Iran J Public Health, Vol. 50, No.4, Apr 2021, pp.764-771

Original Article

The Effects of Initial Rehabilitation Exercise on Range of Motion, Muscular Strength, and Muscle Pain after Surgery for Osteochondritis Dissecans of the Humeral Capitellum in Middle and High School Baseball Players

***Jung-Shik Seo** [1], ***Jin-Ho Yoon** [2]

1. *Elite Sports Medicine Institute, Seoul, Korea*
2. *Department of Sports Rehabilitation, Korea Nazarene University, Cheonan, Korea*

***Corresponding Author:** Email: tkd97@kornu.ac.kr

(Received 12 Aug 2020; accepted 21 Oct 2020)

Abstract

Background: This study evaluated the effects of a 4-week initial rehabilitation program in middle and high school baseball players who underwent removal of a loose body from osteochondritis dissecans of the capitellum humerus.

Methods: Middle and high school baseball players with osteochondritis dissecans of the capitellum humerus were enrolled in this study. Each had more than 3 yr of experience and had undergone arthroscopic removal of loose bodies from the same expert at Kim's Orthop Special Clinic in Seoul. The initial exercise rehabilitation program was based on a two-stage program. Body composition, range of motion of flexion and extension in the elbow and wrist joints, grip strength, and subjective pain scale were measured before and after rehabilitation. To assess the differences between groups, we used a two-way analysis of variance.

Results: The range of motion for flexion and extension of the elbow and wrist joints, grip strength, and score on the visual analog scale each were significantly improved following the 4-week program (P<0.001), had an interactive effect in time × group (P<0.001), and had significance between groups (P<0.05).

Conclusion: The 4-week initial rehabilitation exercise program might improve the overall range of motion of the elbow joint and has a positive therapeutic effect on grip strength and visual analog scores. However, future well-designed studies with more subjects and multicentric research groups are necessary for verification.

Keywords: Baseball players; Humeral capitellum; Muscular strength; Osteochondritis dissecans; Range of motion

Introduction

Baseball involves many overhand throwing motions that cause excessive stress on the elbow and glenohumeral joints (1). Medical injury in baseball players is rapidly increasing. Joint injury can be caused by overuse during their growing phase, since young players have high-intensity training, practice, and games in spite of the physical and mental differences with adult players (2-3).

During throwing motions, repetitive mechanical stress and external force simultaneously inside/outside and anterior/posterior of the elbow joint can induce abnormal osteochondral growth and change the soft tissue. This can affect normal growth and cause permanent deformation of the elbow joint, which results in decreased performance and a shorter athletic career (1).

Osteochondritis dissecans (OCD) of the elbow joint is a relatively common disease in adolescent athletes who perform throwing motions. OCD is caused by repetitive physical trauma and poor blood supply, especially when solid caput radii put pressure and sheering force on the capitulum humeri (4).

Treatment can vary depending on the location of the lesion, size, chondral injury range, existence of a loose body within the joint, and age of the player. Physical therapy, drug treatment, and conservative treatment are administered to young players if there are no loose bodies, no restriction to exercise, and the OCD is in the initial stage despite radiographic signs of symptoms. However, surgical treatment is recommended in cases where symptoms persist or deteriorate and when there are symptoms of a loose body in the glenoid cavity (5). Surgical treatments can be divided into osteochondral extirpation and revision arthrodesis, with osteochondral extirpation being more common. Arthroscopic removal of a loose body was recently attempted, and this is recommended as the most appropriate method to evaluate anterior and posterior joint conditions and identify lesions (6-7). In addition, satisfactory treatment effects from arthroscopic removal of a loose body have been reported, including loss of pain and increase in the range of motion (ROM) (6-7).

