2017

Mechanical Diagnosis and Therapy and Directional Preference as an Adjunct to Lower Extremity Strengthening in Meniscus Tear Treatment: A Case Report

Joel Gourley
University of Iowa

Mechanical Diagnosis and Therapy and Directional Preference as an Adjunct to Lower Extremity Strengthening in Meniscus Tear Treatment: A Case Report.

Joel Gourley

DPT Class of 2017
Department of Physical Therapy & Rehabilitation Science
The University of Iowa

Abstract:

Background: Meniscal tears remain a highly prevalent injury with 61/100,000 people seeking treatment and 35% of people over the age of 50 having a positive meniscal tear finding on MRI.[1,2] Partial meniscectomies are one treatment option for meniscal tears, but 71.4% of surgical patients show signs of osteoarthritis at a 7-year follow-up.[6] With this high prevalence, conservative treatment provides another possible treatment. Thus, the purpose of this case report is to present the conservative treatment option of Mechanical Diagnosis and Therapy (MDT) and directional preference as adjunct therapies to lower extremity strengthening in a patient with a meniscus tear. **Case Description:** A 56-year-old female with a history of knee osteoarthritis, injured the medial meniscus of her right knee when attempting to stop a fall on her steps at home. **Intervention:** Mechanical Diagnosis and Therapy (MDT) and directional preference was used as an adjunct to lower extremity strengthening. Treatments included repeated knee flexion and extension and strengthening exercises such as step ups, squats, and manual therapy. **Outcomes:** The Lower Extremity Functional Scale (LEFS), manual muscle testing, and subjective percentages of improvement were used to assess progress throughout the treatment episode. The patient improved by 10 points on the LEFS with a MDC and MCID of 9 points.[21] This correlates with an increase of 12.5% in function while the patient reported 70% improvement. Her right lower extremity strength improved from 3+/5 to 4+/5 in all myotomes with initial deficits. **Discussion:** The results were inconclusive for MDT and directional preference as an adjunct to lower extremity strengthening as our patient had similar functional and self-reported outcomes when compared to a study using similar strengthening exercises.

Introduction and Background

Meniscal tears are a highly prevalent orthopedic injury with an approximately 61/100,000 people seeking treatment per/year.[1] Older populations have an even greater incidence with one study finding 35% of people older than 50 having a positive finding of a meniscus tear on MRI.[2] Meniscal tears are even more prevalent with 75% of subjects having a positive meniscal tear finding on MRI combined with symptomatic osteoarthritis (OA).[3] While a meniscus tear in itself can be trying for the patient and their healthcare providers, it is this connection to osteoarthritis and further knee degeneration that makes meniscus management so crucial. While a meniscus tear can lead to increased degeneration, surgery for meniscus tears may also increase the risk of developing OA.

The menisci play a vital role in load distribution transmitting approximately 70-90% of axial load and tears or degeneration lead to an increased risk of knee osteoarthritis.[4,5] Partial meniscectomies account for approximately 50% of all orthopedic surgeries completed in the U.S and research shows they are a leading cause of knee OA.[6] One study found that 71.4% of their subjects displayed radiographic evidence of knee osteoarthritis on a 7-year follow-up from arthroscopic meniscectomy.[7] Additionally, 40% of their subjects that displayed evidence of knee OA upon follow-up had negative preoperative findings supporting the premise that meniscal damage and surgery increases a patient's chance of developing OA. Further studies have revealed that the amount and location of the removed meniscus following surgery also plays a role. One study found that there is an inverse relationship to the amount of meniscus removed and the function of the knee in meniscal surgeries except when treating a bucket-handle tear with a partial meniscectomy.[8] They also discovered that conserving the peripheral rim of the meniscus results in the best functional outcome. Furthermore, anywhere from 9-42% of meniscus repairs may fail.[9,10] Meniscal surgeries come with all the risks of normal surgery as well as the risks noted above. These findings support the preservation of meniscal tissue and emphasize the importance of investigating conservative treatment.

In addition to surgical treatment, there are several conservative treatment options for meniscal damage or tears including lower extremity strengthening and repetitive movements. Studies support conservative treatment approaches for degenerative meniscal damage as well as in the presence of osteoarthritis.[11] Research also supports partial meniscectomies when the tear/damage is in the white zone of the meniscus and meniscal repairs when the patient is capable of completing post-surgical rehab. Conservative treatment techniques have been explored with positive findings for increasing knee joint function and reducing knee joint pain.[12] These studies have typically focused on lower extremity strengthening. Fewer studies have investigated the effects of specific approaches, such as Mechanical Diagnosis and Therapy (MDT), on joint function and reduction of pain in patients with meniscal tears/damage.

