Review Article

Grade I Osteochondritis Dissecans in a Young Professional Athlete

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Abstract

Background: Osteochondritis dissecans (OCD) is a disorder primarily affecting subchondral bone, with secondary effects on the overlying articular cartilage. Knee joint (75%) and radiocapitellar joint (6%) are the most common sites for OCD lesions. The presence of an open growth plate differentiates juvenile osteochondritis dissecans from adult form of osteochondritis. Early diagnosis and treatment produce best long term results. The objective of this study is to determine the best mode of management of a Grade I osteochondritis lesion in a young athlete. **Materials and Methods:** A PubMed search was made using the keywords "OCD" and "athlete". Articles that were based on participants between the ages of 6–24 years (children, adolescent and young adult) and early stages of OCD were included in this study. A total of 25 articles were thus included for the review. **Results:** The healing potential is based on the age of the patient, status of physis, and stage of the lesion. Most authors have observed good to excellent results of drilling of early OCD in skeletally mature patients. Similarly, most authors also reported equally successful outcomes of nonoperative treatment for early OCD in skeletally immature patients. **Conclusions:** We recommend initial nonoperative line of management in patients with open physis. In case of progression of the lesion or failure of conservative treatment a reparative, restorative or palliative surgical intervention can be done. For Stage I OCD lesions in patients with closed physis, we advocate reparative surgery either by means of retro- or trans-articular drilling.

Keywords: *Athlete, Grade I, osteochondritis dissecans*
MeSH terms: *Osteochondritis, cartilage, articular, knee joint*

Introduction

The term osteochondritis dissecans (OCD) was coined by König in 1888 when[1] OCD is a disorder primarily affecting subchondral bone, with secondary effects on the overlying articular cartilage. Knee joint (75%) and radiocapitellar joint (6%) are the most common sites for OCD lesions.[2,3] The talus (4%) is the third most frequently affected anatomic site.[4]

Incidence is higher in boys than girls.[5] Majority of the patients (55%–60%) are regularly involved in sports. Young athletes can be frustrated by the condition due to slow healing, extended period of sports restriction, and persistent pain or discomfort. The rationale behind conducting this review was to settle the debate on how to accurately predict which patients will heal with nonoperative treatment and which will require operative treatment.

Materials and Methods

A PubMed search was made using the keywords "OCD" and "athlete." A total of 152 articles were found. Out of these, only studies in humans were included in this study, which narrowed the search down to 127 articles. We included articles for which only English full text was available that were 93 in number. We focused on articles that were based on subjects between the ages of 6–24 years (children, adolescent, and young adult), thus further narrowing our selection of studies to only 72 in number. We excluded articles based solely on advanced stages of OCD. We also excluded articles that were predominantly focused on injuries to ligaments, menisci, and other such structures, not directly pertaining to osteochondritis. Twenty five articles were shortlisted; out of which only those published in the last two decades were included for the review of the literature, giving us a final list of 18 articles [Figure 1]. All articles were reviewed for an in-depth study of the etiology, pathology, clinical presentation, evaluation, and management of early OCD in young athletes.

Etiology

The exact etiology of juvenile osteochondritis dissecans (JOCD) still

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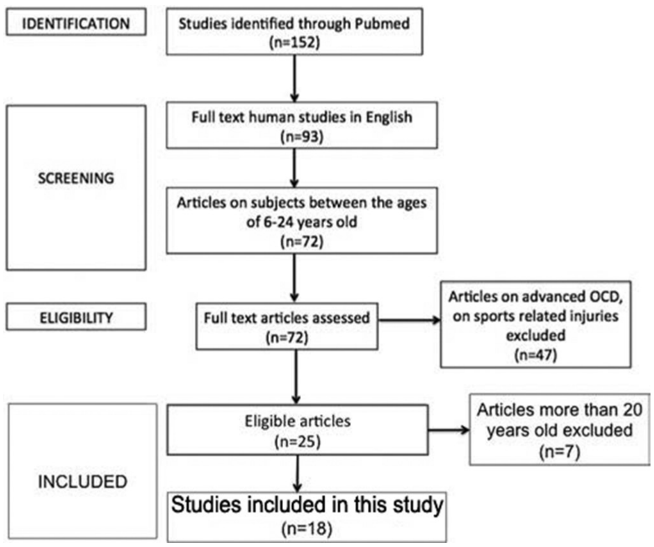

