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OSTEOCHONDRITIS DISSECANS OF THE ELBOW

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SUMMARY

Osteochondritis dissecans of the elbow is predominantly located in the capitellum humeri and causes disability and pain in the throwing adolescent athlete. It refers to an acquired lesion of the subchondral bone with varying degrees of resorption, fragmentation, and sclerosis and potentially involves the overlying cartilage. It is typically observed in repetitive overhead or weight bearing sports. Although the etiology of the underlying pathological process is likely to be multifactorial secondary to repetitive stress, biomechanical mismatch or vascular supply, the true cause still remains unknown. The key diagnostic tool is magnetic resonance imaging, because it discovers early stages of the disease. Hence, early treatment of stable lesions can result in healing with later resumption of sporting activities. Unstable lesions or those failing non-operative therapy can be treated with various surgical interventions including arthroscopy with debridement and loose body removal. In situ fixation of unstable lesions or transplantation of osteochondral allografts harvested from the knee or rib provide new but promising techniques in the treatment of advanced cases.

Keywords: osteochondritis dissecans, elbow, treatment

ODDZIELAJĄCA MARTWICA KOSTNO--CHRZĘSTNA STAWU ŁOKCIOWEGO (OCD)

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STRESZCZENIE

Oddzielająca martwica kostno- chrzęstna stawu łokciowego (OCD) jest głównie zlokalizowane w główce kości ramiennej i powoduje utratę funkcji oraz ból u rzucającego dorastającego sportowca. Rozpoznanie odnosi się do nabytej zmiany kości podchrzęstnej o różnym stopniu resorpcji, fragmentacji, stwardnienia i potencjalnie obejmuje otaczającą chrząstkę. Zwykle obserwuje się to w przypadku powtarzających się obciążeń u sportowców wykonujących czynności ponad głową i dźwigających ciężary. Chociaż etiologia leżącego u podłoża procesu patologicznego może być wieloczynnikowa w następstwie powtarzalnego stresu, niedopasowania biomechanicznego lub zaopatrzenia w naczynia, prawdziwa przyczyna pozostaje wciąż nieznana. Kluczowym narzędziem diagnostycznym jest obrazowanie metodą rezonansu magnetycznego, ponieważ uwidacznia wczesne etapy choroby. W związku z tym wczesne leczenie niepostępujących zmian chorobowych może doprowadzić do wyleczenia, a następnie powrót do aktywności sportowej. Postępujące zmiany chorobowe lub niepowodzenie leczenia zachowawczego można leczyć operacyjne, w tym artroskopią stawu łokciowego z oczyszczeniem i usunięciem ciał wolnych. Operacyjna miejscowa stabilizacja postępujących zmian chorobowych lub przeszczep kostny z kolana lub żebra dostarcza nowych, ale obiecujących technik w leczeniu zaawansowanych przypadków.

Słowa kluczowe: oddzielająca martwica kostno- chrzęstna, staw łokciowy, leczenie

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Introduction

The first description of an Osteochondritis dissecans (OCD) of the elbow was given by Franz König in 1887 (König, 1887) (Figure 1). He had given a profound report of his observations and his pathophysiological interpretations on the occurrence of loose bodies found in joints. He concluded three ways by which loose bodies were created: First, direct trauma with an acute osteochondral fracture; second, multiple minimal trauma that develops into an osteonecrosis and subsequent fragmentation; or third, spontaneous development without any evidence of trauma that he termed "osteochondritis dissecans". In his description, a young 16 year old boy suddenly developed a pain free extensional deficit in his elbow accompanied by some crepitus with passive movement (König, 1887). He hypothesized that random parts of the joint surface could be released due to an unknown mechanism and that many of those loose bodies observed might be the result of this obscure process (König, 1887). Today, 130 years later, many contributing factors were researched but the exact pathophysiology is not clarified (Edmonds and Polousky, 2013). It is disillusioning, but Königs´s final statement in his 1887 paper remains true even today: "The etiology of the proposed pathological processes is still unknown." It is truly remarkable how König correctly speculated on the basic process when he had so little material available (Brand, 2013). At the current stage of knowledge, OCD is described as an acquired lesion of subchondral bone characterized by osseous resorption, collapse, and sequestrum formation. The articular cartilage can be involved in this process. It delaminates from the underlying bone but is unrelated to an acute osteochondral fracture of normal cartilage (Edmonds and Polousky, 2013).

Aim

This research paper presents current opinions on treatment of osteochondritis dissecans of the elbow.

Material and methods

Etiology

Many etiologies of OCD have been postulated including trauma, inflammation, genetics, vascular abnormalities, and constitutional factors. Because there was no conclusive explanation for his observations, König thought OCD to be the result of an inflammation (König, 1887). However, an inflammatory etiology could not be established by histologic studies (Barrie, 1980, 1984). Instead, necrotic areas are the main observation within the OCD lesions rather than inflammation. Therefore, ischemia was first proposed to be causative (Green and Banks, 1953). Subsequent studies found revascularization in partially detached OCD lesions and necrosis could not be demonstrated in intact

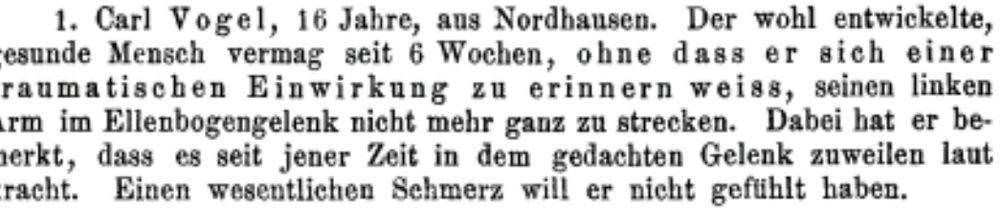
1. Carl Vogel, 16 Jahre, aus Nordhausen. Der wohl entwickelte, gesunde Mensch vermag seit 6 Wochen, ohne dass er sich einer traumatischen Einwirkung zu erinnern weiss, seinen linken Arm im Ellenbogengelenk nicht mehr ganz zu strecken. Dabei hat er bemerkt, dass es seit jener Zeit in dem gedachten Gelenk zuweilen laut kracht. Einen wesentlichen Schmerz will er nicht gefühlt haben.