MDT, proposed by McKenzie, is a method of diagnosing conditions in patients based on symptomatic and mechanical responses to movement.[13] Instead of determining the exact medical cause of pain or lack of function, MDT determines more broad causes and breaks them down into dysfunction categories. These categories include: derangement, articular dysfunction, contractile dysfunction, postural syndrome, and other categories. If a condition doesn't fit in one of the first 4 conditions then it is in the "other category" and considered non-mechanical. This may include trauma or surgery. While MDT will diagnose and classify mechanical syndromes, directional preference is a treatment method proposed based on being placed in the derangement category.[13] This implies the patient has a derangement in the joint that will respond either positively or negatively to a repeated movement. For instance, a patient with a bulging disc may have increased symptoms with repeated forward flexion and decreased symptoms with repeated extension. So, the treatment for such patient is repeated extension to improve function and decrease pain.

Positive effects of MDT and directional preference treatments have been seen for knee OA and meniscus tears.[13,14,15] However, there remains little information about the use of MDT and directional preference treatment specifically for meniscal tears. Thus, the purpose of this case reports is to describe the implementation of MDT and directional preference treatment as an adjunct to lower

extremity strengthening in a 56-year-old female with a medial meniscus tear and several co-morbidities to consider.

Case Description

A 56-year-old female was referred to physical therapy by her physician for conservative treatment of a medial meniscus tear in right knee as an attempt to avoid surgery. Her injury was confirmed by x-rays and an MRI. In addition, she had several co-morbidities, including arthritis, diabetes mellitus, hypertension, and morbid obesity. This patient was chosen due to the complexity of the case, the lack of research completed for Mechanical Diagnosis and Treatment and directional preference treatment, and the patient's unique presentation. Additionally, most literature demonstrates a relationship between older patients with arthritis and degenerative meniscal tears while our patient was an older patient with a traumatic tear.

History of chief complaint: The patient reported feeling a stabbing sensation through the front and inside of her right knee after a near fall in her home approximately 6 weeks prior to her initial evaluation. While walking up the stairs at home, she began to fall and tried catching herself with her right leg. She said that she felt a pop in her right knee and her niece ended up catching her to prevent the fall. Our patient said that maneuvering up and down stairs as well as sudden movements were the most difficult and painful.

Past medical history: The patient's past medical history was involved and included several conditions that can complicate the healing and therapy process. Our patient had diagnoses of arthritis, diabetes mellitus, hypertension, and morbid obesity among others.

Living situation: The patient lives in a house with 5 family members, and multiple stairs. There are 3 stairs inside of the home, 8 stairs to enter from the back door, and 4 stairs to enter the front door. The patient informed us that the back stairs have handrails on each side while the remaining stairs have no handrails.

Examination and evaluation: As a part of the initial examination, we assessed range of motion (ROM) and strength measurements using goniometry and manual muscle testing (MMT). The patient presented with decreased right knee range of motion with limited terminal knee extension and flexion (11-124 degrees) when compared to the uninvolved leg (0-137 degrees). The patient's strength was also greatly limited compared to the uninvolved leg, receiving 3+/5 on manual muscle testing throughout the right leg and 5/5 throughout the left leg. Pain was rated as 7/10 at the initial evaluation.

The initial evaluation also included special and standardized tests as well as a gait assessment. The patient had increased tenderness on the medial joint line of the right knee. She also tested positive with McMurray's Test and Apley's compression/distraction test with increased reports of pain with McMurray's compression, but decreased reports with distraction. McMurray's test has been found to have a sensitivity of 79.7% and specificity of 78.5%, while Apley's has a sensitivity of 83.7% and specificity of 71.4% for identifying meniscal tears.[16] She had increased pain with a knee valgus test as well. The Lower Extremity Functional Scale (LEFS) is a standard measure used to assess patient function. She scored 27/80 on the LEFS at her initial evaluation which is equivalent to 33.75% of normal function. The patient ambulated with a quad tip cane, decreased knee flexion, decreased knee extension, decreased toe off, and decreased stance time on the right lower extremity. The patient indicated her goals included being able to stand on her feet for 4+ hours and to be able to ambulate stairs with pain less than 5/10. Additional goals included: increasing all MMT grades by ½ grade, being independent with her home exercise program, and improving her LEFS score to 65/80.