Figure 1: Flowchart showing the process of selecting studies for the review of literature

remains unknown. The three most well-recognized etiologic factors are repetitive trauma, ischemia, and genetics.[6] Limb malalignment, presence of lateral discoid meniscus, and inflammatory pathologies are other factors that are thought to contribute to the development of OCD.[7,8]

Repetitive stress, especially in young athletes, is one of the most accepted causes of JOCD. Repetitive cyclical stress through a joint may lead to chondral injury and possible vascular damage, leading to ischemia. It has also been postulated that JOCD lesions result from repetitive stress to the growth plate of the secondary ossification center that lies just between the articular cartilage and its supporting bone in the epiphysis.

OCD of the capitellum is a well-defined condition in adolescent javelin throwers, gymnasts, and weightlifters.[9] During valgus loading, the radiocapitellar joint carries the majority of the force across the elbow and provides axial stability. During late cocking and acceleration phase of throwing, there is compressive force on the lateral aspect of elbow. During the follow through phase, there are shear forces across the joint.[10] These motions are repetitive in athletes and are thought to underlie the pathologic process of OCD development. Microtrauma from compressive and shear forces sustained at the radiocapitellar joint during such activities may lead to microvascular injury and eventually to OCD.

Paget described loss of blood flow as an etiological factor.[11] In skeletally immature patients, blood supply to the capitellum is provided by very few end vessels posteriorly, leaving the epiphysis vulnerable to vascular insufficiency.[12] Most histological studies support "ischemic theory"due to the presence of osteonecrosis.[13,14] However, few studies have found rich blood supply and high percentages of viable chondrocytes in detached fragments.[15,16] Ischemia hypothesis forms the basis for some of the treatment options such as drilling and microfracture.

Mubarak found an autosomal dominant pattern of inheritance.[17] However, Petrie refuted this, citing a lack of familial inheritance.[18] As yet, there is no conclusive evidence backing specific genes or gene products in the development of OCD lesion.

Malalignment of the lower limb leading to mechanical axis deviation would increase strain on specific aspects of the joint. Valgus alignment has been associated with lateral condyle lesions, whereas varus alignment has been associated with medial condyle lesions.[7]

Clinical assessment

Patients usually present with activity-related pain and stiffness, which gradually worsens. Dominant extremity is affected. Occasionally, clicking, locking, and catching might be present. These symptoms point toward the presence of loose bodies.

Radiocapitellar OCD patients have tenderness over radiocapitellar joint, with associated crepitus during pronation and supination. Terminal 15°–30° of extension might become restricted. Radiocapitellar compression test can become positive, where active pronation and supination with elbow in extension produces pain.[19]

Knee OCD presents with nonspecific knee pain, effusion, catching, locking, and muscle atrophy. Tenderness is usually present at medial femoral condyle, owing to the fact that the lateral surface of the medial femoral condyle is the most common site for OCD of knee. Wilson's sign, pain on extension and internal rotation, is no longer considered specific to OCD.[20]

Imaging and investigations

Initial imaging for OCD elbow includes three-view plain films of the elbow: extension anterior-posterior (AP), 45°-flexion AP, and lateral. Initial radiographs may not show any abnormality. However, later findings include lucencies, flattening, sclerosis, and fragmentation along with intraarticular loose bodies.[19]

For the knee, since most lesions are located posteriorly, tunnel or notch view radiographs are required [Figure 2]. The lesions appear as dark bone deficient areas just beneath articular surface. However, radiographs have low sensitivity for early OCD lesions.[21]

Technetium-99 m diphosphonate quantitative bone scans were also tried in the past for osteochondritis but was demonstrated to have only limited prognostic significance.[22] In addition, the tracer from the bone scan persists in the lesion for a long time even after healing of the lesion and hence limits the ability of bone scan to determine resolution of the lesion.[23]