Figure 1. Original text from Franz König´s publication "On loose bodies in the joints" from 1887: " 1. Carl Vogel – 16 years - from Nordhausen. This well-developed healthy man noted in the last 6 weeks, without remembering any trauma, that he could not extend his left arm at the elbow completely. He has noticed since that time in the joint sometimes pops loudly. He has had no significant pain."

OCD lesions (Milgram, 1978; Yonetani *et al.,* 2010). In most biopsies from the lesion viable osteocytes could be observed which led to the hypothesis that necrosis is a result rather than the cause of the detachment (Uozumi *et al.,* 2009). Familial inheritance was proposed to be autosomal-dominant but the link is weak and only 1.2% of first-degree relatives were found with OCD lesions on radiographic examination (Petrie, 1977). Although the mechanisms are unclear, the most prominent and commonly accepted etiology for OCD is a history of repetitive trauma. Particularly when associated with sports (Edmonds and Polousky, 2013). Subsequent studies have demonstrated an association between athletic activity and OCD. A multicenter study demonstrated that 55% of OCD patients were either regularly active in sports or performed "strenuous athletic activity" (Hefti *et al.,* 1999). However, evidence of repetitive trauma as the etiology of OCD is lacking. The anatomy of the radiocapitellar joint and blood supply to the capitellum are thought to play a significant role in the development of OCD. A cadaveric study evaluating the biomechanical characteristics of the radial head and the capitellum revealed that the stiffness of the capitellar articular surface decreased from medial to lateral (Schenck *et al.,* 1994). Furthermore, the central portion of the radial head was significantly stiffer than the lateral capitellum creating a biomechanical mismatch that could lead to increased strain on the lateral aspect of the capitellum during loading activities (Schenck *et al.,* 1994).

Axis malalignment and subsequent aberrant mechanical pressure was suggested to contribute to OCD formation in the knee (Jacobi *et al.,* 2010).

Another etiological concept claims the epiphyseal growth plate to be mainly causative in the OCD development (Edmonds and Polousky, 2013). With this concept, the lesion evolves over time and with patients age. At a specific time point during growth an injury to the endochondral epiphyseal growth plate is hypothesized to represent the crystallization moment of an OCD. After this injury, which could be single or repetitive, an aberrant development of only a portion of the epiphyseal growth plate is suggested. The uninjured region continues to ossify, while the injured region stops ossification completely or only temporarily. When ossification stops completely a cartilaginous OCD without any endochondral ossification is possible. When ossification is stalled temporarily either partial ossification or complete ossification can result over time (Edmonds and Polousky, 2013). The capitellar blood supply enters from the posterior aspect of the distal humerus by two arteries (Baker *et al.,* 2010; Greiwe *et al.,* 2010; Haraldsson, 1959). The combination of this vascular anatomy and the immature capitellum lacking substantial metaphyseal collateral flow creates a potential situation where blood flow can be disrupted in the setting of repetitive trauma (Baker *et al.,* 2010; Greiwe *et al.,* 2010).

Clinical presentation

Patients with capitellar OCD are usually between 11 and 17 years old and participate in repetitive overhead activities (Churchill *et al.,* 2016). It is a common cause of activity-related elbow pain and disability in adolescent throwing athletes, typically affecting the throwing arm. Skeletally immature children who have OCD can also be found incidentally on radiological examination because of another unrelated injury or in association with activity related unspecific joint pain. However, pain can also be related to idiopathic adolescent joint pain rather than associated with an OCD lesion. It affects primarily the capitellum because the radiocapitellar joint provides axial stability to the elbow with the capitellum transmitting approximately 60% of compressive forces across it (Kosaka *et al.,* 2013; Tis *et al.,* 2012). Lesions are also rarely seen in the radial head, olecranon, and the trochlea. Trochlear OCD is reported in only 22 cases

in english literature (Baker *et al.,* 2010; Miyake *et al.,* 2013). OCD must be distinguished from Panner's disease, which also involves the capitellum. Panner's disease is a self-limiting condition of osteochondrosis of the capitellum that primarily affects boys under 10 years of age without any history of trauma (Christopher *et al.,* 2006; Ahmad *et al.,* 2011; Baker *et al.,* 2010). In contrast, OCD is not self-limiting and the major clinical symptoms are elbow pain and restricted range of motion. These symptoms become increasingly pronounced as the disease progresses. Some present with mechanical locking or popping which is indicative for loose bodies. Effusion is not common and only present in less than 20% at presentation (Hefti *et al.,* 1999). On physical exam, patients most often have tenderness over the radiocapitellar joint and may lack 15–30° of extension (Churchill *et al.,* 2016). Similarly, a positive radiocapitellar compression test may occur, where active pronation and supination with the elbow in extension reproduces pain at the radiocapitellar joint (Churchill *et al.,* 2016). The prevalence of OCD of the humeral capitellum of young baseball players (14.5 ± 1.5 years) is reportedly at 3.4% and thereby twice as high as reported previously (Kida *et al.,* 2014). Players with OCD lesions began playing baseball at earlier ages, had played for longer periods, and had experienced more elbow pain. Many patients of this age continue playing sports without visiting a doctor despite their symptoms, and they often present for medical examination only after their injuries become serious. Asymptomatic or minimally symptomatic patients rarely visit medical institutions. In overhead throwing athletes, the elbow is subjected to valgus overload with significant compression and shear forces applied to the radiocapitellar joint between 30 and 90° of flexion, and with repetitive overhead throwing these may cause capitellar OCD (Kajiyama *et al.,* 2017).