Clinical Impression

The patient had significant impairment due to her recent traumatic knee meniscal tear, as indicated by her low LEFS score as well as her strength and ROM assessments. Additionally, her function was compromised by her complex medical history. Arthritis can limit the exercises we could prescribe in both her uninvolved and involved legs due to pain. Further, diabetes, hypertension, and

obesity can all impair the body's ability to heal. We chose to target her impairments with the use of strengthening exercises coupled with high repetitions following the MDT approach to reduce pain.

Interventions

Specific treatments and interventions were developed and progressed from the available research outlined below. Repetitions and weight were advanced according to patient tolerance. The patient completed 8 therapy sessions including the initial evaluation and discharge visits. The sessions were spread over 5 consecutive weeks with an initial plan of seeing the patient 2x/week for 8 weeks.

The interventions we implemented with our patient included aerobic conditioning, lower extremity strengthening, and aspects of MDT and directional preference treatment. The general lower extremity strengthening exercises were accrued from a variety separate studies. Part of our interventions were taken from a case series that included 20 middle-aged patients with knee OA and a meniscal tear.[17] These patients' treatment program included aerobic training on the stationary bike, double-leg squats, single-leg squats, step-ups, hip abduction stability, and single-leg press, curl, hops, and extension. Similarly, the University of Southern Maine has released a meniscal tear rehabilitation protocol that includes quad sets, straight leg raises (SLR), short-arc quads (SAQ), toe raises, lunges, and squats.[18] The next study included middle-aged patients (average age 53.8 years) who were diagnosed with horizontal, degenerative tears of the medial meniscus.[19] Their home exercise program (HEP) and treatment included soft tissue mobilization with stretching of knee flexors and extensors, stationary biking, seated knee flexion and extension, half-squats and squats. The program emphasized strengthening, endurance, and flexibility. Additionally, a prospective randomized trial underlined the importance of proprioception being included in the rehabilitation process for meniscal tears.[20]

While the exercises described above were implemented to improve strength, endurance, or proprioception and decrease pain secondarily, MDT diagnoses conditions and utilizes directional preference movements to target pain primarily. Based on this method, it is hypothesized that joint derangements, such as meniscal tears, can utilize repeated movements to smooth down lesions/derangements to decrease pain and increase function.[13,14,15] In the derangement classification of pain syndromes, repeated movements into the non-painful motion, or motion that decreases the pain, and temporary cessation of movements into the motion that increases pain are the proposed treatments.[13] Less research has been completed on the usage of MDT and directional preference as an adjunct to treating meniscal tears. A case report completed using MDT and directional preference utilized repeated passive knee extension on an 18-year-old swimmer for treatment of a meniscus lesion.[14] Exercises began in seated and were progressed to standing to utilize increased force in weightbearing. The patient completed 40-50 repetitions daily at home and following 20 days and 5 sessions reported 95% improvement.

All treatment sessions began with aerobic training on the Nustep for 7-8 minutes or squats on the total gym for 4 minutes. Following aerobic training, the first session included repeated, active/passive knee flexion and extension with short walks following to assess effect of repeated movements. Straight leg raises and quad sets were implemented to begin strengthening exercises (1 set of 10 repetitions).

In addition to the exercises performed at the first visit, the second and third sessions included SAQs (60 repetitions) for strengthening and as a repeated movement for pain management. The patient also completed terminal knee extension with a yellow theraband (30 repetitions). Additionally, 4-inch step ups and lateral heel touches were performed as a progression of quad strengthening. The step-ups were also used to assess progression of achieving her goal for walking up stairs with less than 5/10 pain.

The fourth session included SAQ for 30 repetitions for pain management, SLR (20 repetitions), 6" steps ups (30 repetitions), and lateral heel touches (20 repetitions). Hip adduction and abduction isometrics were added to begin hip stability strengthening, and seated hamstring stretching and patellar mobilizations were added to improve mobility. The fifth session began with red theraband terminal knee

extension for 30 repetitions as the patient had begun to receive more pain relieve from this than SAQ. 6" step ups and lateral step ups were also completed. Hip abduction and stability strengthening were progressed to isotonics at 30 repetitions and 5lbs per lower extremity. The sixth session included all exercises completed in the fifth session as well as the addition of single leg stance and tandem stance for proprioceptive exercises.