Magnetic resonance imaging (MRI) is the best imaging modality and diagnostic method of choice for evaluating

OCD [Figure 3]. The articular cartilage can also be visualized and assessed on MRI. It can demonstrate early stage lesions when radiographs may appear normal. The earliest findings on MRI are low-signal-intensity changes on T1-weighted imaging with normal T2 imaging. Changes are seen on both T1 and T2 imaging with progression of the lesion.[24] Gadolinium contrast enhancement of the lesion suggests vascularity of the fragment and good viability. MRI also helps in identifying poor prognostic factors such as bone cysts, subarticular high-signal lines, and articular fissures.[10]

Lately, ultrasound has garnered attention as a screening tool. It can show loss of smooth articular surface, which is a good indicator of osteochondral lesion, with reportedly 100% positive predictive value.[25] In the hands of an experienced operator, ultrasound can not only identify lesions but also provide information on stability of the lesion.[26]

Arthroscopy is widely considered to be the gold standard for the assessment of articular cartilage and detachment of subchondral bone.[27] However, for early lesions, where articular cartilage may not be defective, arthroscopy findings may be falsely negative. MRI is more sensitive for early stage lesions.

Arthroscopic evaluation of osteochondritis lesion is prone to interobserver and intraobserver variations. Ultrasound arthroscopy (UA) is generating interest for objective intraoperative assessment of cartilage and subchondral bone. Quantitative ultrasonography detects an increase in articular cartilage surface roughness, degradation of superficial collagen, changes in subchondral bone mineralization, and cartilage healing after surgical repair.[28] Ultrasound catheter is inserted into the joint through conventional portals. US and arthroscopy videos were synchronously recorded. US parameters for cartilage and subchondral bone characteristics are measured and combined to perform cartilage grading. UA has the advantage of visualization of an OCD lesion not detected by conventional arthroscopy. US-guidance can also aid retrograde drilling and decrease the need for fluoroscopy.[29]

Classification

Plain radiography is not optimal for staging of lesions due to inadequate assessment of articular cartilage; it is used extensively to assess healing progression. MRI is more accurate for classifying OCD lesions. Dipaola *et al*. classified OCD by correlating radiographs, MRI, and arthroscopic findings [Table 1].[30] MRI and arthroscopy together can help differentiate between stable and unstable lesions. De Smet *et al*. described four signs of instability [Table 2].[31]

Management

Treatment of OCD has come a long way from the era of open surgical exploration and debridement to arthroscopic

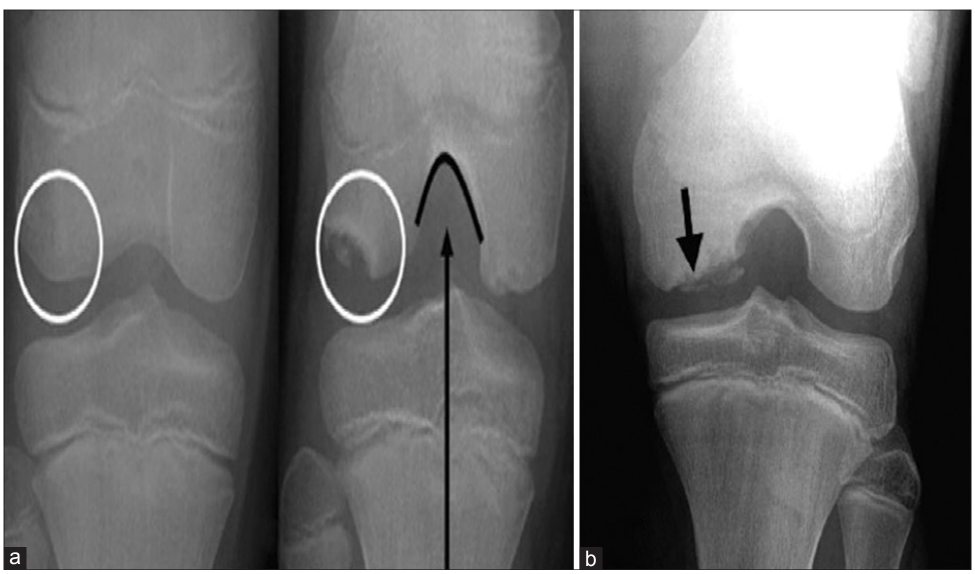

Figure 2: (a) Anterior-posterior and notch views of the same patient. The lesion (white circle) cannot be seen on the anterior-posterior radiograph. The lesion is well visualized on the notch radiograph. (b) Radiograph of an osteochondritis dissecans lesion showing lucency in subchondral region