Arthroscopic surgery has a short recovery time, since damage is low and rehabilitation training can be started quickly. However, recovery alone is not satisfactory for athletes, instructors, and parents, who desire more knowledge and information about injury treatment and rehabilitation exercises (8). Thus, multilateral studies on surgery and treatment of OCD were conducted, and various improvements have been suggested. However, most studies were based on surgical treatment or academic guidelines for OCD, and reports related to the actual effect of exercise rehabilitation are lacking. Thus, the purpose of this study was to provide objective data about the effect of a 4-week initial rehabilitation training program in middle and high school baseball players who underwent removal of a loose body from OCD of the capitellum humerus.

Materials and Methods

Participants

We enrolled ten middle and high school baseball players with OCD of the capitellum humerus to participate in the study. They were each more than 3 yr into their careers and had undergone arthroscopic removal of a loose body from the same expert at Kim's Orthop Special Clinic in Seoul. Data were divided into the affected arm (I; involved) and the opposite arm (U; uninvolved). We restricted participation to individuals who had no other orthomechanical disease in the past 6 months and no physical limitations that would prevent participation in the exercise.

All study participants provided informed consent, and the study design was approved by the Korea National Sports University. Both the adolescents and their parents agreed the study, since the subjects were minors. The characteristics of the participants are listed in Table 1.

Table 1: Characteristics of the participants

n	*Age (yr)*	*Height (cm)*	*Weight (kg)*	*Body mass index (kg/m²)*
10	16.20 ± 1.55	168.60 ± 6.40	65.00 ± 8.34	25.26 ± 5.74

Values are means ± standard deviations

Rehabilitation exercise training

A modified program was designed to minimize stiffness, contracture, and atrophy by focusing on 1st and 2nd stages of the 3-stage program, as suggested by Altchek and Andrews (9). The rehabilitation exercise methods are shown in detail in Table 2.

Table 2: Postoperative rehabilitation protocol for loose body removal

Stage	*Goal*	*Exercises and modalities:*
I (Acute phase)	- Full wrist and elbow ROM decrease swelling - Decrease pain - Retardation or muscle atrophy	Cryotherapy, ultrasound, electrical stimulation
		Begin gently moving elbow in bulky dressing
		Immediate postoperative hand, wrist and elbow exercises (putty/grip strengthening, wrist flexor/ extensor stretching, wrist curls, reverse wrist curls, neutral wrist curls, pronation/supination, active/active assistive ROM elbow extension/flexion)
		Scapular muscles strengthening (especially retractor, protractor)
		Passive ROM elbow extension/ flexor (motion to tolerance)
		Begin progressive resisted exercises with 1-lb weight (wrist curls, reverse wrist curls, pronation/supination, Broomstick roll-up)
II (Intermediate phase)	- Improve muscular strength and endurance - Normalize joint arthrokinematics	Addition of biceps curls and triceps extension
		Progress isotonic strengthening
		Initiate rotator cuff exercises program (external rotators/ internal rotators, deltoid, supraspinatus, scapulothoracic strengthening)

ROM, range of motion

Experiment and measurement method

Body composition

An autonomic height and weight meter (SH-9600A, Sewoo, Seoul, Korea) was used to measure height and weight. The percent body fat and body mass index (kg/m^2) were calculated using a body composition analyzer (Inbody 4.0, Biospace, Seoul, Korea). Measurements with minimal clothing were obtained immediately when the subject arrived at the laboratory following limited physical activity and 12 h of fasting.

Measurement of flexion and extension ROM

The ROM measurements for the extension and flexion of the elbow and wrist joints were performed using a goniometer (EZ Read Jamar Goniometer, HPMS, Inc. USA). For the elbow tests, the subject was placed in the supine position, and the pad was placed at the lower part of the humerus to make the humerus parallel to the ground. The axis of the scale was placed at the lateral epicondyle, with one end located at the centerline of the hipbone and the other end at the centerline of the humerus. The ROM was measured by extension and flexion of the elbow joint by passive movement until the endpoints were felt (10).

For the wrist joint tests, the subject was seated, and the forearm was stabilized on a table. The axis of scale was placed at the lateral wrist (triquetrum), with one end located at the centerline of the ulna and the other end at the centerline of the fifth metacarpal. The ROM was measured by extension and flexion of the wrist joint by passive movement until the endpoints were felt (10).