The seventh session the patient reported a setback with increased pain. SAQ were completed with no-to-little pain relief. Repeated knee flexions were then completed with decreased pain and symptoms. Passive knee flexions were then continued for 30 repetitions and added to the patients' HEP. The patient then completed a follow-up with her doctor who informed her physical therapy was no longer necessary and the patient was discharged on her 8th visit with instructions to continue her home exercise program and call if any problems arose.

Outcomes

The patient completed 8 visits, including initial evaluation and discharge visits, over the course of 5 weeks. Several evaluative measures were taken with primary measures of LEFS scores, manual muscle testing, and subjective percentage of improvement. The patient's pain level and knee ROM were also recorded as secondary measures allowing us to assess improvements in pain, function, strength, and range of motion categories. The patient achieved 4 out of 5 goals by increasing all manual muscle test scores by at least ½ grade, being able to stand for more than 4 hours, being able to ambulate home stairs with less than 5/10 pain, and being independent with her home exercise plan and self-care management. Her fifth goal, outlined below, was based on her LEFS scores and was partially met.

The patient began with 33.75% of normal function based on the LEFS. The minimal detectable change and the minimally clinically important difference (MCID) for the LEFS is a change of 9 points.[21] Our patient had an increase of 10 points to 37/80 which correlates with a 12.5% increase in function since the beginning of rehabilitation and exceeds the MCID. However, our goal for the patient was an LEFS score of 65/80, or 81.25% of normal function, and so this goal was only partially met.

The patient's initial MMT grades and knee ROM have been discussed above. Following the 5-week physical therapy intervention, the patient received 4+/5 on all manual muscle tests for the right lower extremity and improved her right knee range of motion to 0-125 degrees. The MDC for knee goniometry has been found to be 8.2, but no MCID was found for this measure.[22] The last two measures that were recorded throughout the treatment episode were subjective pain scales and percentage of improvement. The patient's reported pain ranged from 0-7/10 with a score of 7/10 on evaluation and 4/10 on discharge. The patient had only one session with a score of 0/10 for pain. When asked during discharge what her overall improvement had been since beginning therapy the patient reported 70% improvement. Additionally, the patient was no longer using a cane and had no noticeable deficits with gait.

Discussion

The purpose of this case report was to present the use of MDT and directional preference as an adjunct to lower extremity strengthening in a complex patient with a medial meniscus tear. MDT and directional preference hypothesize that mechanical dysfunctions, such as a torn meniscus, can be treated by repeated movements in a direction that improves pain. Overall, the patient showed improvement in both strength and pain in 5 weeks and 8 visits. While we cannot ascertain whether the addition of MDT resulted in better outcomes than if strengthening exercises alone had been utilized, on most visits, the patient tolerated the highly repetitive movements into a pain-free range very well. Throughout our sessions the patient discovered that her pain could be managed through the repeated movements and often would begin her session with these exercises or repeat these exercises when her pain was elevated. She originally responded to repeated knee extension with decreased pain and improved function following SAQ and terminal knee extension. Prior to our 7th session, though, the

patient had a setback completing tandem stance exercises at home and had increased pain to 7/10 at the 7th session. Repeated knee extension exercises were attempted at the beginning of the session with no reduction in symptoms. As a part of MDT and directional preference protocol, repeated flexion exercises were then completed as a reevaluation to see if the patient's directional preference had changed. Passive knee flexion was completed at the edge of the bed followed by a short walk around the gym. The patient's pain score was then slightly decreased and so 30 repetitions of passive knee flexion were completed with her pain score decreasing to 4/10 upon completion of the session.

The benefits of lower extremity strengthening and neuromuscular training have been seen in a study on rehabbing degenerative meniscal tears. The study found 16/20 patients had improved function on the KOOS scale, and 19/20 patients rated themselves at "better" or "a lot better" on the Global Rating of Change scale using similar strengthening exercises as our patient.[17] Additionally, all patients in this study improved their knee extension strength from 5-74% and 18/20 subjects improved their knee flexion torque by at least 3%. The study evaluated performance through the 1-leg hop for distance and 6-meter timed hop with 14 patients improving on the 1-leg hop and 16 patients improving on the 6-meter timed hop. This further supports conservative treatment and the effects of lower extremity strengthening for degenerative meniscal tear treatment.