Table 1: Classification of osteochondritis dissecans

Stage	Arthroscopy	MRI	Radiography
I	Irregularity and softening of cartilage	Low-signal changes	No visible fragment
II	Articular cartilage breached, fragment not displaceable	Low-signal rim behind fragment	Fragment attached
III	Displaceable fragment but attached with some cartilage	High signal changes behind fragment	Undisplaced fragment without attachment
IV	Loose body	Loose body	Displaced fragment

MRI=Magnetic resonance imaging

stem cell implantation. Stage I OCD lesions are stable lesions with minimal cartilage changes, and hence, the aim of treatment is healing of the lesion with early return to sports in professional athletes. The main debate on the management of Stage I OCD in athletes is about which lesions will nonoperatively and which ones will require surgical intervention. This decision mainly rests on the age of the patient. Healing potential of the lesion is good in patients with open physis. Success rate of nonoperative treatment in patients with open physis and stable lesions is reported to be between 50% and 100%.[27,32-37]

Apart from age and lesion staging, the size and site of the lesion has also been shown to influence healing potential. Small longitudinal diameter and surface area of the lesion as measured on MRI are more likely to heal by nonoperative means.[34,35] Lesions at atypical sites also show poor healing potential.[38]

The treatment for a stable JOCD lesion remains controversial because the condition is rare, the success rate of various treatments is unknown, the progression or healing of the condition is slow, and there are no uniform criteria to determine success. In addition, symptoms often resolve before radiographic signs of resolution, which leads to poor treatment compliance and loss to followup.[34]

Nonoperative management

Most authors agree that small stable lesions, in young patients with open growth plates show greatest potential for healing by nonoperative methods. Nonoperative treatment

Table 2: Signs of instability of lesion on magnetic resonance imaging

Signs of instability	Description
Focal osteochondral defect	A defect in cartilage and subchondral bone. The defect is filled with joint fluid. Pathognomic sign
Articular fracture	High-signal fluid passing into the lesion reflects visualization of the articular fracture indicating an unstable lesion
Subchondral cyst	Fluid-filled cyst of 5 mm or greater in diameter. These cysts are caused by intrusion of joint fluid or cancellous bone resorption
Line of high-signal intensity between the lesion and bone	Suggests joint fluid seeping in between lesion and underlying bone