Measurement of grip strength

The grip strengths of the involved and uninvolved arms were measured using a Smedley-type dynamometer (TTK-5401, Takei Scientific Instruments Co., Ltd., Tokyo, Japan) in 0.1 kg units. The proximal interphalangeal finger joint was rectangular to the grab dynamometer, the torso and arms were kept at 15 degrees such that the dynamometer did not come into contact with the body or that the elbows were bent, and the arm was pulled straight. The mean grip strength was calculated from three trials, and the highest score was recorded.

Assessment of subjective pain

The visual analog scale (VAS) was used to quantify and measure the degree of subjective pain. VAS is one of the most frequently used methods for pain intensity measurement, in which 0 mm is no pain, 20 mm is mild pain, 40 mm is moderate pain, 60 mm is severe pain, 80 mm is very severe pain, and 100 mm is the worst possible pain (11). VAS measures the distance and pain degree from the first to the marked point. VAS measurements were performed before and after the experiment.

Statistical analysis

All values were calculated as mean ± standard deviation using Windows SPSS version 18.0 (IBM Corp., Armonk, NY, USA). A repetitive analysis of variance was conducted to determine the relationship between groups for grip strength and ROM according to measurement time (before and after participating in the exercise rehabilitation). For the post-hoc test, we conducted an independent *t*-test to determine the pre-and post-intervention differences and inter-group variations. Statistical significance was set at $P<0.05$.

Results

The results of the changes in flexion and extension ROMs in the elbow and wrist joints are shown in Table 3. Analysis of the elbow joint flexion ROM showed a significant difference for the measurement time ($P<0.001$), an interactive effect of time × group ($P<0.001$), and a significant difference between groups ($P<0.001$).

Table 3: Change to range of motion

Item		*1st week*	*2nd week*	*3rd week*	*4th week*	*Significance*
Elbow joint flexion ROM	Involved	83.30 ± 12.27[a]	119.40 ± 17.99[b]	128.70 ± 16.65[c]	132.40 ± 13.32	T: $P<0.001$ T × G: $P<0.001$ G: $P<0.001$
	Uninvolved	141.80 ± 4.29	141.30 ± 4.24	141.40 ± 5.06	140.50 ± 4.48	
Elbow joint extension ROM	Involved	11.40 ± 4.93[a]	1.90 ± 5.55	-0.40 ± 4.27	-0.30 ± 3.80	T: $P<0.001$ T × G: $P<0.001$ G: $P=0.026$
	Uninvolved	0.30 ± 0.48	-0.10 ± 0.88	0.60 ± 0.84	0.20 ± 1.03	
Wrist joint flexion ROM	Involved	36.50 ± 20.34[a]	46.90 ± 12.08[a]	70.00 ± 12.47	71.00 ± 11.01	T: $P<0.001$ T × G: $P<0.001$ G: $P<0.001$
	Uninvolved	77.50 ± 3.14	77.60 ± 3.17	78.20 ± 3.34	77.20 ± 3.65	
Wrist joint extension ROM	Involved	49.40 ± 9.03[a]	64.80 ± 3.33[a]	69.30 ± 1.34	70.80 ± 1.75	T: $P<0.001$ T × G: $P<0.001$ G: $P<0.001$
	Uninvolved	70.00 ± 0.67	70.10 ± 0.57	70.20 ± 0.42	69.90 ± 0.57	

Values are means ± standard deviations
ROM, range of motion; T, time; G, group; T × G, interaction
[a]$P<0.001$, [b]$P<0.01$, [c]$P<0.05$ (involved vs. uninvolved), tested by repeated analysis of covariance and independent *t*-test

Post-hoc tests showed that the involved arm had a lower flexion ROM compared with the uninvolved arm 1 (*P*<0.001), 2 (*P*=0.001), and 3 (*P*=0.033) weeks after surgery. Similar results were found for elbow joint extension ROM: a significant difference for the measurement time (*P*<0.001), an interactive effect of time × group (*P*<0.001), and a significant difference between groups (*P*=0.026). In post-hoc tests, the involved arm showed a lower extension ROM compared with the uninvolved arm 1 week after surgery (*P*<0.001).