This case supports the hypothesis that MDT and directional preference are appropriate adjuncts for treating and decreasing pain in a patient with a complex medical history and a meniscus tear, but we are unable to assess whether this intervention improved her function more than strengthening alone. Our patient had similar functional outcomes when compared to the patients in the above case series, who received only strength training. However, we assessed function employing the LEFS and reported percent improvement versus the previous study which used the KOOS scale and Global Rating of Change Scale, thus a direct comparison is not possible.

The strengthening protocol utilized for this patient was a combination of exercises collected from 3 different studies that had investigated meniscal tear rehabilitation with each study having positive, but different outcome evaluations. While these studies involved patients suffering from degenerative meniscal tears, our patient responded reasonably well with improved strength, decreased pain, and improved function. As mentioned earlier, degenerative meniscal tears have been found to respond well to conservative treatment, such as physical therapy, while traumatic tears more often are treated surgically. This case report provides one example of a patient that had minimal adverse effects from the strengthening program, and overall demonstrated improvement despite having a traumatic meniscal tear.

The patient was originally to receive 16 treatments at 2 visits per week for 8 weeks. Due to scheduling and doctor and patient preference, the patient was discharged following only 8 visits and 5 weeks. The lack of completing the entire treatment episode and receiving all interventions may have led to decreased outcomes for the patient. Based on her LEFS percent improvement and manual muscle testing, the patient continued to have functional and strength deficits that may have been able to be improved or assessed had the entire treatment protocol been completed. However, it is also possible that the one episode of increased pain was a deterrent to continuing with the conservative treatment approach.

In addition to the MDT approach, another potential conservative treatment option we could have used is the Mulligan Concept (MC) Squeeze Technique. This is a manual therapy intervention that involves repeated knee movements with pressure over tender areas.[6] To complete this technique, the patient flexes their knee through a pain-free motion. The therapist then places overlapping thumbs over the area of tenderness and swelling and the patient extends their knee. As the patient extends their knee and the joint space closes, the therapist decreases their overpressure. The patient then flexes their knee again with the therapist reapplying pressure and providing overpressure for knee flexion for 2 seconds at end range.

One study completed utilized the MC Squeeze Technique looked at 5 athletes ranging from 15-24 years old with acute meniscus tear symptoms.[6] Treatments were completed over an average of 14.2

days and all patients were discharged following 6 treatment sessions. This study found statistically significant improvements in all outcome assessments including the KOOS. Additionally, all participants were able to return to full activity and sport status following interventions

Another possible adjunct for lower extremity strengthening in patients with meniscus tears is a foot-worn device. A study completed looked at the effects of foot-worn devices on 34 patients with degenerative meniscus tears.[23] The study analyzed each patients' gait and then used the Apos System and AposTherapy to apply a biomechanical device to each patients' shoe. The device includes two half spheres attached to a platform on the sole of the shoe. Each element was sized specifically to each patient and adjusted to provoke biomechanical challenges based on patient's need. Patients were then instructed to walk every day with the device on beginning with 10 minutes/day and increasing their time gradually. The study found that by 12 months significant improvements had been made in patients' gait velocity, step length, and single-limb support. Significant improvements were also found in patients' WOMAC scores which evaluates pain, stiffness, and physical function.

Conclusion

In conclusion, there are numerous options and tactics for treating a meniscus tear. While surgery remains very common for traumatic meniscal tears, research supports the use of conservative care for degenerative tears.[11] This case report highlighted the use of MDT and directional preference as an adjunct to lower extremity strengthening in a patient with a traumatic meniscus tear coupled with a complex medical history.

Our patient, with a traumatic tear, had positive outcomes that generally exceeded assessment MCD or MCIDs, and had similar results to patients with degenerative tears in studies utilizing solely strengthening protocols. While this makes our results somewhat inconclusive as to whether the MDT helped beyond the strengthening, the patient received pain relief from MDT and directional preference therapy. This case supports that strengthening with repetitive movements consistent with the MDT approach should be further investigated in controlled research studies. Further research remains essential as meniscus tears continue to be a common orthopedic injury.[1]

References:

