Treatment of Adolescent Osteochondritis Dissecans of the Capitellum: A Systematic Review of the Literature

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INTRODUCTION

Osteochondritis dissecans of the capitellum is a common cause of elbow disability in adolescent athletes.[1] Repetitive microtrauma from overuse in the setting of a tenuous blood supply to the capitellar chondroepiphysis is widely accepted as the etiology.[2,3] In these skeletally immature patients, the capitellum is supplied by very few end vessels posteriorly, leaving the epiphysis vulnerable to vascular insufficiency.[4,5] The condition is most commonly seen in adolescent athletes, predominately affecting gymnasts, weightlifters and baseball pitchers, where there is excessive loading of the radiocapitellar joint.[3,5] During the late cocking and acceleration phase of throwing, young pitchers will experience compressive forces on the lateral side of the elbow. Additionally, during the follow-through phase, there are shear forces across the joint.[1,2] Gymnasts experience similar trauma and shear forces with activities that require heavy weight bearing by the upper extremities.[6]

Early anatomic and radiographic changes include flattening of the subchondral bone with intact overlying cartilage.[7,8] As the subchondral bone fragments and collapses, there is disruption of the articular cartilage. The cartilage fragments may become loose within the joint, leaving large osteochondral defects and incongruity of the radiocapitellar joint, with subsequent changes of the radial head.[8,9] Multiple staging systems have been presented, based on radiographic or MRI findings[8] or arthroscopic findings.[10,11] Initial radiographic evaluation should be performed with anteroposterior (AP), lateral and flexion radiographs to help guide treatment.[12,13]

Clinically, these adolescents usually present following many years of highly competitive sport. Initially, the complaint is of dull pain, localized to the lateral aspect of the elbow, which is worse with elbow motion.[3] There is gradual loss of motion in the elbow, as well as reports of "locking" and "stiffness" with tenderness over the radiocapitellar joint.[3] Indeed, at the time of initial presentation, up to 50% of patients will have loss of elbow motion and 20% may have mechanical symptoms of locking or giving way.

Treatment is guided by stage of the lesion, as well as expertise of the surgeon. Surgical options for unstable OCD lesions include joint debridement, abrasion chondroplasty, removal of loose bodies, excision of lesion with and without subchondral drilling, closed-wedge osteotomy of the capitellum, and fragment fixation or replacement of articular cartilage with osteochondral autograft transfer system (OATS). (**Figure 1**) The goal is to obtain a pain free motion of the radiocapitellar joint and preserve articular (cartilage) integrity. Timing of surgical intervention, however, and which surgical approach to take still remains unclear. The objective of this review is to assess both the quality of the literature published over the last twenty years and recommendations for treatment.

MATERIALS AND METHODS

Study Design and Objective:

The aim of this systematic review is to determine which surgical treatment is the most effective in adolescent athletes with osteochondritis dissecans of the capitellum: joint debridement, abrasion chondroplasty, removal of loose bodies, excision of lesion with and without drilling, closed-wedge osteotomy of the capitellum, fragment fixation or replacement of articular cartilage with OATS. Clinical outcomes were assessed based upon elbow range of motion of elbow, pain, and return to sport.

Criteria for Studies:

Studies were limited to peer-reviewed articles published between 1980 and February 2010, within English-language literature. Subjects had to be between ages 9 and 18, with a mean length of follow-up of at least 12 months.

Identification of Studies:

A computerized search of the electronic databases, EMBASE, PUBMED and COCHRANE databases for articles published from 1980 to October 2009 was conducted with use of the keywords, "Osteochondritis Dissecans AND Capitellum", "Osteochondritis Dissecans AND elbow", " OCD AND Capitellum" and "OCD AND elbow." Published studies in all languages were considered for inclusion. The titles and abstracts of these potentially relevant studies from the computerized search were reviewed independently by two reviewers. Reference lists of all key articles were also reviewed for additional eligible articles. We noted frequently cited articles

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and conducted a Science Citation Index search (SciSearch) to locate potentially relevant studies that had cited those articles. Additional strategies to identify relevant studies included (1) a manual search of the table of contents of four major orthopaedic journals (The Journal of Bone and Joint Surgery [American and British], American Journal of Sports Medicine, and Clinical Orthopaedics and Related Research and Journal of Pediatric Orthopedics) from 1990 through June 2009; (2) a review of the bibliographies of three important textbooks in orthopaedic sports medicine and/or pediatric orthopaedics (The Elbow and its disorders by Morrey et al.,[14] Lovell and Winters Textbook of Pediatric Orthopedics,[15] Instructional Course Lectures on Shoulder and Elbow by Warner et al.[16]).