Imaging

The mainstay of OCD diagnosis is imaging. Because many lesions can be asymptomatic until they separate from the joint surface, imaging is the key to an early diagnosis. Anteroposterior (AP) radiographs with the elbow in 45° of flexion is reported to be the best position to detect capitellar OCD (Kajiyama *et al.,* 2017; Takahara *et al.,* 1998). Due to differences in applied stress, capitellar OCD lesions in throwers are located more anteriorly compared with those seen in gymnasts who should be radiographed in full extension (Kajiyama *et al.,* 2017). Radiographs can show fissuring, lucencies, fragmentation, and change in the contour of the capitellum. These changes are usually seen in the antero-lateral aspect of the capitellum (Baker *et al.,* 2010; Greiwe *et al.,* 2010). Later imaging shows reossification which usually coincides with resolution of symptoms (Greiwe *et al.,* 2010; Ahmad *et al.,* 2011). Radiographic assessments have greatly evolved based on the advances in technology. Some authors recommended scintigraphy because it provided information regarding blood flow to the lesion. However, it fails to provide detailed information about articular cartilage. OCD lesion classification can be done according to four schemes: Minami, Berndt and Harty, Ferkel and Sgaglione, and the Anderson classification (Table 1) (Claessen *et al.,* 2015). Although the Minami classification seems to be the most reliable it has fair interobserver agreement and none of them is reliable when applied without magnetic resonance imaging (MRI) (Claessen *et al.,* 2015). A routine radiographic examination of the elbow has limited sensitivity for detecting osteochondritis dissecans of the capitellum and associated intraarticular loose bodies with only 66% sensitivity (Figure 2) (Kijowski and De Smet, 2005). Therefore, MRI has become the diagnostic test of choice (Figure 3). It delivers additional information concerning cartilage health including fissuring, thickness and

water content. It is a noninvasive method to assess size, location, and character of the OCD lesion very early. It can demonstrate early-stage lesions when radiographs may appear normal (Baker *et al.,* 2010; Greiwe *et al.,* 2010; Zbojniewicz and Laor, 2014). Further, it can give an estimation of lesion stability by evidence of linear high-intensity signals on T2 sequences between the lesion and parent bone. An unstable lesion is defined by either fractured cartilage or separation of the underlying subchondral bone. The earliest MRI findings are uniform low-signal-intensity changes in the superficial capitellum on T1-weighted imaging with normal T2 imaging. As the lesion progresses, changes are seen on T1 and T2 imaging (Baker *et al.,* 2010; Greiwe *et al.,* 2010; Zbojniewicz and Laor, 2014). Gadolinium contrast enhancement of the OCD lesion suggests vascularity of the fragment and good viability (Baker *et al.,* 2010). Lesional stability is the key differential for further treatment and prognosis. Stable lesions are believed to have a better likelihood of relief of symptoms and resolution of radiographic findings. A stable OCD lesion is typically considered for non-operative management, whereas unstable lesions are better treated with surgical intervention. A high T2 signal line between the lesion and the normal bone is the most predictive factor of instability.

On T2-weighted MR images four findings correlate with lesional instability when compared with arthroscopy (Edmonds and Polousky, 2013):

1. High T2 signal line beneath the lesion
2. Focal, fluid filled osteochondral defect
3. Thin high T2 articular cartilage fracture line
4. Subchondral cysts

The diagnostic accuracy for instability raises up to 85% when both, the high T2 signal separating the lesion and a breach of the articular cartilage on T1-weighted images can be seen (Edmonds and Polousky, 2013).

The presence of all criteria was 100% sensitive for unstable lesions (Jans, Ditchfield, Anna, Jaremko, and Verstraete, 2012). The specificity was also 100% in adult OCD but in childhood OCD there was only 11% specificity for instability (Edmonds and Polousky, 2013). Satake *et al.* (2013) also recently evaluated the ability of imaging studies, including MRI, to predict intraoperative stability of lesions and found that

Table 1. Four classification schemes for OCD based on plain radiographs and CT scans. The Minami classification is reported to be the most reliable but interobserver agreement is only fair. None of them seems to be reliable enough when applied without MRI.

Minami classification	Grade I: localized flattening or radiolucency	Grade II: non-displaced fragment	Grade III: displaced or detached fragment		
Berndt and Harty taging	Stage I: small area of subchondral bone compression	Stage II: osteochondral fragment partially detached	Stage III: osteochondral fragment completely detached but not displaced	Stage IV: osteochondral fragment completely detached and displaced	Stage V: subchondral cyst present
Ferkel and Sgaglione staging	Stage I: intact roof/ cartilage with cystic lesion beneath	Stage IIA: cystic lesion with communication to the surface	Stage IIB: open surface lesion with overlying fragment	Stage III: non-displaced fragment with lucency underneath	Stage IV: displaced fragment
Anderson ostochondritis dissecans staging	Stage I: early – subchondral bone flattening in the epiphyseal plate before growth plate closure	Stage IIA: stable – subchondral cyst present	Stage IIB: unstable – inclomplete separation of the osteochondral fragment due to repetitive force	Stage III: unstable – effusions (fluid around an undetached, undisplaced osteochondral fragment)	Stage IV: terminal – complete separation (detachment of osteochondral fragments, mechanical irregularities and formation of loose bodies

