[Sports Physical Therapy]

Perioperative Rehabilitation Using a Knee Extension Device and Arthroscopic Debridement in the Treatment of Arthrofibrosis

Angie Biggs-Kinzer, MS, PT,* Brian Murphy, MS, ATC, K. Donald Shelbourne, MD, and Scott Urch, MD

Background: Arthrofibrosis is a postoperative complication of intra-articular knee surgery that can be difficult to treat. Evidence suggests that maximizing knee range of motion may improve outcomes in patients with arthrofibrosis who undergo arthroscopic debridement.

Hypothesis: Patients who achieve greater knee range of motion will have better subjective scores.

Study Design: Retrospective case series analysis.

Methods: A review of records was performed for 33 patients with arthrofibrosis who underwent knee arthroscopy and scar resection coupled with perioperative rehabilitation to maximize knee range of motion. Patient demographics and preoperative and postoperative range of motion measurements were extracted from the records. The International Knee Documentation Committee (IKDC) Subjective Knee Form was administered to assess pain, activity, and knee function. Patients performed a preoperative and postoperative rehabilitation program utilizing a knee extension device to maximize knee extension.

Results: According to the IKDC range of motion criteria, 27 of 33 patients achieved normal knee extension, and 14 of 33 achieved normal knee flexion at a mean of 8.6 months after surgery. Patients with normal knee motion had a mean IKDC Subjective Knee Form score of 72.6 ± 13.6, which was significantly higher than patients who did not achieve normal motion ($P = .04$). Overall, mean IKDC Subjective Knee Form scores improved from 45.3 ± 16.7 preoperatively to 67.1 ± 18.0 postoperatively ($P < .01$) at a mean of 14.7 months after surgery.

Conclusions: Perioperative rehabilitation that emphasizes restoration of normal knee range of motion appears to improve outcomes in patients with arthrofibrosis who undergo arthroscopic scar resection. In support of our hypothesis, patients who achieved greater knee range of motion had better subjective knee scores.

Keywords: arthrofibrosis; rehabilitation; range of motion; treatment

Arthrofibrosis is an abnormal proliferation of fibrotic tissue in and around a joint that can lead to pain, range of motion (ROM) loss, stiffness, muscle weakness, swelling, and functional limitations. It often occurs following intra-articular knee surgery such as anterior cruciate ligament (ACL) reconstruction or total knee arthroplasty (TKA).[13,15,22,24,27] Timing of surgery, correct surgical technique, preoperative ROM, and early postoperative rehabilitation are important factors in the prevention of arthrofibrosis.[6,16,33] Despite recognition of preventative measures, the incidence of arthrofibrosis ranges from 4% to 35% and remains a difficult postoperative complication to treat.[5,9]

The treatment of arthrofibrosis focuses primarily on a surgical approach, specifically arthroscopic soft tissue releases, manipulation, and open debridement as a salvage procedure.[2,5,13,14,18,25,28,34] The rehabilitation that has been reported is minimal and generally consists of serial casting and extension bracing. Millet et al[19] used a custom drop-lock

From the Shelbourne Knee Center at Methodist Hospital, Indianapolis, Indiana

*Address correspondence to Angie Biggs-Kinzer, MS, PT, Shelbourne Knee Center, 1815 N. Capitol Ave, Suite 600, Indianapolis, IN 46202 (e-mail: akinzer@aclmd.com).

One or more authors has declared a potential conflict of interest: K. Donald Shelbourne is a consultant for Kneebourne Therapeutics.

DOI: 10.1177/1941738110379088

knee orthosis to maintain knee extension postoperatively but reported that this method was inadequate. Cosgarea et al[5] reported surgical lysis of adhesions followed by bivalve casting. The cast was removed several times a day to perform supervised ROM exercises. Jackson and Schaefer[13] reported arthroscopic debridement and manipulation of the knee followed by extension casting and spring-loaded splinting for the first 30 days following surgery. Noyes et al[22] reported on the treatment of arthrofibrosis after ACL reconstruction using a heel prop exercise with a 15- to 25-lb weight over the knee for 5 to 10 minutes, 8 to 10 times a day. Knees that did not respond to this treatment were placed in daily serial casts until 0° of extension was achieved followed by posterior night splinting for an additional 7 to 10 days. Daily physical therapy visits and extension casting are both time-consuming and costly for the patient, health care provider, and insurance company. Although these techniques have been shown to improve knee ROM, it has not been reported to what extent normal ROM is achieved and what kind of functional outcomes are obtained.