Titles were reviewed, and if the title suggested any possibility that the article might meet eligibility criteria, the abstract was retrieved and reviewed. We then chose potentially eligible studies for retrieval if the abstract indicated a possibility that the study had a comparative study design, involved human subjects, and demonstrated any clinically relevant outcome. The review of the complete articles for eligibility included only the methods section and was thus blinded with regard to author, institution, journal, and results.

RESULTS

A systematic literature search identified 47 published articles, which reported on the outcomes specified. After review of abstracts, the full manuscript of 36 articles were reviewed in a blinded fashion with 20 studies meeting inclusion criteria in this analysis, the first of which was published in 1982. **Table 1** summarizes the baseline characteristics of these studies. One study was excluded secondary to a concern that three patients had been previously reported on in another study included in our review. All studies were retrospective case series. The mean sample size was 26.5 (range 3-176 persons) with only 10.0% of studies reporting on >50 patients and only one study (5%) including ≥100 patients. Secondary to the heterogeneity of the studies it was felt that a meta-analysis would be inappropriate, and therefore a qualitative summary of the literature was undertaken.

SUMMARY OF TREATMENT OPTIONS FOR OCD IN THE ADOLESCENT CAPITELLUM:

Non-operative treatment:

There is evidence to suggest that osteochondritis dissecans, in its early stages, has the capacity to heal without surgical intervention. Early stable lesions are therefore managed non-operatively, with limits on activity, non-steroidal anti-inflammatory medication and therapy to improve range of motion. Satisfactory results have been seen in patients whom are able to comply.[18,19] However, results from other series have showed that healing is variable, with 50% of patients with poor long-term outcomes. Of larger lesions, non-operative treatment was not adequate, as 100% of these adolescents continuing to have to have pain and limited motion