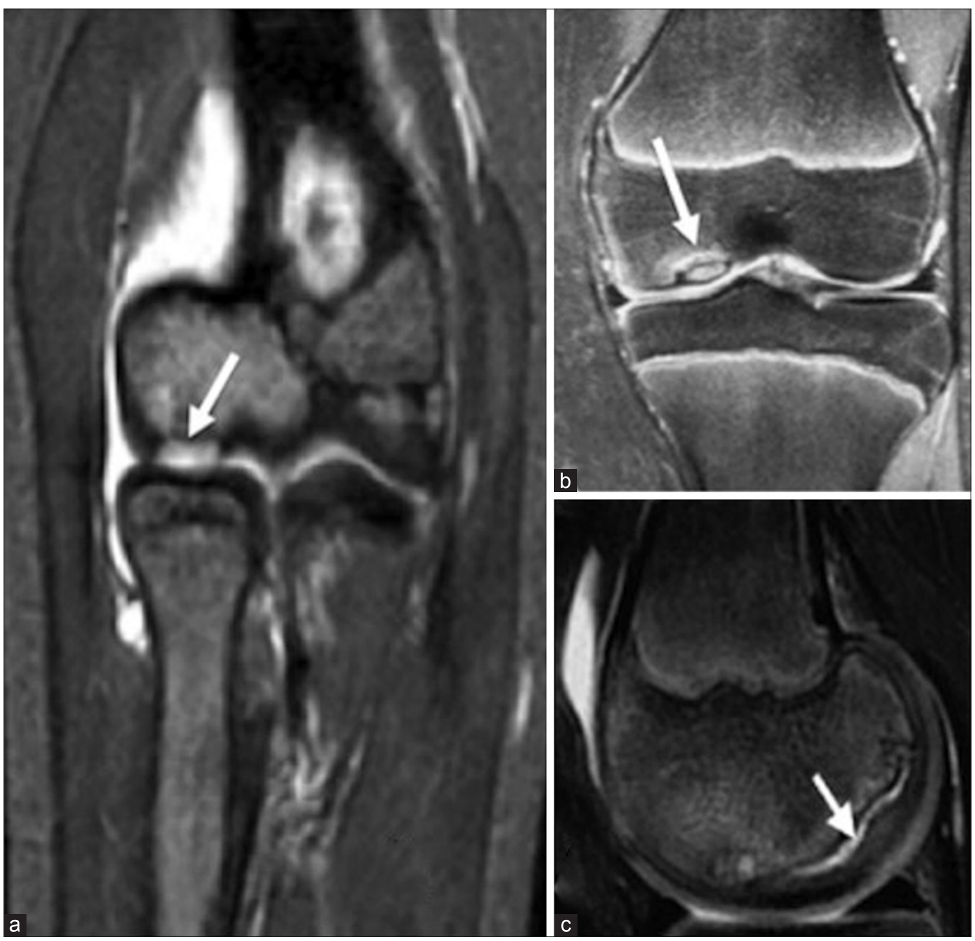

Figure 3: (a) T2-weighted coronal magnetic resonance imaging elbow, showing an osteochondritis dissecans lesion of the capitellum. (b) Coronal magnetic resonance imaging of juvenile osteochondritis dissecans lesion clearly demarcated from underlying subchondral bone and an intact articular mantle. (c) Magnetic resonance imaging showing a high-signal line at the interface between the osteochondritis dissecans lesion and its bed indicating an early deep separation at the bone-cartilage junction, which would not be seen on arthroscopy

involves immediate cessation of aggravating activities.[39] Alternate forms of exercise can be encouraged such as swimming, stationary bikes, deep-water running, and other nonimpact activities.[40]

Controversy exists regarding the duration of immobilization and speed of rehabilitation. Authors who focus on subchondral bone argue that the limb should be protected in a cast or immobilizer and treated as a fracture. Conversely, authors focused on articular cartilage cite the role of continuous motion. The use of continuous passive motion device or repetitive active-assisted range of motion may help to nourish the articular cartilage. Ahmad *et al*. suggested the use of a hinge elbow brace for 1–6 weeks to allow intermittent range of motion exercises and hence prevent stiffness.[41] Greiwe *et al*. recommended only rest, without immobilization.[19]

For OCD knee, immobilization may be required for 4–16 weeks by means of cylindrical cast, hinged brace, unloader-type brace, or ambulatory aids. Immobilization of more than 16 weeks can lead to detrimental effects.[42] There are still no established guidelines for the duration of rest, immobilization, and allowable range of motion. The American Academy of Orthopaedic Surgeons clinical practice guideline was also unable to recommend any one particular form on nonoperative treatment.[43]

Some authors suggest a 3-phase nonoperative management for OCD [Table 3].[23] The first phase involves knee immobilization for 4–6 weeks, with crutch-protected partial weight-bearing gait. At the end of this period, the patient should be pain free. In phase 2 (weeks 6–12), weight bearing as tolerated is permitted without immobilization. A rehabilitation program is initiated emphasizing knee range of motion, quadriceps, and hamstring strengthening exercises. Electrical stimulation can facilitate muscle strengthening. Phase 3 can begin, if there are radiographic and clinical signs of healing at 3–4 months after the initial diagnosis. This includes supervised initiation of running, jumping, and sports readiness activities. A gradual return to sports with increasing intensity is allowed in the absence of knee symptoms.