As with the elbow joint, the wrist joint flexion ROM showed a significant difference for the measurement time (*P*<0.001), an interactive effect of time × group (*P*<0.001), and a significant difference between groups (*P*<0.001). In post-hoc tests, the involved arm showed a lower flexion ROM compared with the uninvolved arm 1 (*P*<0.001) and 2 (*P*<0.001) weeks after surgery. Results for the wrist joint extension ROM were statistically similar to the flexion results and showed a significant difference for the measurement time (*P*<0.001), an interactive effect of the time × group (*P*<0.001), and a significant difference between groups (*P*<0.001). In post-hoc tests, the involved arm showed a lower extension ROM compared with the uninvolved arm 1 (*P*<0.001) and 2 (*P*<0.001) weeks after surgery.

The results of the changes in grip strength and the VAS are shown in Table 4. Analysis of grip strength showed a significant difference for the measurement time (*P*<0.001), an interactive effect of time × group (*P*<0.001), and a significant difference between groups (*P*<0.001). In post-hoc tests, the involved arm showed lower grip strength compared with the uninvolved arm 1 (*P*<0.001), 2 (*P*<0.001), and 3 (*P*<0.001) weeks after surgery. Analysis of VAS showed a significant difference for the measurement time (*P*<0.001), an interactive effect of time × group (*P*<0.001), and a significant difference between groups (*P*<0.001). In post-hoc tests, the involved arm showed higher pain levels compared with uninvolved arm 1 week after surgery (*P*<0.001).

Table 4: Change of grip strength and visual analog scale

Item		*1st week*	*2nd week*	*3rd week*	*4th week*	*Significance*
Grip strength	Involved	5.40 ± 1.84[a]	9.70 ± 1.70[a]	17.30 ± 1.89[a]	28.50 ± 2.17	T: *P*<0.001 T × G: *P*<0.001 G: *P*<0.001
	Uninvolved	28.50 ± 2.22	28.50 ± 2.22	28.50 ± 2.22	28.50 ± 2.22	
Visual analog scale	Involved	46.00 ± 18.97[a]	3.00 ± 6.75	0.00 ± 0.00	0.00 ± 0.00	T: *P*<0.001 T × G: *P*<0.001 G: *P*<0.001
	Uninvolved	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	

Values are means ± standard deviations
T, time; G, group; T × G, interaction
[a]*P*<0.001(involved vs. uninvolved), tested by repeated analysis of covariance and independent *t*-test

Discussion

This study investigated the effects of a 4-week basic rehabilitation exercise program for enhanced recovery in middle and high school baseball players who underwent removal of a loose body from OCD of the capitellum humerus. The throwing motion of an adolescent baseball player generates tensible force at the medial part and pressure force at the lateral part of the elbow joint; especially, pressure force at the caput radii and capitulum humeri induces OCD of the elbow joint (12). If OCD is left untreated, progressive joint injury occurs, and secondary degenerative disease breaks out, including the formation of osteophytes, pain, a decrease in the ROM, and dysfunction (13).

The pathogenesis of OCD is described by the theories of trauma and circulatory disturbance. The circulatory disturbance theory states that the pressure force at the lateral part of the elbow joint disrupts the end-artery that supplies the capitulum humeri, which results in blood supply dysfunction in the subchondral bone (14). The trauma theory states that continuous traumatic contact induces fracture of the cartilage and subchondral bone (12-13). In other words, pressure is a cause, but whether or not OCD is a result of a dysfunction in blood circulation, from trauma, or both, the pathological mechanism and cause of OCD are not clear (15).