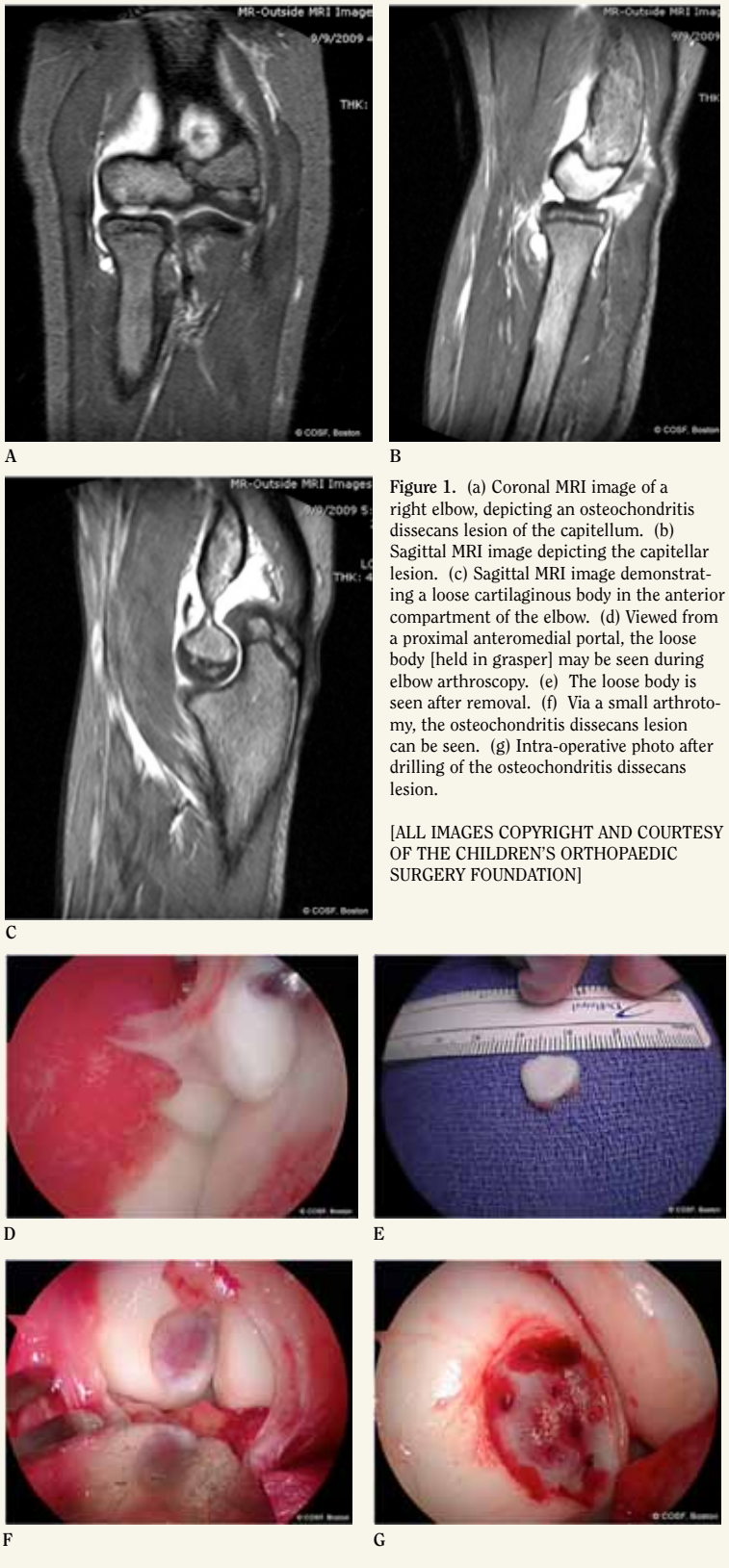

Figure 1. (a) Coronal MRI image of a right elbow, depicting an osteochondritis dissecans lesion of the capitellum. (b) Sagittal MRI image depicting the capitellar lesion. (c) Sagittal MRI image demonstrating a loose cartilaginous body in the anterior compartment of the elbow. (d) Viewed from a proximal anteromedial portal, the loose body [held in grasper] may be seen during elbow arthroscopy. (e) The loose body is seen after removal. (f) Via a small arthrotomy, the osteochondritis dissecans lesion can be seen. (g) Intra-operative photo after drilling of the osteochondritis dissecans lesion.