Table 3: Rehabilitation protocol for nonoperative management of osteochondritis dissecans

Phase	Knee	Elbow
Phase I (4-6 weeks)	Immobilization	Immobilization
	Valgus unloader brace	Hinged elbow brace
	Crutch-protected partial weight bearing	
Phase II (6-12 weeks)	Weight bearing as tolerated	Isometric exercises
	Closed chain exercises	Isotonic exercises
	Cycling, swimming	Gentle ROM
	Aquatic therapy	
	Muscle strengthening	
Phase III (3-6 months)	Supervised running	Eccentric exercises
	Supervised jumping	Plyometric exercises
	Pivoting	Interval throwing

ROM=Range of motion

Most authors report that athletes that respond to conservative treatment may start gentle sports at 3–4 months and return to competitive sports at 6 months.[32]

Younger patients are likely to be less compliant, and hence, immobilization may be more beneficial in them. Patients who experience symptoms even in daily activities may require a slower and stricter rehabilitation protocol.[34]

Healing should be assessed at 6–8-week interval. Clinical assessment can be made on the basis of decrease in symptoms. Early radiographic and MRI healing can be seen as early as 4 weeks.[44] Progressive reossification is a sign of radiographic healing.[34] Reduction in size and reduction in high-signal intensity around the lesion are signs of healing seen on MRI.[33]

Operative management

Operative treatment in Stage I OCD should be considered in the following situations:[45]

1. Skeletally mature patients
2. Patients approaching physeal closure
3. Failure of nonoperative management.

Surgical techniques for OCD of the knee can be classified as reparative, restorative, and palliative. Reparative techniques include transarticular and retroarticular drilling, microfracture, open reduction or arthroscopic-assisted reduction, and fixation. Restorative techniques include autologous chondrocyte implantation and auto or allograft transplantation into the osteochondral lesion. Palliative techniques including loose body removal or debridement of the defect.[46] Restorative and palliative techniques are reserved for advanced stage lesions and failed cases of reparative techniques.

For Grade I OCD, the aim of surgery is to stimulate healing of the lesion. This is achieved by drilling of subchondral bone either in a retrograde manner without articular penetration (transepiphyseal/retroarticular) or through the articular surface (transarticular).

Drilling through the epiphysis avoids articular surface violation but is associated with technical challenges of maintaining drill depth and placement accuracy. Posterior condylar lesions are more readily accessible through retroarticular technique.[47] In comparison, transarticular drilling is technically straightforward; however, it involves the penetration of the articular cartilage. These drill holes may not heal even a year later.[48]

For retroarticular drilling, patient is placed supine on a radiolucent operating table, with a tourniquet on the proximal thigh. The lower extremity is placed in about 20° of hip flexion, to facilitate fluoroscopic imaging.

Diagnostic arthroscopy is performed to inspect the OCD lesion. The C-arm is positioned in such a way that the lesion can be visualized in AP, notch, and lateral views. Under fluoroscopic guidance, a smooth Kirschner-wire (K-wire) of 1.6 mm (0.062 inch) diameter is inserted through a 1 cm skin incision. The K-wire is inserted just anterior to the midcondyle on the lateral view and in skeletally immature patients; it must begin just distal to the femoral growth plate. It is directed into the OCD lesion up to the bone-cartilage junction, avoiding penetration into the articular cartilage. Using this first K-wire as a guide, multiple K-wires can be inserted about 3 mm–8 mm away from each other. The K-wires can be over-drilled using a 3.2-mm-cannulated drill bit. The initial pass of the drill is stopped 10 mm short of the tip because the drill often pushes the wire into the joint. The drill is then backed out, and K-wire is removed. The blunt end of the wire is then inserted into the bone tunnel, and the drill is advanced over the blunt-tipped K-wire to penetrate into the OCD lesion, but not into any of the articular cartilage. The cannulated drill bit is disconnected from the drill and is removed with twisting by manually.[49] To accelerate healing, these tunnels can be filled with stem cells from iliac crest. Lately, electromagnetic navigation system assisted retroarticular drilling has shown promise and is being explored to eliminate the need for fluoroscopy.[50,51] For transarticular drilling, the patient is placed supine on the operating table, with a tourniquet applied on the proximal thigh. Diagnostic arthroscopy is performed through the anteromedial and anterolateral portals. The fibrillations of articular cartilage and softening of cartilage observed on probing identify the OCD lesion. Multiple drill holes are then made into the lesion using 0.45 mm–0.62 mm K-wires. Drilling is done from periphery to center and up to a depth of 2 cm. Oozing of blood and fat