In 2003, we began using a knee extension device with a rehabilitation program before and after arthroscopic debridement for arthrofibrosis.[4] To our knowledge, there have been no published reports describing a perioperative rehabilitation approach emphasizing symmetric knee extension and utilizing a knee extension device.

MATERIALS AND METHODS

Approval for the study was obtained from the institutional review board at our institution. A review of records was performed for 33 patients who sought treatment after having failed previous surgery and/or nonoperative treatment for arthrofibrosis elsewhere. Patient demographics, preoperative and postoperative ROM measures, and subjective survey results were extracted from the records. There were 19 female and 14 male patients with a mean age of 31 years at the time of surgery. The right knee was the involved limb for 18 patients and the left knee for 15 patients. Twenty-seven of the 33 patients had developed arthrofibrosis following an ACL reconstruction and 6 patients developed arthrofibrosis following a different surgical procedure or postoperative complication.

All patients underwent preoperative rehabilitation, knee arthroscopy and scar resection for arthrofibrosis, and postoperative rehabilitation. The International Knee Documentation Committee (IKDC) Subjective Knee Form had been administered prospectively as part of another ongoing study to assess pain, activity, and knee function. The IKDC Subjective Knee Form has been shown to be reliable and valid for a variety of knee disorders.[3,12] A paired *t* test was used to determine whether there was a significant difference between preoperative and postoperative IKDC Subjective Knee Form scores. The significance level was set at $P < .05$.

Range of motion measurements were taken using a goniometer as described by Norkin and White.[21] The measurements were recorded as A-B-C, with A being the degrees of hyperextension, B indicating lack of extension from 0, and C the degrees of flexion.

Figure 1. A knee extension device can be used to increase extension by applying downward pressure on the knee. The patient places the straps above and below the knee. The patient then lies supine to relax the hamstring muscles. A crank handle is used to increase the extension moment on the knee. This is performed for 10 minutes 3 to 4 times per day.

Treatment Program

Preoperative Rehabilitation. All patients were required to undergo preoperative physical therapy to maximize knee extension. Patients were issued and instructed in the use of a knee extension device (Elite Seat, Kneebourne Therapeutics, Noblesville, Indiana) (Figure 1). The knee extension device is patient controlled and provides a low-load, long-duration stretch. Patients were instructed to use the extension device for 10 minutes 3 to 4 times per day followed by towel stretching (Figure 2), heel propping (Figure 3), and prone hanging (Figure 4) exercises. Patients were also instructed to shift weight onto the involved extremity and to extend and lock out the knee when standing (Figure 5).

Surgical Procedure. Patients continued with the preoperative rehabilitation program until their progress with extension plateaued, indicating that any remaining limitation was probably attributable to the presence of scar tissue rather than the associated soft tissue tightness. Once the patient achieved maximum knee extension, he or she underwent a knee arthroscopy and scar resection. This surgical procedure has been previously described by Shelbourne et al.[32] The patient was kept overnight in the hospital and given intravenous ketoralac for inflammation and pain control. An antiembolism stocking was applied to the patient's leg and the leg was elevated in a continuous passive motion machine set at 0° to 30° degrees of movement to help prevent postoperative

Figure 2. The patient holds on to the ends of a towel that is wrapped around the ball of the foot. While using 1 hand to hold part of the leg above the patella down on the table, the other hand pulls the ends of the towel so that the knee is hyperextended and the heel lifts off the table. This stretch is held for 10 seconds and the patient performs 10 repetitions 3 to 4 times per day.

Figure 3. The patient's heel is on a bolster so that the back of the knee and thigh are off the table. The patient allows the knee to lower into extension for 10 minutes 3 to 4 times per day.

swelling. A cold/compression device (DJ Orthopedics, Inc, Vista, California) was also used to assist in preventing a hemarthrosis.