1. Jones JC, Burks R, Owens BD, Sturdivant RX, Svoboda SJ, Cameron KL. Incidence and risk factors associated with meniscal injuries among active-duty US military service members. J Athl Train. 2012;47(1):67-73.
2. Englund M, Guermazi A, Gale D, et al. Incidental meniscal findings on knee MRI in middle-aged and elderly persons. N Engl J Med. 2008;359(11):1108-15.
3. Bhattacharyya T, Gale D, Dewire P, et al. The clinical importance of meniscal tears demonstrated by magnetic resonance imaging in osteoarthritis of the knee. J Bone Joint Surg Am. 2003;85-A(1):4-9.
4. Kim JG, Lee YS, Bae TS, et al. Tibiofemoral contact mechanics following posterior root of medial meniscus tear, repair, meniscectomy, and allograft transplantation. Knee Surg Sports Traumatol Arthrosc. 2013;21(9):2121-5.
5. Rai MF, Mcnulty AL. Meniscus beyond mechanics: Using biology to advance our understanding of meniscus injury and treatment. Connect Tissue Res. 2017;58(3-4):221-224.
6. Hudson R, Richmond A, Sanchez B, et al. AN ALTERNATIVE APPROACH TO THE TREATMENT OF MENISCAL PATHOLOGIES: A CASE SERIES ANALYSIS OF THE MULLIGAN CONCEPT "SQUEEZE" TECHNIQUE. Int J Sports Phys Ther. 2016;11(4):564-74.
7. Boszotta H, Helperstorfer W, Kölndorfer G, Prünner K, Ohrenberger G. [Long-term results of arthroscopic meniscectomy]. Aktuelle Traumatol. 1994;24(1):30-4.
8. Hede A, Larsen E, Sandberg H. The long term outcome of open total and partial meniscectomy related to the quantity and site of the meniscus removed. Int Orthop. 1992;16(2):122-5.

9. Getgood A, Robertson A. Meniscal tears, repairs and replacement- a current concepts review. Orthop Trauma. 2010;24(2):121-128.
10. Bin S, Kim J, Shin S. Radial tears of the posterior horn of the medial meniscus. Arthroscopy, 2004;20(4):373-378.
11. Mordecai SC, Al-hadithy N, Ware HE, Gupte CM. Treatment of meniscal tears: An evidence based approach. World J Orthop. 2014;5(3):233-41.
12. Börjesson M, Robertson E, Weidenhielm L, Mattsson E, Olsson E. Physiotherapy in knee osteoarthrosis: effect on pain and walking. Physiother Res Int. 1996;1(2):89-97.
13. Fernández de las Peñas CCA, Cleland J, Dommerholt J. *Manual therapy for musculoskeletal pain syndromes: an evidence- and clinical-Informed approach*. Elsevier; 2016.
14. Lynch G, May S. Directional preference at the knee: a case report using mechanical diagnosis and therapy. J Man Manip Ther. 2013;21(1):60-6.
15. Rosedale R, Rastogi R, May S, et al. Efficacy of exercise intervention as determined by the McKenzie System of Mechanical Diagnosis and Therapy for knee osteoarthritis: a randomized controlled trial. J Orthop Sports Phys Ther. 2014;44(3):173-81, A1-6.
16. Rinonapoli G, Carraro A, Delcogliano A. The clinical diagnosis of meniscal tear is not easy. Reliability of two clinical meniscal tests and magnetic resonance imaging. Int J Immunopathol Pharmacol. 2011;24(1 Suppl 2):39-44.
17. Stensrud S, Roos EM, Risberg MA. A 12-week exercise therapy program in middle-aged patients with degenerative meniscus tears: a case series with 1-year follow-up. J Orthop Sports Phys Ther. 2012;42(11):919-31.
18. Spencer N, Willis J, Schilling J. Conservative Treatment for Meniscus Rehabilitation. *Conservative Treatment for Meniscus Rehabilitation*.
19. Yim JH, Seon JK, Song EK, et al. A comparative study of meniscectomy and nonoperative treatment for degenerative horizontal tears of the medial meniscus. Am J Sports Med. 2013;41(7):1565-70.
20. Herrlin S, Hållander M, Wange P, Weidenhielm L, Werner S. Arthroscopic or conservative treatment of degenerative medial meniscal tears: a prospective randomised trial. Knee Surg Sports Traumatol Arthrosc. 2007;15(4):393-401.
21. Lower Extremity Functional Scale (LEFS). Lower Extremity Functional Scale (LEFS) - Physiopedia. https://www.physio-pedia.com/Lower_Extremity_Functional_Scale_(LEFS). Accessed December 2, 2017.
22. Scott, W N, and John N. Insall. *Insall & Scott Surgery of the Knee*. Philadelphia, PA: Elsevier/Churchill Livingstone, 2012.
23. Elbaz A, Beer Y, Rath E, et al. A unique foot-worn device for patients with degenerative meniscal tear. Knee Surg Sports Traumatol Arthrosc. 2013;21(2):380-7.