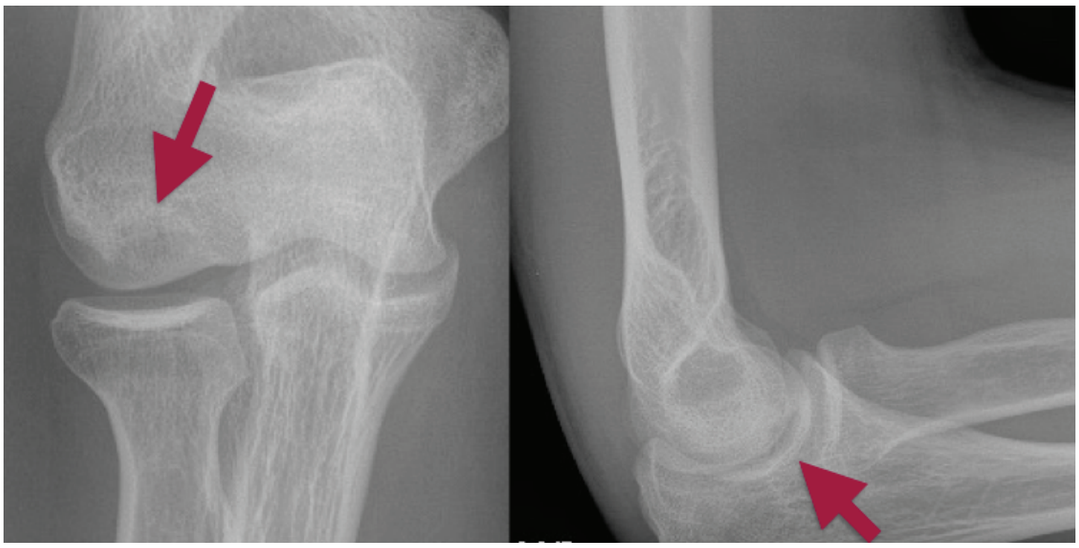

Figure 2. A 16-years old patient with AP and lateral radiographs of the elbow. The defect in the capitellum is difficult to visualize (arrows).

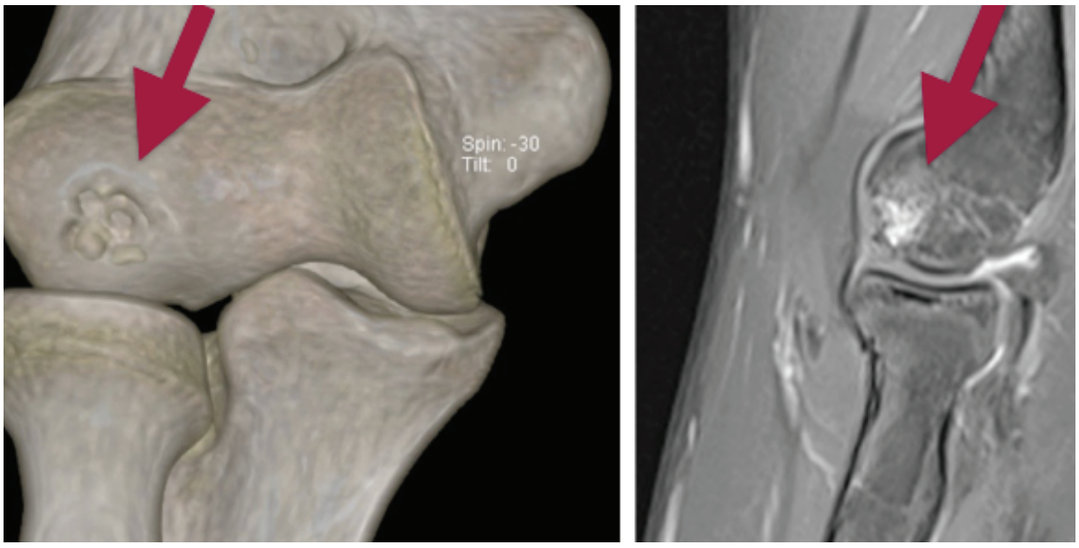

Figure 3. CT scan (left) and MRI (right) of the same patient shown in Figure 2. On both, the CT scan and the MRI the defect (arrows) can be visualized.

preoperative MRI directly related to the intraoperative stability of lesions. As such, MRI should still be considered the best imaging tool available for evaluating OCD lesion stability. Itsubo *et al.* (2014) provided a MRI staging scheme, which provides accurate and reliable evidence for estimating the arthroscopic International Cartilage Repair Society (ICRS) classification for lesion stability. Ultrasound can be used to detect an OCD lesion cost effectively and quick in the clinical routine. The method was described by Harada *et al.* for visualizing the capitellum (Harada *et al.,* 2006; Kida *et al.,* 2014). The positive predictive value was reported to be 100% and the authors suggested that a distinctive loss of the smooth articular surface on ultrasound was a good indicator of an osteochondral lesion (Kida *et al.,* 2014). In uncertain cases or when stability has to be verified an arthroscopy is the diagnostic method of choice (Figure 4).