Postoperative Rehabilitation. The patient was placed on bed rest with the exception of bathroom privileges for 5 days. Knee extension exercises were initiated on the day of surgery. Patients used the knee extension device for 10 minutes 4 times per day followed by the towel stretch, heel prop, and straight leg-raise exercises. Having the patient remain on bed rest is an important factor following surgery to prevent a hemarthrosis. Evidence exists that a hemarthrosis may contribute to an inhibitory effect on the quadriceps and hamstrings muscles resulting in muscle atrophy.[7] Early quadriceps muscle activation plays a key role in achieving and maintaining knee extension.[27]

After the 5 days of bed rest, patients were allowed to resume normal activities of daily living. They were encouraged to

Figure 4. In prone position, the patient suspends both knees off the edge of a table, allowing the knees to passively extend. A weight may be added to the ankle to increase the stretch. This exercise is performed for 10 minutes 3 to 4 times per day.

Figure 5. The patient stands with full weight on the affected leg and locks out the knee into full hyperextension.

Figure 6. Patient activates the quadriceps muscle in order to raise the heel off the table.

Table 1. Grading of knee range of motion established by the International Knee Documentation Committee (IKDC).[1]

IKDC Rating[a]	Extension Difference, deg	Flexion Difference, deg
Normal	≤2	≤5
Nearly normal	3-5	6-15
Abnormal	6-10	16-25
Severely abnormal	>10	>25

[a]The difference in range of motion is compared with the opposite normal knee.

focus on increasing and maintaining knee extension and minimizing swelling. Once patients achieved knee extension equal to the opposite normal knee and were able to perform an active heel-lift exercise (Figure 6), they were instructed to begin knee flexion exercises. Patients were instructed in heel slides and wall slide exercises and educated on the importance of continuing to maintain extension during the progression to flexion exercises. If at any time, a patient began to lose knee extension, flexion exercises were discontinued until full extension was regained. The progression of this program was not time-based but rather criterion-based.

Patients were instructed to continue to work on flexion until they were able to sit on their heels and/or flexion had been maximized. If a patient had patella baja, symmetrical flexion was generally unobtainable because of the patellar tendon contracture. Three of 33 patients had patella baja.

Once patients had maximized knee ROM, they were instructed on low-impact strengthening and conditioning exercises. Patients were instructed in the progression of using a bike, elliptical trainer, or StairMaster (StairMaster, Vancouver, Washington). They were also instructed to perform a single-leg–press exercise to increase strength. Progression of the low-impact and strengthening program continued as long as ROM was not lost or compromised.

RESULTS

The mean ROM preoperatively was 0°-8°-117° in the involved knee versus 5°-0°-147° in the noninvolved knee. The mean ROM postoperatively was 3°-0°-134° in the involved knee versus 5°-0°-147° in the noninvolved knee at a mean of 8.6 months (257 days) after surgery. According to the IKDC, a difference in ROM between knees of ≤2° extension and ≤5° flexion is considered normal knee ROM (Table 1).

Twenty-seven of 33 patients achieved normal knee extension, 14 normal knee flexion, and 14 normal knee ROM (Table 2). Patients who achieved greater ROM had higher IKDC Subjective Knee Form scores (Table 3). Patients with normal knee ROM had a mean IKDC Subjective Knee Form score of 72.6 ± 13.6 (range, 45-97), which was significantly better than patients who did not achieve normal ROM ($P = .04$).

Overall, the mean IKDC Subjective Knee Form scores improved from 45.3 ± 16.7 preoperatively to 67.1 ±18.0 postoperatively ($P < .01$) at a mean of 14.7 months after surgery. All patients in this study demonstrated improved ROM, and 29 of 33 had an increase in subjective survey scores.

DISCUSSION

The results demonstrated an improvement in both ROM and subjective outcomes following arthroscopic debridement and perioperative rehabilitation. The rehabilitation program along with the use of the knee extension device preoperatively and postoperatively provided an efficient and effective way to achieve good outcomes.

Twenty-seven of 33 patients in this series achieved normal knee extension, which has been shown to be an important factor related to a good outcome after ACL reconstruction.[30] Fourteen of 33 patients achieved normal knee flexion. However, only 14 patients achieved an overall IKDC ROM rating of "normal" (evaluation of both extension and flexion), which means the limitation for most patients after treatment was in flexion. Four patients were in the "severely abnormal" category after treatment and 2 of them had patella baja. Once the patellar tendon becomes contracted, normal flexion may be unobtainable. For patients in this series, the mean flexion difference between knees was 13° at discharge, which is considered "nearly normal" by IKDC criteria. The mean improvement in extension from preoperative to postoperative was 11° (range, 2°-28°) and the mean improvement in flexion was 17° (range, –5° to 60°).