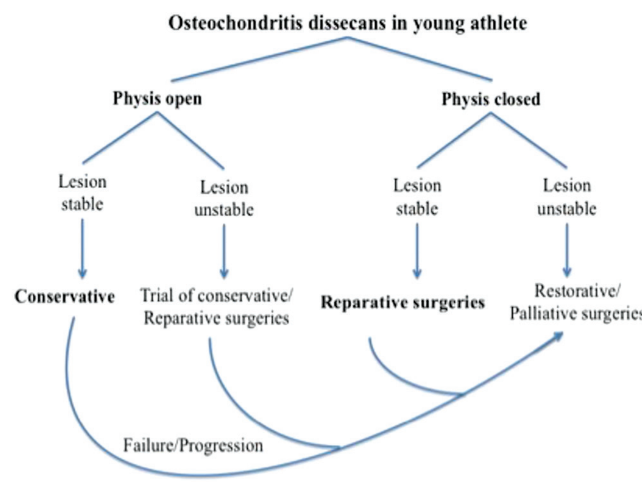

Figure 4: Protocol of authors preferred the treatment of osteochondritis dissecans

Table 4: Summary of recent studies on early capitellum osteochondritis dissecans in young athletes

Author, year	Cases	Average age (years)	Lesion	Intervention	Followup (years)	Outcome
Takahara *et al*., 1999[59]	24	13.3	Early and late	Conservative	5.2	None of the advanced lesions healed, half of the early lesions improved
Kiyoshige *et al*., 2000[60]	7	11-18	Late phase of the first stage	Closed-wedge osteotomy	7-12	Healing within 6 months and 6 patients returned to sports
Byrd and Jones 2002[61]	10	13.8	Grade I - 2 Grade II - 1 Grade IV, V - 7	Arthroscopic debridement	3.9	All patients had good outcome, but only 4 returned to previous level of sports
Takahara *et al*., 2007[62]	106	15.3	Stable - 36 Unstable - 70	Conservative treatment for stable lesions. Rest underwent surgical management	7.2	Good outcome in terms of pain and radiological healing
Matsuura *et al*., 2008[39]	176	12.8	Grade I and II lesions	Conservative	2	90% of Stage I healed and 53% of Stage II healed
Mihara *et al*., 2009[32]	39	12.8	Grade I - 26 Grade II - 8 Grade III - 5	Conservative for early operative for advanced	1.2	23 of 26 Grade I lesions healed
Jones *et al*., 2010[63]	22	13.1	Not mentioned	10 had arthroscopic drilling. Rest loose body removal or bone grafting	4	86% returned to sports
Schoch and Wolf 2010[64]	13	16	Grade I - 2 Grade II - 3	Trans-articular drilling	3.6	Improved functional status but only 40% could return to sports
Bojanić *et al*., 2012[65]	9	15	Grade II and III	Arthroscopic debridement and microfracture	5.3	Excellent outcome in 8 patients, good in 1. That patient was unable to return to previous sporting level
Tis *et al*., 2012[66]	13	13.1	Grade I -3 Grade II - 2 Grade IV, V - 8	Retroarticular and transarticular drilling	2	67% patients had no pain, and none had activity restrictions

Table 5: Summary of recent studies on early knee osteochondritis dissecans in young patients