McManama et al (16) reported that 12 of 14 players (86%) returned to the field after OCD surgery. Ten of 11 baseball players recovered to the prior pitching level (17). However, Gudas et al (18), with 17.2 years of follow-up after OCD surgery, reported only 17% showed good results, 62% showed fair, and 21% showed failure, suggesting that prognosis is very poor. Young athletes recovered after OCD surgery, but 50% of players had chronic pain and a limited ROM (19).

Initial rehabilitation after removal of a loose body showed improvement in the ROM of the involved arm over time, suggesting that the program for ROM in the initial rehabilitation exercise had a positive effect. An advanced study reported that initial ROM exercise should be conducted in the elbow joint after removal of a loose body because it provides nutrients to cartilage (20), helps arrangement and resynthesis of collagen tissue, and it is effective in cicatricial tissue formation and stricture of tissue (21).

Pain is one of the most common subjective symptoms of musculoskeletal disease, but it is hard to measure since the general definition is vague and the objectiveness of pain is not recognized (22). Therefore, some researchers have utilized VAS to obtain the overall degree-of-pain scale (23). The advantage of this measurement method is that it is easy to grade, instruction is simple, and it is widely used in clinical areas (24-26). According to the results of this study, pain lasts about 2 weeks after removal of a loose body and then almost disappears, which suggests that after 2 weeks rehabilitation can be accelerated, and the main exercise program can be applied. In the case of grip strength, a gradual increase was measured over time. Grip strength increased by 81% one week after surgery, the pain gradually decreased, and the results were similar to those of the uninvolved arm. Fast recovery was observed, except for the 1st and 2nd weeks after surgery; this coincides with the fact that pain almost disappeared 2 weeks after removal of the loose body.

Treatment for elbow joint OCD in adolescent baseball players is controversial (27). There are follow-up studies on the percentage of players that return to the field after surgery for OCD. However, there is a lack of studies about rehabilitation exercise programs for returning to the field, for which the recent clinical field is at a higher ratio compared to past. In addition, treatment follows a foreign rehabilitation exercise program without consideration. Therefore, it seemed necessary to develop a working rehabilitation program, such as the one evaluated in this study, that can be prescribed for musculoskeletal-related exercise and sports medicine to enable adolescent baseball players to return to the field after OCD surgery.

This study had limitations. First, the subjects of this study were adolescent players in their growth phase; therefore, natural rehabilitation by growth cannot be excluded. Second, this study could not control the sleeping time and diet of the participants for the 4 weeks, except for intervention variables. Third, the small sample size of this study may not be representative of all Korean baseball players who undergo removal of a loose body from OCD of the capitellum humerus. Future studies should enroll more subjects to further investigate the study results.

Conclusion

The 4-week initial rehabilitation exercise program was found to increase the total ROM of the elbow joint and had a positive therapeutic effect on grip strength and visual analog scores. However, future well-designed studies with more subjects and multicentric research groups are necessary to verify the effectiveness of the rehabilitation exercise program.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

This research received no external funding.

Conflict of interest

The authors declare that there is no conflict of interest.