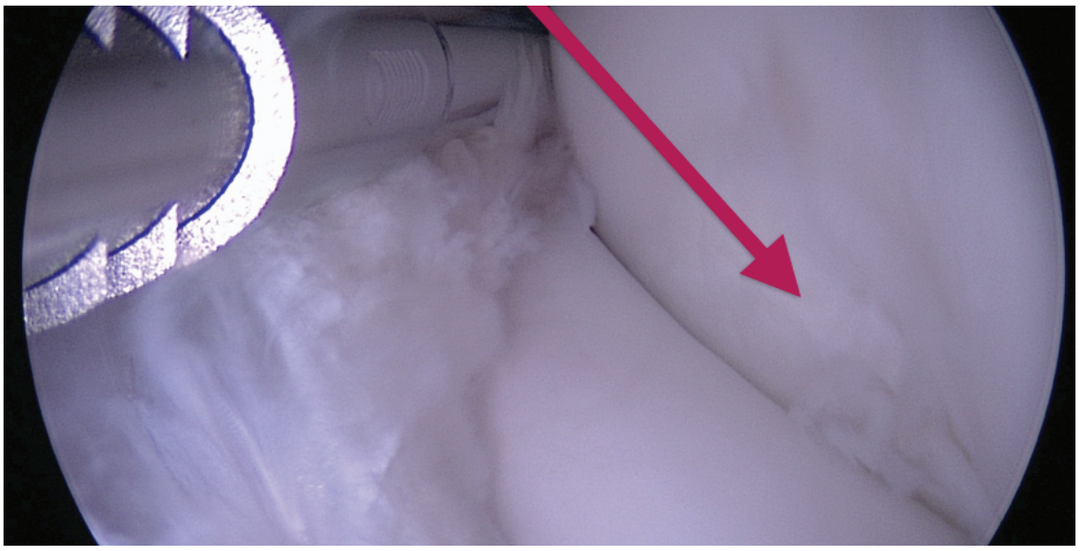

Figure 4. An arthroscopic image of the capitellum visualized from the ulnar portal representing the same patient shown in Figures 2 and 3. The arrow indicates the OCD lesion in the capitellum.

Results

Treatment

There is common consensus that treatment should be based on skeletal maturity and lesion stability. There are numerous classification systems that respect these two major points. Non-operative management is commonly accepted as the first-line treatment for stable OCD lesions in children with a reported success rate of 50%–94% (Edmonds and Polousky, 2013). But the therapy regime is inconsistent and involves simple activity modification, bracing and casting. It should be continued for at least 3 to 6 months before opting for any operative treatment (Chambers *et al.,* 2011; Edmonds and Polousky, 2013; Wall and Von Stein, 2003). Takahara *et al.* found that stable lesions occurred in patients who had an open capitellar physis, localized flattening or radiolucency, and good elbow range of motion at initial presentation whereas patients with unstable lesions (closed capitellar physis, fragmentation on X-rays, and a range of motion lacking >20°) had better outcomes with operative intervention (Takahara *et al.,* 2007).

Treatment success is not very well defined. Most studies assessed radiographic outcomes, others declared healing when the symptoms have resolved. However, no study to date has defined an outcome measure for OCD lesions (Edmonds and Polousky, 2013). Because the pathophysiology of OCD is not fully understood treatment modalities are based merely on unproven hypotheses.

Conservative

Bearing this in mind, the rates of healing for non-operative treatment have varied from 50% to 94% (Edmonds and Polousky, 2013). Generally it involves immediate cessation of aggravating activities that load the radiocapitellar joint, i.e., throwing, gymnastics, weightlifting (Churchill *et al.,* 2016). Some authors advocate the use of a hinged elbow brace for a period of 1–6 weeks in the initial resting period to allow intermittent range of motion exercises to prevent stiffness, while others recommend rest without immobilization (C. S. Ahmad *et al.,* 2011; Greiwe *et al.,* 2010). Most athletes who respond to conservative management may start gentle overhead throwing at 3–4 months with return to play at 6 months (Churchill *et al.,* 2016). In patients who present with abnormal T1 and T2 signals a follow-up MRI at 2–3 months is advocated. If there was no improvement after 3–6 months of conservative treatment, then surgery can be considered (Greiwe *et al.,* 2010).

The indication for surgery is generally set when the lesion is either unstable or stable but failed non-operative treatment or when loose bodies leading to mechanical symptoms are present. Surgery includes various methods of debridement, drilling, fixation and grafting. Arthroscopic methods are most often preferred because debridement, drilling or even lesion fixation can be securely preformed.

Arthroscopic loose body removal, drilling, microfracture and abrasion chondroplasty

Drilling is hypothesized to stimulate neovascularization and ossification of the cartilaginous lesion as a result of stem cell migration (Edmonds *et al.,* 2010). The healing rates range from 82% to 98% with arthroscopic drilling regardless whether success is defined as radiographic or symptomatic (Edmonds and Polousky, 2013). Whether the drilling should be performed transarticular or retrograde is not clear. Retrograde techniques do not violate the cartilage but they can be demanding because fluoroscopy is necessary to position the drill exactly (Edmonds *et al.,* 2010). A 1.6mm K-wire is drilled retrograde from the posterolateral, distal humerus into the OCD lesion under fluoroscopic guidance taking care not to violate the articular cartilage (Churchill *et al.,* 2016).

When the cartilage is unstable, drilling could be done directly without violating the overlying loose cartilage. However, surgical fixation of the cartilage should be performed.

Loose bodies can be removed arthroscopically and abrasion chondroplasty is a debridement of the defect until a stable cartilage rim is reached. However, for patients with greater than 50% of the capitellar surface involved the outcome is inferior when compared to reconstructive procedures (Takahara *et al.,* 2007). Additinally, those with the lesion at the lateral capitellum and thereby compromising the lateral column should not undergo debridement only (Churchill *et al.,* 2016). All arthroscopic procedures including microfracture, retrograde drilling, chondroplasty and loose body removal are reported to remain painful in 33% of patients (Tis *et al.,* 2012). Arthroscopy alone does not seem to be the ideal treament for lesions greater than 50% of the capitellar surface, those that extend into the lateral capitellum, and patients with high athletic expectations (Churchill *et al.,* 2016).