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Author	Year	Study Design	Subjects	No. of Elbows	Time from symptom onset to surgery	Age at Intervention	Follow-Up
Jackson	1989	Retrospective	High-performance female gymnasts	10	Not specified	Avg 13.3yrs (10yrs-17yrs)	Avg 2.9yrs (7mos-7yrs)
Mitsunaga	1981	Retrospective Case Series	Consecutive adolescent athletes at Mayo	84	Not specified	Avg 17.4 yrs	Avg 13.6 years
Singer	1984	Retrospective Case Series	High performance female gymnasts	7	Not specified	11yrs-13yrs	3yrs
Janary	1997	Retrospective	Consecutive casse seen at St. Gorans hospital	13	Avg 1.0yrs (0yrs-3yrs)	Avg 13.5 (11yrs-16yrs)	Avg1.3yrs (0.3yrs-3.0 years)
Ruch	1998	Retrospective Case Series	All patients who underwent elbow arthroscopy for OCD	12	Avg 30mo (12mo- 65mo)	Avg14.5 (11yrs-17yrs)	Avg3.2 (2.2yrs- 5.9 yrs)
Baumgarten	1998	Retrospective	Throwing athletes, gymnasts, basket ball players and weight lifters	17	Avg 17mos (1-50)	Avg 13.8yr (10yrs-17yrs)	Avg 48mos (24mos-75mos)
Takahara	1999	Retrospective Case Series	Adolescent baseball or softball players	24	Not specified	Avg 13.3yrs (11yrs-16yrs)	Avg 5.2yrs (6mo-15yrs)
Kiyoshige	2000	Retrospective Case Series	Male baseball players with 6-9 yrs of play	7	Avg 1.9yrs	11-18yrs	7-12 yr s
Byrd	2002	Retrospective Case Series	Consecutive adolescent patients with OCD who received arthroscopy and >3yrs fu	10	Avg 9mos (1mo-24mos)	Avg 13.8 (11-16yrs)	Avg3-6yrs
Takeda	2002	Retrospective Case Series	Adolescent male baseball players	11	Not specified	Avg 14.7yrs (12yrs-16yrs)	Avg 57mos (31mos-95mos)
Shimada	2005	Retrospective Case Series	Adolescent male baseball players and one high level judo athlete	10	Not specified	Avg 14.3 (12yrs-17yrs)	Avg 25.5mos (18mos-45mos)
Bojanic	2005	Retrospective Case Series	High level gymnasts	3	Not specified	Avg 14yrs (13yrs-15yrs)	Not Specified
Jawish	1992	Retrospective	Consecutive adolescents treated for capitellar OCD lesion at enfants malades hospital, paris between	13	Range 0-6 mos	Avg 14.5 (13yrs-17.5yrs)	9 cases with follow-up; Range 2-13 yrs
Harada	2002	Retrospective	male belonging to senior baseball team with 5-6 yrs experience	4	Avg 1.5yrs (0.5yrs-2yrs)	Avg 14 (14yrs-15yrs)	7.5 yrs (2.1yrs-11yrs)
Yamamoto	2006	Retrospective Case Series	Adolescent male baseball players	18	Not specified	Avg 13.6yrs (10yrs-16yrs)	Avg 45mos (24mos-63mos)- Grade 3 Avg 38mos (24mos-60mos)- Grade 4
Matsuura	2007	Retrospective Case Series	Adolescent male baseball players	176	Not specified	Avg 12.8 (9yrs-17yrs)	Avg 24mos (12mos-60mos)
Nobuta	2008	Retrospective Case Series	Male adolescent baseball pitchers and one tennis player	28	Avg 17mo (3mo-73mo)	Avg 14yrs (12 to 19yrs)	Avg 17mo (7mo-36mo)
Iwasaki	2009	Retrospective Case Series	Competive adolescent male atheletes	19	Not specified	Age 14.2yrs (11yrs-19yrs)	Avg 45.1mos (24mos-87mos)
Mihara	2009	Retrospective Case Series	Male baseball players	39	Avg5.6mos (1wk-30mos)	Avg 12.8yrs (10yrs-18yrs)	Avg 14.4mos (6mos-56mos)
Jones	2010	Retrospective Case Series	Consecutive adolescents treated for capitellar OCD with arthroscopy	25	10.2mo (2 -36mos)	Avg 13.1yrs (10yrs-17yrs)	48mos (21-83 mo)