Table 2. Number of patients in each International Knee Documentation Committee category for range of motion before and after treatment.

	Normal	Nearly Normal	Abnormal	Severely Abnormal
Before treatment	0	7	5	21
After treatment	14	12	3	4

Table 3. Mean ± standard deviation (range) of International Knee Documentation Committee (IKDC) subjective total scores for each IKDC objective category for range of motion at follow-up.

	Normal	Nearly Normal	Abnormal	Severely Abnormal
Mean IKDC score after treatment[a]	72.6 ± 13.6 (45-97)	68.8 ± 20.6 (38-99)	63.0 ± 11.5 (54-76)	45.8 ± 8.3 (39-57)

[a]Patients who had an overall rating of normal for the IKDC objective rating had statistically significantly higher subjective scores than patients in other groups ($P = .04$).

Patients had significant improvements in IKDC Subjective Knee Form scores following treatment, and the improvement in subjective scores was related to the improvement in knee ROM. A mean Subjective Knee Form score of 67, although not ideal, represents functional improvement for patients but also illustrates the importance of following postoperative rehabilitation protocols that prevent arthrofibrosis from occurring.

Range of motion is an important factor in successful outcomes in both operative[2,10,16,19,26,29,32] and nonoperative knee injuries and knee pain.[20,35] While any loss of knee ROM can lead to pain and functional limitations, the loss of knee extension is less tolerated than the loss of knee flexion.[27] It is difficult to improve both knee extension and flexion at the same time; therefore, the focus was to increase and maximize knee extension first followed by knee flexion. Research has shown that obtaining full knee hyperextension equal to the opposite normal knee is one of the most important factors in contributing to a successful outcome after ACL reconstruction.[2,10,19,30,31,33] Knee hyperextension is normal for many patients[8] and therefore important to restore in the rehabilitation process. This rehabilitation program emphasized the restoration of knee extension and flexion equal to the opposite knee and these results indicate that greater ROM is associated with better subjective outcomes (Table 3). These results are consistent with other reports showing an association between subjective outcomes and improved ROM.[11,19,32] Therefore, patients were instructed to maximize and maintain as much ROM as possible because this is the key for optimal knee function in the long term.

Noyes et al[22] reported on 9 patients who underwent serial casting following a loss of ROM after ACL reconstruction. The mean extension before surgery was –4° (or lacking 4° from 0° extension) and all patients achieved 0° of extension at a mean of 26 weeks postoperatively. However, they did not report ROM of the noninvolved knee and there were no subjective outcomes reported.[22]

Hassan et al[11] reported on 13 knees in 12 patients who had a symptomatic loss of knee extension following ACL reconstruction. Patients underwent arthroscopic debridement and manipulation at a mean of 12 months after surgery. The rehabilitation protocol emphasized knee extension via prone heel hang and quadriceps muscle strengthening with occasional extension board splinting. Knee extension deficits improved from a mean of 10° to 3°; however, ROM from the opposite normal knee was not considered. The mean postoperative Lysholm score was 89 of a possible 100 and the mean modified Hospital for Special Surgery score was 90 of a possible 100 at final evaluation.

Aglietti et al[2] reported on 31 patients who underwent arthrolysis for loss of ROM and reported ROM using the IKDC criteria. Although patients did improve in ROM, no patients achieved normal knee ROM and 15 achieved near-normal ROM at final follow-up.

It is difficult to compare results between studies because of differences in ROM measurement and reporting. Some authors report knee extension measurements taken in a supine position, while others report knee extension based on heel-height differences when prone. Flexion is measured supine, prone, or sitting, and ROM measures are rarely compared to the opposite knee. According to the IKDC, patients who have ≤2° difference in extension between knees and ≤5° difference in flexion have normal knee ROM (Table 1). For example, if a patient's noninvolved knee has 5° of hyperextension and the involved knee is lacking 2° of extension from 0°, a 7° difference in knee extension should be reported (not 2°). In

addition to differences in ROM measurement techniques, there are significant differences in what is considered normal or acceptable ROM following treatment. In contrast to some authors who believe that the goal of knee ROM should be 0° to 135°,[22] we believe that normal knee ROM is unique to each individual, and people with normal knees have symmetric ROM. According to DeCarlo and Sell,[8] 95% of males and 96% of females have some degree of knee hyperextension. On average, males have a mean of 5° and females have a mean of 6° of hyperextension.[8] Regaining knee hyperextension equal to the opposite normal knee is important to obtain normal knee function, help prevent anterior knee pain, and prevent arthrofibrosis.