In lesions without lateral column extension microfracture can be used even when the cartilage is disrupted. After the lesion has been debrided a K-wire (1.1 or 1.6mm) is used to create holes within the lesion to stimulate marrow healing and a fibrocartilage response (Churchill *et al.,* 2016; Lewine, Miller, Micheli, Waters, and Bae, 2016). Microfracture treatment is reported to be successful in traumatic knee osteochondral defects (Bedi, Feeley, and Williams, 2010), but in OCD the subchondral bone is believed to be the primary site of pathology. Therefore, microfracture cannot adequately restore the subchondral support and joint congruity (Edmonds and Polousky, 2013). The healing response assessed with MRI showed fibrocartilage growth restoring articular congruity in 80% of patients (Wulf *et al.,* 2012). Return to any sport occurs reportedly in 86% of patients and return to the primary sport in 67% (Bojanic *et al.,* 2012; Churchill *et al.,* 2016; Lewine *et al.,* 2016). Microfracture and retrograde drilling remain good options with consistent, reproducible results in shallow OCD lesions without lateral column involvement (Churchill *et al.,* 2016).

In situ fixiation

Unstable Lesions can be fixated in situ with various methods. Metallic compression screws which are used in the knee are usually too bulky for the capitellum and they tend to fail after long term and often have to be removed in a second procedure (Gomoll *et al.,* 2007; Johnson *et al.,* 1990).

Usually, headless compression screws are used with good results in the knee and show a high healing rate of up to 100% (Edmonds

and Polousky, 2013). In the elbow this can render to be impossible because the access via safe portals is limited and the lesion cannot always be approached in the proper direction (Gancarczyk *et al.,* 2015). Bioabsorbable implants can have advantages because there is no need for screw removal and a better visualization of healing in MRI. Large, unstable OCD lesions with a mean width and thickness of 12.0 and 5.4 mm, respectively were reported to heal in 77% with absorbable implants (Hennrikus *et al.,* 2015). Fixations with hydroxyapatite (HA)/poly-L-lactate acid (PLLA) threaded pins were reported to deliver excellent results after arthroscopic in situ fixation in 18 cases with a 94% return-to-sports at 3-year follow-up with 15 of them at the same level or higher (Uchida *et al.,* 2015). However, these implants can get loose which leads to opposing cartilage damage and they seem to promote synovitis (Friederichs *et al.,* 2001). In cases where fixation is impossible (e.g. lesions greater than 50% of the articular surface), osteochondral transplantation should be considered since at this size patients predispose to osteoarthritis (Uchida *et al.,* 2015).

Osteochondral autograft transplantation system (*OATS*)

Another method is to implant an osteochondral plug into the defect, which can offer both biologic and mechanical stability. Radiologic healing rates are high with 66% to 95% and the outcomes are promising (Fonseca and Balaco, 2009; Kobayashi *et al.,* 2004; Miura *et al.,* 2007). The plug is harvested from non-weight-bearing portions of the knee via a small arthrotomy. Average cartilage depths in the knee are thicker than in the elbow *et al.* sites. However, the best fitting areas recommended for harvest are the posterior aspect of the medial femoral condyle and the distal-most aspect of the anterior-lateral femoral condyle (Schub *et al.,* 2013).

OATS seems to be a good option when a large, unstable lesion is present. Particularly when the lesion affects more than 50% of the articular surface, and when it extends into the lateral border of the capitellum and involves the lateral column. The defect in the capitellum is prepared by coring out the lesion to a depth of approx. 10 mm (Zlotolow and Bae, 2014). The donor plug is impacted until flush with surrounding cartilage (Figures 5 and 6). This technique has the advantage of replacing the defect with hyaline cartilage (Ahmad and ElAttrache, 2006; Zlotolow and Bae, 2014). The return to the previous competitive level of throwing is reached by a mean of 7 months postoperatively (Maruyama *et al.,* 2014). All patients achieved graft incorporation by an average of 3.8 months, and all patients had improved outcome scores with 91% reporting no pain at follow-up (Figure 7) (Maruyama *et al.,* 2014). One large plug of 10 mm, is recommended by some authors over mosaicplasty for greater graft support which is supposed to contribute to a quicker return to play (Lyons *et al.,* 2015). However, donor site morbidity can be a problem in OATS. A recent review revealed knee pain during activity in 7.0% and locking sensations in 0.8% (Bexkens *et al.,* 2017).

Arthroscopic OATS can be feasible but requires adequate recipient tunnels. They can be created in lesions that are as high as 75° to 80° anterior to the humeral shaft encompassing most clinically relevant lesions (Gancarczyk *et al.,* 2015). This is significant given that the majority of lesions occurs 45–60° anterior to the humeral shaft. Achieving perpendicularity in lesions more anterior to these values seems to be impossible due to anatomic constraints of the radial head in maximal elbow flexion (Gancarczyk *et al.,* 2015).