Table 1

	Intervention	Lesion grade	Outome measurements
	Arthroscopy with curretage, driling and loose body removal	Not indicated	*ROM *Return to Sport *Appearance on Xray
	Open exploration with variable excision, debridement and drilling-42pts Conservative treatment- 24 pts	Type 1-24 patients Type II- 37 patients Unknown- 5 patients	*Pain *Residual functional deficit
	Conservative Treatment Arthrotomy with removal of loose body	Not indicated	*Return to sport *ROM *Appearance on xray
	Arthroscopy with removal of loose body or flap if present +/- driling or shaving	Lesions varied between 10X10 and 20x20 mm	*ROM *Subjective symptoms *Return to Sport
	Athroscopy with debridement and loose body removal	mean lesion size 2.5cm (7 detached, 5 hinged)	*Subjective pain *ROM *Appearance on Xray
	Athroscopy with abrasion chondroplasty with removal of partial fixed or loose body (grades 3-5)	Grades 2-5 as characterized by Baumgarten et al.	*Return to sport *ROM *Appearance on xray
	Conservative treatment	Classified as early (radiolucency with no loose fragment) or advanced (displaced subchondral bone)	*Subjective pain *Appearance on xray
	Closed-wedge osteotomy	Late phase of first stage	*Flexion/extension *Carrying angle *Return to sport *Subjective pain *Appearance on xray
	Arthroscopy with synovectomy, chondroplasty, abrasion arhtrosplasty or loose body removal	*Grade I=2,Grade II=1, Grade II=0, Grade IV=2, Grade V=5 *ASMI grading system	*Timmerman and Andrews score *Appearance on Xray *Return to Sport
	Fragment fixation with pull-out wiring and bone grafting	Not indicated	*ROM *Appearnace on xray
	OATS	5 free body in situ; 5 displaced fragments	*JOA elbow score *Radiocapitellar congruity on xray *Viability of cartilage on MRI *Return to sport
	Arthroscopy with loose body removal (if present) and derbridement and microfractures	Defects between 10 x10mm to 20x10mm	*ROM *Return to sport *Mayo Elbow Performance Score
	Conservative Tx- 6pts Removal of loose or fragments with subchondral drilling-7pts	Radiolucency only on Xray -5 patients Loose body on Xray-5 patients Unknown= 3 patintients	*ROM *Appearance on Xray
	Fragment Fixation with Dynamic staplingand bone graft	Non-displaced fragment on Xray- 2 patients Displaced fragment on Xray- 2 patients	*ROM *Appearance on Xray *Return to sport
	OATS	9 patients with grade 3 and 9 patients with grade 4 as characterized by Nelson et al.	*Timmerman and Andrews Score *Appearance on xray
	Conservative treatment	Grade I and II lesions only	*Return to Sport *Appearnace on Xray
	Fragment fixation with kirschner wires	By Minemi et al. grading Grade I-1 pt Grade II with non-displaced fragment -12 pts Grade II with min displaced grafment -15 pts	*Tivnon et al. score *ROM *Appearnace on xray (Minami et al.)
	OATS	All grade III (detached fragment) by Minami et al grading.	*Timmerman and Andrews Score *ROM *Return to sport
	Conservative treatment	By Iwase et al. classification Grade I- 26 patients Grade IIA- 4 patients Grade IIB-4 patients Grade III- 5 patients	*Iwase's classification on Xray *Return to Sport
	Arthroscopy with curretage, driling and loose body removal and +/- bone graft	Not indicated	*SANE

in their activities.[12] Those patients managed conservatively should be monitored closely with consideration for surgical intervention if patients do not improve after six months.

Operative Treatment:

In patients with persistent pain or unstable lesions, multiple surgical treatment options have been described. Exploration of the joint either arthroscopically or via arthrotomy is done to assess the anatomic extent of the injury, articular surface integrity and fragment stability.

The most widely described technique for a capitellar lesion is debridement of the joint, removal of loose bodies if present, and drilling of the subchondral bone to promote vascularization and healing. (**Figure 1**) Removal of the loose bodies may help with mechanical symptoms. However, even early studies in the literature show removal of loose bodies with or without drilling in later stage lesions is often inadequate; pain may be relieved, but long-term function may be compromised.[3,12,19-22] Woodward et al. and Tivnon et al. demonstrated that removal of loose bodies and drilling could relieve pain, but did not predictably allow patients to return to their previous level of sport. Bauer et al. described the long-term outcome (mean 23 years follow-up) of 31 patients who underwent removal of loose bodies with the majority showing degenerative changes (61%) and nearly half (42%) complaining of pain.[4,12]

In cases where a lesion is unstable, the cartilage and bone may be stabilized through a variety of techniques. Fragment fixation has been performed using Herbert screw,[23] dynamic staples,[24] pull-out wiring[24,25] and grafting with bone pegs in older patients[7]. The majority of these studies, including those by Takeda et al. and Kuwahata et al., described excellent results with these methods, even in completely detached lesions in small cohorts, with 90-100% of these patients returning to sport. Nobuta et al. cautioned that, for large lesions >9mm or more in thickness, fixation with pull-out wiring was not sufficient, with only 58% of those patients going on to heal, without further intervention. These authors also suggest that any completely detached lesions should be excised as blood supply to the fragment may be compromised.