Many of the articles written on arthrofibrosis pertain to its occurrence after ACL reconstruction.[9,11,17,23] We have found that arthrofibrosis can occur following ACL surgery with any graft source (patellar tendon, hamstring, and cadaver) as well as after arthroscopy, patellar realignment, and meniscus or articular cartilage repairs. Most of the patients in this study developed arthrofibrosis following an ACL reconstruction; however, an emphasis of proper rehabilitation and restoration of normal knee ROM following any knee surgery is warranted.

The treatment of arthrofibrosis can be costly to both the patient and the insurer. Many patients will undergo numerous physical therapy treatments and sometimes multiple surgical procedures in an attempt to increase knee ROM and function and to decrease pain. Serial casting is time-, labor-, and cost-intensive. Using a knee extension device may help reduce some of the costs and time associated with the treatment approaches described by others,[5,13,19,22] because the knee extension device can be used independently and as often as necessary without having to attend daily physical therapy sessions. Therefore, the knee extension device may not only provide for better knee extension, but also assist in reducing costs in the treatment of arthrofibrosis. The actual cost of the rehabilitation was not evaluated in this study, however, and further study is needed to establish which method might reduce health care costs while achieving the best results.

SUMMARY

This study provides a perioperative rehabilitation program using a knee extension device in the treatment of arthrofibrosis and reports the outcomes achieved. This program focused on increasing knee extension both preoperatively and immediately postoperatively using a knee extension device. Patients who achieved greater ROM reported higher IKDC Subjective Knee Form scores, demonstrating the importance of increasing knee ROM. While prevention of arthrofibrosis remains the best form of treatment, this program provides a means to improve the function and outcomes of patients who do develop arthrofibrosis.