Author, year	Cases	Average age (years)	Lesion	Intervention	Followup (months)	Outcome
Anderson *et al*., 1997[53]	24	13.6	Stable lesions	Trans-articular drilling	24	15 excellent, 7 good, 1 fair and 1 poor. 50% of skeletally mature patients did not heal
Ganley *et al*., 2002[54]	51	<18	Stable lesions	Trans-articular drilling		Curative in 83% of skeletally immature patients and in 75% skeletally mature patients
Donaldson and Wojtys 2008[67]	16	12	Stable lesions	Retroarticular drilling	21	12 had excellent outcome. One lesion did not heal. Rest had fair to good outcome
Adachi *et al*., 2009[58]	20	12	7 were Stage I and 13 were Stage II	Retroarticular drilling	12	Clinical improvement in all and radiographic healing in all except one. 75% returned to sports in 6 months
Edmonds *et al*., 2010[56]	59	13.4	Stage I and II	Retroarticular drilling	36	All showed radiographic healing and returned to sports. 7 required repeat surgeries
Boughanem *et al*., 2011[57]	34	<16	16 were Stage I or II, rest Stage III	Retroarticular drilling	48	Clinical and radiological improvement in all cases
Yonetani *et al*., 2012[55]	19	12	Stage I lesions	Trans-articular drilling	30	All patients returned to sports at 6 months. Only one had incomplete pain relief
Krause *et al*., 2013[33]	76	12	Stable lesions	Conservative	12	67% showed no healing

droplets from the drill holes indicates that adequate depth of drilling has been achieved.

A meta-analysis by Gunton *et al*. compared short-term outcomes after retroarticular and transarticular drilling.[48] They reported comparable healing rates (86% in retroarticular and 91% in transarticular at an average of 5.6 months and 4.5 months, respectively) after both types of procedures. No major complication of either procedure was reported.

Rehabilitation following drilling procedures usually involves 4–12 weeks of nonweight-bearing ambulation. Full range of motion is allowed immediately following drilling procedures. Unloader braces are recommended to help resume weight bearing and mobility while protecting the knee from overload. After 4–6 months, the patient may transition to a staged running program and after 6 months, to sport-specific activities such as pivoting, cutting, and jumping.

Bradley and Dandy performed transarticular drilling and noted healing on radiographs and pain relief in 9 of 11 knees within a 1-year period.[52] Anderson *et al*. performed transarticular drilling in 20 knees with open physis and in four patients with closed physis.[53] In the skeletally immature group, 90% lesions healed. In the skeletally mature group, 50% lesions healed at a followup of 5 years. At the Children's Hospital of Philadelphia, transarticular drilling was performed on 51 knees up to 18 years of age. It was curative in 83% of skeletally immature patients, in contrast to 75% in skeletally mature.[54] Lesions in atypical locations, multiple lesions, and underlying medical conditions are associated with inadequate healing. Yonetani revealed a healing rate of 79% following transarticular drilling for stable JOCD lesions of the knee.[55]

Edmonds *et al*. reported on 59 JOCD patients treated with retroarticular drilling.[56] The average time to return to sports was 3 months. Nearly 98 lesions had healed completely at 36 months. Similarly, Boughanem showed 94% healing rates after retroarticular drilling in stable JOCD.[57] Adachi *et al*. also reported 95% healing rate at an average of 4.4 months following retroarticular drilling for stable JOCD.[58]

Although most of these studies report excellent outcomes of drilling procedures. A closer look at the profile of patients that improved reveals that a high percentage of patients had open physis; hence, better healing potential and might have fared well on conservative treatment alone. This critical point perhaps exaggerates the benefit of drilling procedures. However, there is no denying that in patients with closed physis nonoperative treatment is unlikely to benefit. A summary of recent results of operative management of early OCD in young athletes is provided in Tables 4 and 5.

Conclusions

The management of OCD in a young professional athlete is based on early diagnosis and assessment of healing potential of the lesion. The healing potential is based on the age of the patient, status of physis, and stage of the lesion. Size and site of lesion also have a bearing on the healing potential. The ultimate aim for an athlete is early return to the previous level of competitive sports. For Stage I OCD (stable) lesions, we recommend initial nonoperative line of management in patients with open physis [Figure 4]. Case of progression of the lesion or failure of conservative treatment a reparative, restorative, or palliative surgical intervention can be done. For Stage I OCD lesions in patients with closed physis, we advocate reparative surgery either by means of retro or transarticular drilling. The technique of drilling can be chosen as per surgeons' preference and experience since both have comparative results.

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Conflicts of interest

There are no conflicts of interest

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