Arthroscopic procedures have become standard treatment for OCD. The less invasive nature of arthroscopy decreases the risk flexion contracture or ectopic ossification. Arthroscopic treatment with removal of loose bodies, debridement and abrasion chondroplasty have been employed to minimize pain and increase range of motion. There has been variable return to sports in short-term follow-up studies.[6,11,14,28,29]. Baumgarten et al. treated 16 patients with arthroscopic abrasion chondroplasty and removal of loose bodies. Thirteen of those patients were able to return to their previous level of sport with the others failing to return secondary to pain. Two patients with severe lesions underwent reoperation for pain and prohibited range of motion. Byrd et al. reported on 10 adolescent baseball players with varying degrees of lesion severity. Patients underwent a variety of arthroscopic interventions including: synovectomy, chondroplasty, abrasion, arthroscopy, loose body removal and were followed for a mean of 3.9 years. Only 4 of 10 players were able to return to previous level of sports, but all had good to excellent results, as determined by the author on exam. Jones et al., on the other hand, reported results showing significantly improved range of motion and a high rate of return to athletic activity (86%) in his patients. [9] Bojanic et al. advocates the microfracture technique introduced by Steadman, which preserves the subchondral layer, but recruits multipotent cells to help promote new cartilage growth which is made up of hyaline and fibro-cartilage. [30] With such variable results and techniques, the conclusive role of arthroscopy in OCD treatment remains unclear though its minimally invasive character likely provides benefit.

Mosaicplasty first introduced for OCD lesions of the knee has been shown to be successful at short-term follow-up for capitellar lesions.[31-33] Hyaline cartilage is biomechanically stronger than fibrous cartilage and unlike other techniques the osteochondral autograft transfer system aims to restore hyaline cartilage in the joint, but also provides subchondral support.[31] Yamamoto et al. described use of OATS in adolescent patients who had failed conservative treatment with more severe lesions with 16 of 18 (89%)[33] patients having overall good or excellent results as measured by a score of 160 or greater on the Timmerman and Andrews scale.[34] Perhaps, more importantly 94% of patients (16 of 17 pts) were able to return to throwing. Proponents for the technique cite biological internal fixation, congruently reconstructed articular surface,[33] and potential to stimulate subchondral bone healing.[35] In addition, Yamamoto et al. has suggested that better bone fusion is achieved for isolated lesions with OATS versus bone-peg grafting. [33] Tsuda et al. advocates arthroscopic examination of the joint with removal of loose bodies and debridement prior to autograft. [33]

Closed wedge osteotomies were described by Kiyoshige et al. to reduce compression force on the capitellum and enhance the potential of revascularization and bone remodeling. [36] The procedure improved congruity of the joint with six of seven patients having improved of pain and able to return to sports. Whether this procedure delays or avoids joint degeneration as the authors suggest will need further investigation.

Though there have been numerous reports of relative efficacy and safety of all of these surgical treatment strategies, little information is available to suggest which is the preferred method of treatment, nor is there a consensus on the longer-term prognosis following surgical intervention, particularly with regards to return to athletic activities or risk of arthritis and pain into adulthood. This highlights the importance of additional study of elbow OCD.

DISCUSSION

In this investigation, the quality of evidence behind current treatment recommendations for elbow OCD in skeletally immature patients was critically appraised. Key findings were the absence of any randomized control trial (RCT) that compared the therapeutic effectiveness and potential complications of subchondral drilling and removal of loose fragments to fragment fixation, osteochondral autograft transfer, or non-

operative treatment. Only one non-randomized comparative trial was identified, but did not meet inclusion criteria based on the age of the subjects.[7] This trial retrospectively compared outcomes between groups managed conservatively and those treated with fragment fixation with bone graft and osteochondral autograft transfer. The indications for each of the surgical interventions though were not clearly defined.

Simunovic et al. concludes there is no developed protocol for determining the methodological quality of observational studies as there is for randomized control trials; therefore, it is better to not judge studies based on an arbitrary composite score, but instead to assess the quality of each study independently. The major limitation of a systematic review like this is the quality of the methodology of the studies included. The internal validity of an observational study is dependent on the selection of participants, the measures of exposure and outcome as well as appropriate use of design and analytical methods. [37] All twenty of the studies reviewed here were retrospective case series, which followed groups of adolescent athletes.