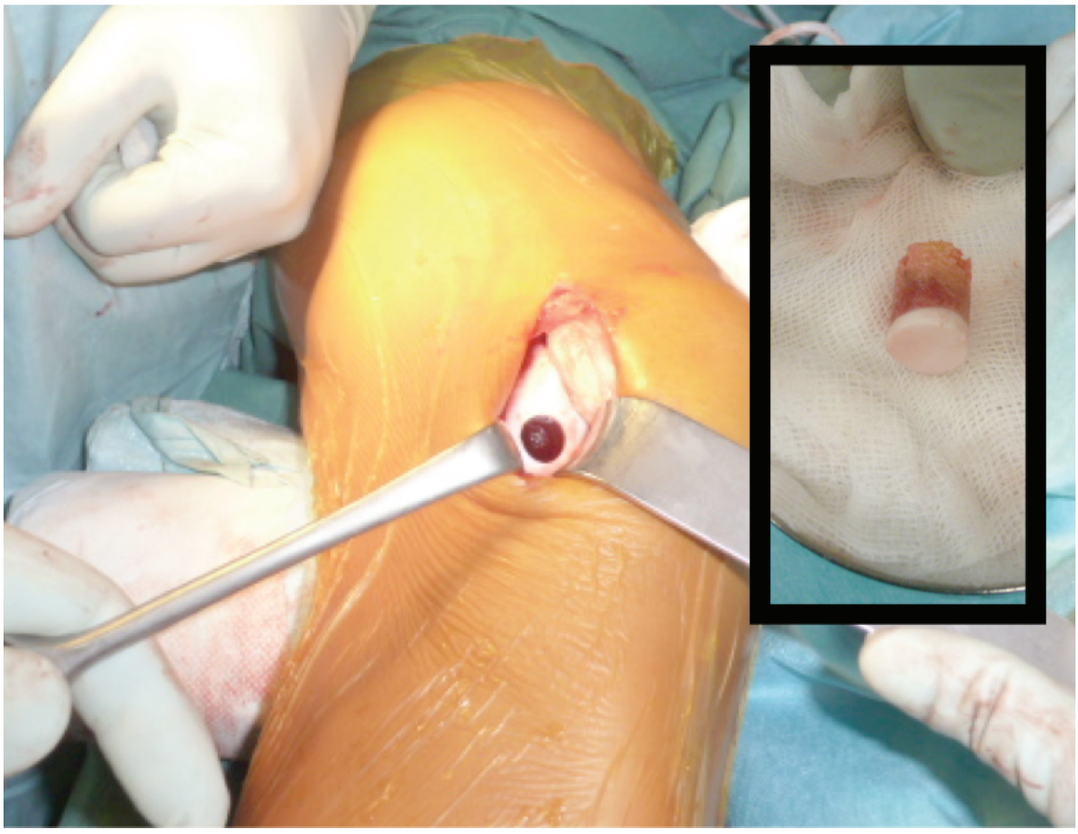

Figure 5. OATS procedure in the capitellum. The OCD lesion is drilled in the capitellum with a 10mm trepan drill. The same drill size is used to harvest the donor plug from the knee (small upper right image).

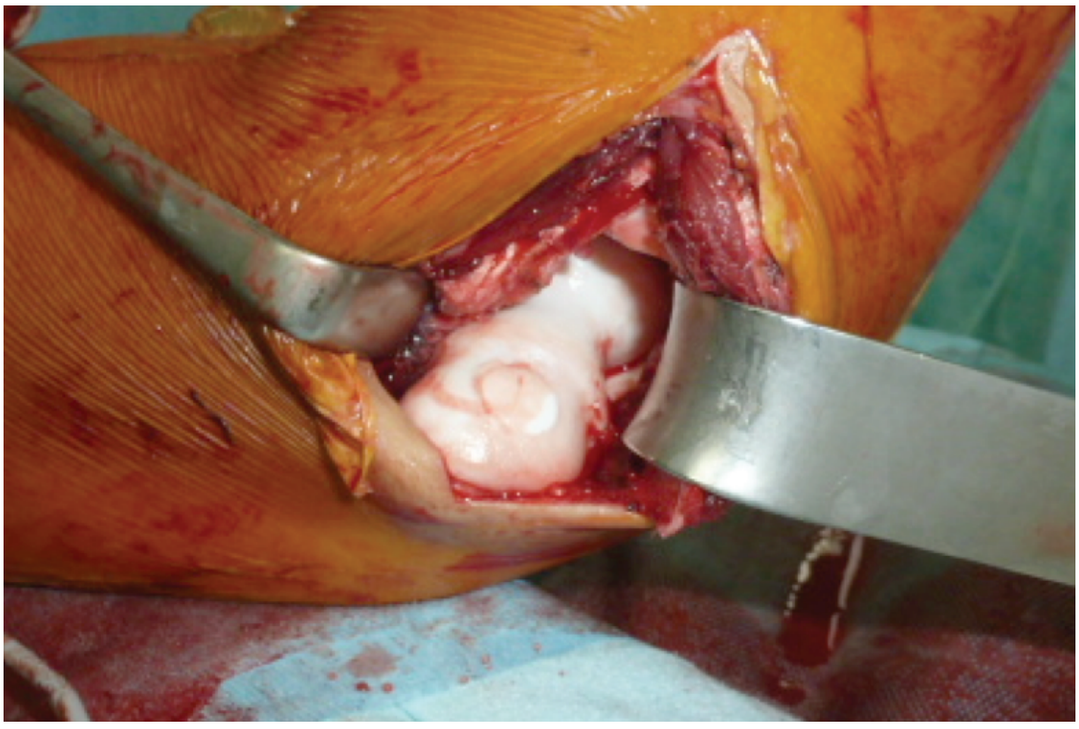

Figure 6. The harvested plug from the knee is impacted with press-fit into the drilled capitellar defect until flush with the surrounding joint cartilage.