REFERENCES

1. American Orthopaedic Society for Sports Medicine. 2000 IKDC Knee Examination Form. Available at: http://www.sportsmed.org/tabs/research/ikdc.aspx. Accessed April 15, 2010.
2. Aglietti P, Buzzi R, De Felice R, Paolini G, Zaccherotti G. Results of surgical treatment of arthrofibrosis after ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 1995;3:83-88.
3. Anderson AF, Irrgang JJ, Kocher MS, et al. The International Knee Documentation Committee Subjective Knee Evaluation Form: normative data. *Am J Sports Med.* 2006;34:128-135.
4. Biggs A, Shelbourne KD. Use of a knee extension device during rehabilitation of a patient with type 3 arthrofibrosis after ACL reconstruction. *NAJSPT.* 2006;1(3):124-131.
5. Cosgarea AJ, DeHaven KE, Lovelock JE. The surgical treatment of arthrofibrosis of the knee. *Am J Sports Med.* 1994;22(2):184-191.
6. Cosgarea AJ, Sebastianelli WJ, DeHaven KE. Prevention of arthrofibrosis after anterior cruciate ligament reconstruction using the central third patellar tendon autograft. *Am J Sports Med.* 1995;23:87-92.
7. de Andrade JR, Grant D, Dixon A St J. Joint distension and reflex muscle inhibition in the knee. *J Bone Joint Surg Am.* 1965;47:313-322.
8. DeCarlo MS, Sell KE. Normative data for range of motion and single-leg hop in high school athletes. *J Sport Rehabil.* 1997;6(3):246-255.
9. DeHaven KE, Cosgarea AJ, Sebastianelli WJ. Arthrofibrosis of the knee following ligament surgery. *Instr Course Lect.* 2003;52:369-381.
10. Fisher SE, Shelbourne KD. Arthroscopic treatment of symptomatic extension block complicating anterior cruciate ligament reconstruction. *Am J Sports Med.* 1993;21:558-564.
11. Hassan SS, Saleem A, Bach BR, Bush-Joseph CA, Bojchuk J. Results of arthroscopic treatment of symptomatic loss of extension following anterior cruciate ligament reconstruction. *Am J Sports Med.* 2000;13(4):201-210.
12. Irrgang JJ, Anderson AF, Boland AL, et al. Development and validation of the International Knee Documentation Committee subjective knee form. *Am J Sports Med.* 2001;29:600-613.
13. Jackson DW, Schaefer RK. Cyclops syndrome: loss of extension following intra-articular anterior cruciate ligament reconstruction. *Arthroscopy.* 1990;6(3):171-178.
14. Klein W, Shah N, Gassen A. Arthroscopic management of postoperative arthrofibrosis of the knee joint: indication, technique, and results. *Arthroscopy.* 1994:10(6):591-597.
15. Maloney WJ. The stiff total knee arthroplasty: evaluation and management. *J Arthroplasty.* 2002;17(4):71-73.
16. Maloney WJ, Schurman DJ. The effects of implant design on range of motion after total knee arthroplasty. *Clin Orthop Related Res.* 1992;278:147-152.
17. Mayr HO, Weig TG, Plitz W. Arthrofibrosis following ACL reconstruction—reasons and outcome. *Arch Orthop Trauma Surg.* 2004;123:518-522.
18. Millet PJ, Wickiewicz TL, Warren RF. Motion loss after ligament injuries to the knee. *Am J Sports Med.* 2001;29:822-828.
19. Millet PJ, Williams RJ, Wickiewicz TL. Open debridement and soft tissue release as a salvage procedure for the severely arthrofibrotic knee. *Am J Sports Med.* 1999;27(5):552-561.
20. Minor M. Exercise in the treatment of osteoarthritis. *Rheum Dis Clin North Am.* 1999;25(2):397-415.
21. Norkin CC, White DJ. *Measurement of Joint Motion: A Guide to Goniometry.* 3rd ed. Philadelphia, PA: FA Davis Co; 2003.
22. Noyes FR, Berrios-Torres S, Barber-Westin SD, Heckman TP. Prevention of permanent arthrofibrosis after anterior cruciate ligament reconstruction alone or combined with associate procedures: a prospective study in 443 knees. *Knee Surg Sports Traumatol Arthrosc.* 2000;8:196-206.
23. Noyes FR, Mangine RE, Barber S. Early knee motion after open and arthroscopic anterior cruciate ligament reconstruction. *Am J Sports Med.* 1987;15:149-160.
24. Papagelopoulos PJ, Sim FH. Limited range of motion after total knee arthroplasty: etiology, treatment, and prognosis. *Orthopedics.* 1997;20(11):1061-1065.
25. Parisien JS. The role of arthroscopy in the treatment of postoperative fibroarthrosis of the knee joint. *Clin Orthop Relat Res.* 1988;229:185-192.
26. Parsley BS, Engh GA, Dwyer KA. Preoperative flexion: does it influence postoperative flexion after posterior-cruciate-retaining total knee arthroplasty? *Clin Orthop Related Res.* 1992;275:204-210.
27. Paulos LE, Rosenberg TD, Drawbert J, et al. Infrapatellar contracture syndrome : an unrecognized cause of knee stiffness with patella entrapment and patella infera. *Am J Sports Med.* 1987;15:331-341.
28. Richmond JD, Assal MA. Arthroscopic management of arthrofibrosis of the knee, including infrapatellar contraction syndrome. *Arthroscopy.* 1991;7(2):144-147.
29. Ritter MA, Stringer EA. Predictive range of motion after total knee replacement. *Clin Orthop Related Res.* 1979;143:115-119.

30. Shelbourne KD, Gray T. Minimum 10-year results after anterior cruciate ligament reconstruction. how the loss of normal knee motion compounds other factors related to the development of osteoarthritis after surgery. *Am J Sports Med*. 2009;37(3):471-480.
31. Shelbourne KD, Johnson GE. Outpatient surgical management of arthrofibrosis after anterior cruciate ligament surgery. *Am J Sports Med*. 1994;22(2):192-197.
32. Shelbourne KD, Patel DV, Martini DJ. Classification and management of arthrofibrosis of the knee after anterior cruciate ligament reconstruction. *Am J Sports Med*. 1996;24(6):857-862.
33. Shelbourne KD, Wilkens JH, Mollabashy A, et al: Arthrofibrosis in acute anterior cruciate ligament reconstruction: the effect of timing of reconstruction and rehabilitation. *Am J Sports Med*. 1991;19:332-336.
34. Steadman JR, Burns TP, Peloza J, et al. Surgical treatment of arthrofibrosis of the knee. *J Orthop Techn*. 1993;1(3):119-128.
35. Vad V, Hong HM, Zazzali M, et al. Exercise recommendations in athletes with early osteoarthritis of the knee. *Sport Med*. 2002;32(11):729-739.