As osteochondritis dissecans more frequently occurs in young athletes, specifically pitchers, gymnasts, and weight lifters, the implicit bias of the selection of participants in these studies is inevitable, recognizing that it may limit generalizability to the non-athlete population. Almost all of the studies reviewed were single-armed surgical case series lacking a comparison group.[6,9,11,12,17,18,19,22-26, 28-33,36,38,39] Those studies that did compare treatments did match for any baseline characteristics including important factors such as lesion severity in order to more accurately compare one intervention to another.

In those studies that did not compare treatments, many methodological errors were noted. The indications for surgery were not well described. Three studies included a single lesion stage, significantly limiting generalizability outside of the severity of lesion included.[17,36,39] Eleven of the twenty studies included were case series of patients who had undergone a specific treatment for the lesion without explicitly specifying the indications for this particular procedure to be performed over another,[9,11,24,26,29,28,31,36] or simply failed to specify the indications for different procedures if multiple types were performed.[20,21,38] Sixteen of twenty studies included the lesion severity,[11,12,17,18,19-24,26, 28-33,36,38,39] which is very likely to influence not only the procedure chosen, but perhaps more importantly the outcome.

Moreover, many authors failed to provide the type of information that would allow critical readers to assess the validity, impact, and applicability of the study results, including frequency of missing data and rate of loss to follow-up. This is further confounded by lack of consensus on the staging of these lesions or outcome measures following operative or conservative treatment. The great majority of studies used return to sport as one outcome measure, indicating the importance of high-level function in these adolescents and their dedication to the sports. Additionally, as the follow-up of most of these studies was very short, longer term follow-up studies are needed to assess the effect on development of osteoarthritis and permanent functional disability.

Observational studies, in order to prevent selection bias and to derive the most valid result, must compare one group to another group with whom they matched as closely as possible excluding the intervention being investigated. In three of the studies evaluated here, two or more different treatments were undertaken; only in one study[21] was a comparison made between the groups. Mitsunaga et al. compared the outcome of those patients, who underwent non-operative management, simple excision or excision and debridement and/or subchondral drilling. The groups were not matched with those receiving surgery more likely to have a more severe lesion type. Additionally, no explicit indications for why one procedure was performed versus another was specified, introducing more potential for bias. The analysis for comparing outcomes between surgical groups was limited to comparing the gross number of "excellent results" for each procedure. No statistical comparison with confidence intervals was performed.

Clearly randomized control trials of surgical procedures are exceedingly challenging, with inability to blind surgeons to the procedure being performed, as well as the logistical and ethical challenges of randomizing and blinding study subjects. Additionally, as new techniques are developed, difficulty in controlling for the surgical skills and experience of individual surgeons arises.[40] These factors are important predictors of outcomes. Without clinical equipoise, it is difficult to justify to surgeons and their patients random allocation to invasive surgical procedures. When there is a dearth of RCTs on a specific topic in orthopedics, it is necessary to use observational studies highlighting the importance of high methodological quality of these.

There are limitations to this systematic review. This study was limited to full-text publications, which may bias the results. Secondly, there is inherent subjectivity of any assessment of methodological quality, even when performed by two independent observers. Additionally, all studies not published in the English language were excluded. Finally, it is likely that quality of the actual methodology is better than what can be determined from the literature; however, this remains the only source for assessment. Given the heterogeneity noted, a qualitative review of the evidence is a more appropriate summary of the literature.

CONCLUSIONS

The published literature on treatment of ostechondritis dissecans of the adolescent capitellum is limited to uncontrolled, observational studies, many of which are of poor methodologic quality and very small in size. These findings raise the question whether any surgical treatment can be deemed superior or "standard of care." This highlights the importance of a quality comparative trial to look at outcomes associated with non-operative treatment, as well as treatment with subchondral drilling and debridement, compared with osteochondral autograft transfer for treatment of these lesions.

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