References

1. William NL, Mark LB, Beth SS, et al (2006). Shoulder adaptive changes in youth baseball players. *J Shoulder Elbow Surg*, 15(5):562-566.
2. Can F (2004). Rehabilitation and return to sports in children. *Acta Orthop Traumatol Turc*, 38 Suppl 1:151-62.
3. Jennifer L, Jennifer WJ (2004). Overuse injuries in pediatric athletes. *Curr Opin Pediatr*, 16(1):47-50.
4. Robert CS, Athanasiou KA, Constantinides G, et al (1994). A Biomechanical analysis of articular cartilage of the human elbow and a potential relationship to osteochondritis dissecans. *Clin Orthop Relat Res*,(299):305-312.
5. Masatoshi T, Motoyuki S, Toshikazu N, et al (1998). Early detection of osteochondritis dissecans of the capitellum in young baseball players-report of three cases. *J Bone Joint Surg Am*, 80(6):892-897.
6. Baker CL (1996). Arthroscopy of the elbow. *Clinics in Sports Medicine*, 15:261-281.
7. Ruch DS, Cory JW, Poehling GG (1998). The arthroscopic management of osteochondritis dissecans of the adolescent elbow. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, 14:797-803.
8. Grana WA, Rashikin A (1980). Pitcher's elbow in adolescents. *Am J Sports Med*, 8(5):333-336.
9. Altchek DW, Andrews JR (2001). *The Athlete's Elbow*. Lippincott Williams & Wilkins.
10. Sölveborn S, Olerud C (1996). Radial epicondylalgia (tennis elbow): measurement of range of motion of the wrist and the elbow. *J Orthop Sports Phys Ther*, 23(4):251-257.
11. *Jensen MP, Chen C, Brugger AM (2003). Interpretation of visual analog scale ratings and change scores: a reanalysis of two clinical trials of postoperative pain. J Pain,* 4(7):407-414.
12. Pappas AM (1981). Osteochondrosis dissecans, *Clin Orthop Relat Res,* (158):59-69.
13. Bauer M, Jonsson K, Josefsson PO (1992). Osteochondritis dessecans of the elbow. *Clin Orthop Relat Res,* (284):156-160.
14. Singer KM, Roy SP (1984). Osteochondrosis of the humeral Capitellum. *Am J Sports Med*, 12(5):351-360.
15. Yadao MA, Field LD, Savoie FH (2004). Osteochondritis dissecans of the elbow. *Instr Course Lect*, 53:599-606.
16. McManama GB, Micheli LJ, Berry MV, et al (1985). The surgical treatment of osteochondritis of the capitellum. *Am J Sports Med*, 13(1):11-21.
17. Takeda H, Watarai K, Matsushita T, et al (2002). A surgical treatment for unstable osteochondritis dissecans lesions of the humeral capitellum in adolescent baseball players. *Am J Sports Med*, 30(5):713-717.
18. Gudas R, Kunigiskis G, Kalesinskas RJ (2002). Long-term follow-up of osteochondritis dissecans. *Medicina (Kaunas),* 38(3):284-288.
19. Stubbs MJ, Field LD, Savoie FH (2001), Osteochondritis Dissecans of the Elbow. *Clin Sports Med*, 20(1):1-9.
20. Wilk KE, Arigo CA, Andrews JR, et al (1996). Rehabilitation following elbow surgery in the throwing athlete. *Sports Medicine*, 4:114-132.
21. Lachiewicz PF (2000). The role of continuous passive motion after total knee arthroplasty. *Clin Orthop Relat Res*, (380):144-150.
22. Hsieh LF, Hongm CZ, Chern SH, et al (2010). Efficacy and side effects of diclofenac patch in treatment of patients with myofascial pain syndrome of the upper trapezius. *J Pain Symptom Manage*, 39(1):116-125.
23. Bergh L, Sjöström B, Odén A, et al (2000). An application of pain rating scales in geriatric patients. *Aging (Milano),* 12(5):380-387.

24. Bala SV, Forslind K, Månsson ME (2010). Self-reported outcomes during treatment with tumour necrosis factor alpha inhibitors in patients with rheumatoid arthritis. *Musculoskeletal Care*, 8(1):27-35.
25. Ohlund C, Lindström I, Areskoug B, et al (1994). Pain behavior in industrial subacute low back pain. Part I. Reliability: concurrent and predictive validity of pain behavior assessments. *Pain*, 58(2):201-209.
26. Furuta K, Ishihara S, Sato S, et al (2009). Development and verification of the Izumo Scale, new questionnaire for quality of life assessment of patients with gastrointestinal symptoms. *Nihon Shokakibyo Gakkai Zasshi*, 106(10):1478-1487.
27. Krijnen MR, Lim L, Willems WJ (2003). Arthroscopic treatment of osteochondritis dissecans of the capitellum: Report of 5 female athletes. *Arthroscopy,* 19(2):210-214.