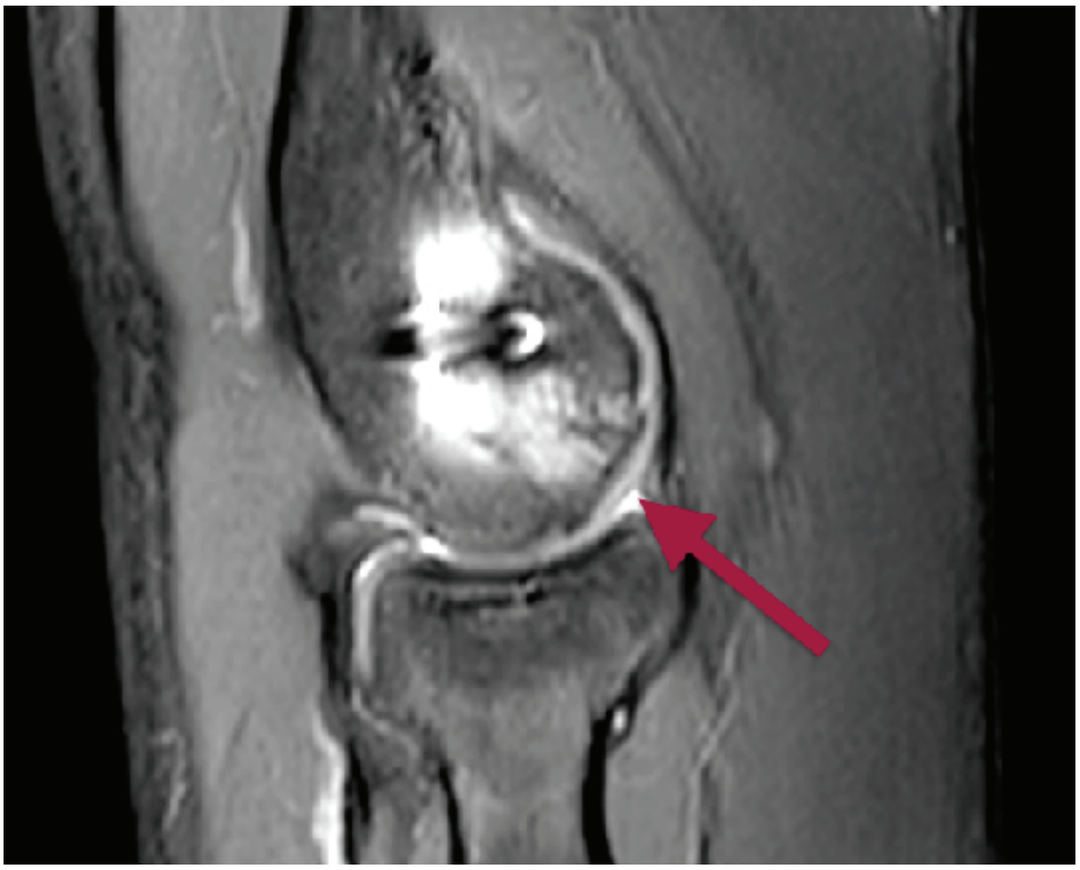

Figure 7. MRI of the elbow showing the capitellum of the patient shown in Figures 2-6. One year after the surgery the plug (arrow) is completely healed and evenly incorporated into the subchondral bone.

Costal osteochondral transplantation (*COT*)
Lateral column OCD lesions can also be addressed with an autograft harvested from the rib. A costal osteochondral fragment with hyaline cartilage is taken most commonly from the sixth rib (Shimada *et al.,* 2012). By comparison, the costal osteochondral plug has a much larger hyaline cartilage cap that must be trimmed to match the capitellar defect. The costal grafts therefore lack a lamina splendens, the most superficial layer of articular cartilage, which has a horizontal fiber arrangement that resists the high tensile and shear forces generated in the joint and blocks entry of degradative enzymes into the cartilage matrix (Zlotolow and Bae, 2014). But COT has the ability to harvest larger grafts with up to 15 mm in diameter allowing for greater coverage (Shimada *et al.,* 2012). In a study on 26 athletes with lesions greater than 15mm all returned to sports after 6 months postoperatively and 77% of them presented with joint congruity on MRI after 6 – 12 months (Shimada *et al.,* 2012). COT represents an alternative for the treatment of large lesions in the lateral column exceeding 15 mm in diameter. But it is a technically demanding operation and a pneumothorax can be a serious complication occurring in 1.6% of cases (Bexkens *et al.,* 2017).

Discussion and conclusions

Osteochondritis dissecans is a long recognized yet poorly understood condition. The exact cause and natural history still remain elusive in the literature. Because OCD in the elbow is still a rare condition it is difficult for the orthopaedic surgeon to treat enough cases to perform any meaningful comparative research.

Early detection of OCD is linked to excellent outcomes for early stage non-operative treatment. Although no direct cause has been elucidated yet, factors such as high levels of activity and frequent participation in throwing sports seem to be the most consistently associated factors in patients with OCD, supporting the repetitive trauma theory.

MRI can help to characterize the lesion's stability and is the diagnostic tool of choice. It is very valuable because the articular cartilage can be reviewed and the interface between the lesion and the surrounding bone is believed to be the strongest indicator to differentiate between a stable or unstable lesion. In those cases in which the lesion appears stable, a trial of non-operative therapy may be attempted for a period of 3 to 6 months.

Non-operative treatment consists of activity restriction with or without immobilization and close follow-up. In cases of unstable lesions and those failing non-operative treatment, surgery is indicated based on the individual situation. Because the prevalence of capitellar OCD in adolescent throwing athletes is much higher than previously thought screening programs are initiated to diagnose OCD sooner. If the lateral column is involved, the outcome is however poor if sufficient subchondral bone support is not reconstructed properly.

OATS and COT procedures seem to represent reliable surgical methods to the orthopaedic surgeon and with both good to excellent results can be obtained. With the advancement of arthroscopic methods these surgical therapies will become less invasive.

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