cast in position that does not allow the screw to articulate with the joint surface. Patients are kept non-weightbearing for a period of six weeks. A second arthroscopic procedure is then performed to remove the screw and to evaluate the lesion with a probe. If the lesion is not healed, then the flap is removed and salvage procedures are performed to treat the defect. If the lesion is stable, then a rehabilitation program is instituted (see below).

Unstable lesions

Methods of fixation for unstable lesions include countersunk compression screws and Herbert screws or pins made of stainless steel or bioresorbable materials. If loose bodies are present, they are removed (Fig. 4). Although each case is unique and the treatment must be considered on an individual basis, we generally perform ACI on large isolated defects in patients approaching skeletal maturity (Fig. 8).

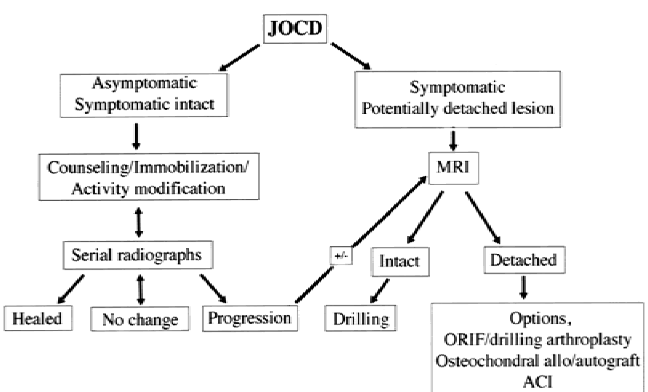

Fig. 7. A treatment algorithm for juvenile OCD lesions based on experiences from The Children's Hospital of Philadelphia. The patients are categorized into two broad categories: (1) asymptomatic or symptomatic with intact lesions, and (2) symptomatic with potentially detached lesions. Patients in the first category are managed non-operatively with immobilization, activity modification, and education. Routine plain radiographs are obtained to monitor progression. If progression occurs, or if patients are in the second category, then an MRI may be performed depending on the patients' symptoms to help determine the severity of the lesion. Intact lesions respond well to arthroscopic drilling, whereas detached lesions require more extensive surgical intervention.

Rehabilitation

Continuous passive motion (CPM) has been used to enhance the healing of the articular surface in the postopera-

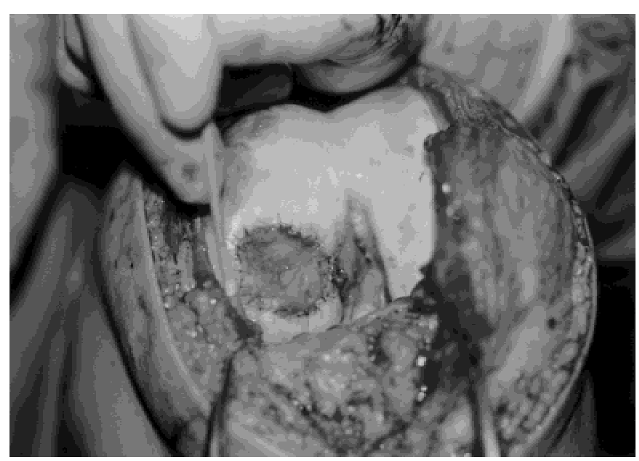

Fig. 8. Intraoperative photograph taken during an autologous chondrocyte implantation procedure showing a periosteal patch sutured over an isolated OCD in the femoral condyle. Autologous chondrocytes, which had been grown in vitro, were injected beneath the patch.

tive period for patients with full-thickness lesions. It was shown to promote articular cartilage healing for moderately small lesions in rabbits (<3 mm in diameter) [31]. Similar effects were found in humans by Rodrigo and Steadman, who reported that CPM for six hours per day for eight weeks produced an improved clinical result [30].

Regardless of the treatment selected, the patient should have a rehabilitation program that combines protection of the compromised articular surface and underlying subchondral bone, with maintenance of strength and range of motion. Straight leg raising and isometric exercises can be performed in the post-operative or immobilization period. In general, the straight leg raising exercises are performed without resistance initially, and advanced by adding 2 to 3 pounds per week, or as tolerated, until 10% of the patient's body weight is reached. A 6- to 8-week home or formal physical therapy program is usually instituted, incorporating range of motion, stretching, progressive strengthening, and functional or sport-specific training. Closed kinetic chain exercises are initiated on the sixth week. During this time, the patients are kept out of running and jumping sports but are permitted to perform low impact activities, such as walking, sub-maximal biking, swimming, and activities of daily living. Patients may return to running and jumping sports when healing is noted on plain radiographs. Those who have undergone marrow stimulation or ACI are protected from high impact loading for one year. If patients return to activity before the cartilage has become firm, they will typically complain of pain with maneuvers such as squatting or jumping.

The Future

Maintaining the transplanted cells in the damaged area, especially in large lesions, has traditionally been a significant challenge. Scaffolds, or matrices, have been used in attempts to retain the transplanted cells in the defect and to deliver bioactive agents. A variety of materials have been investigated, including: fibrin, collagen, ceramics, and synthetic polymers. Biodegradable matrices perhaps show the most promise for the future [32]. On-going research also focuses on the regulatory conditions needed to differentiate the recruited or transplanted primitive mesenchymal cells into mature chondrocytes. In a study of OCD lesions in adult rabbits, Sellers et al. reported good results when using collagen impregnated with recombinant human bone morphogenetic protein-2 [33]. Methods to deliver growth factors and cytokines locally with temporal control will be the subject of many future studies. Synthetic polymers that closely approximate the biomechanical characteristics of normal articular cartilage are also being developed.

Summary

The most significant factor leading to an unsatisfactory outcome may be to miss, ignore, or disregard OCD as a non-problem or as a natural progression of growth and development. While variations of ossification occur, patients with OCD lesions often develop signs and symptoms of pain, effusion, and changes on plain radiographs, which can also present as signal changes within the subchondral bone on MRI. While these lesions demand a healthy respect in patients of all ages, this is especially true for younger patients since the prognosis deteriorates after skeletal maturity. Untreated or inadequately treated lesions may progress from stable, intact lesions to unstable lesions with loose body formation, chondral tears, and full thickness defects with underlying loose fibrous tissue. Allowing patients to continue their activities unchanged despite intermittent pain, mechanical symptoms, and radiographic changes is to allow patients to potentially progress to full thickness lesions and significant early gonarthrosis. A primary complication of treatment therefore may be considered failure to promote healing by skeletal maturity.

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