Management of Acute Patellar Dislocation: A Case Report

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Abstract

Objective: The purpose of this case study is to describe the evaluation and management of patellar dislocations and the different approaches used from providers in different countries.

Clinical Features: An individual dislocated her left patella while traveling abroad and received subsequent care in Thailand, China, and the United States.

Intervention and Outcome: Nonoperative treatment protocols including manual closed reduction of the patella, casting of the leg, and rehabilitation exercises were employed.

Conclusion: Receipt of care when abroad can be challenging. The patient's knee range of motion and pain continued to improve when she was diligent about performing the home exercise program. This case highlights the importance of a thorough examination, a proper regimen of care, and patient counseling to ensure a full recovery and minimize the chance of re-injury.

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Introduction

Acute patellar dislocation is a common orthopedic condition that occurs when the confinement of the patella is disrupted from the patella-femoral groove,

most often laterally.¹ These injuries can result in damage to the medial patellofemoral ligament (MPFL) and may cause osteochondral fractures.^{2–4} The average incidence of first-time patellar dislocation is 5.8 per 100,000.^{1,5} Of these patients who sustain a first-time patellar dislocation, 44% to 70% will experience a subsequent recurrent dislocation.¹ A previous history of contralateral patellar dislocation increases the risk of redislocation by 6-fold and after a second dislocation

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the risk of re-dislocation increases by 49%.⁵ Primary dislocations of the patella are often associated with sports.⁵ One study of first-time dislocations reported that 61% of dislocations happened during sporting events and 9% occurred while dancing.⁵ Up to 55% of those athletes do not return to their sporting activities, and 58% have restrictions with strenuous activity 6 months after their date of injury.⁴ There is a higher risk of occurrence in adolescent females along with persons with multiple predisposing factors including increased quadriceps angle, patella alta, patellar hypermobility, vastus medialis weakness, increased femoral anteversion, and shallow femoral trochlear groove (Fig 1).^{5,6}

Most first-time traumatic patellar dislocations are treated nonoperatively with a closed reduction technique unless there is evidence of osteochondral fracture, a displaced osteochondral fragment, or gross patellofemoral instability.^{7,8} The presence of large amounts of sub-patellar effusion which may require aspiration of fluid, raises the likelihood of a significant osteochondral fracture.⁴ While most patients affected by this injury report to a hospital emergency department for initial assessment and treatment, they may present to a chiropractic physician or general practitioner's office, especially in rural areas. They often present with an already reduced patellofemoral joint and a history of feeling their knee "going out of place".^{3,5} Treatment and outcomes of first-time patellar dislocations vary dependent upon the extent of the injury and the access to standardized care.^{4,9}

There is a debate as to what is the best treatment option for primary patellar dislocations.^{4,6,8} Nonoperative treatment protocols include a manual closed reduction of the patella followed by casting or splinting

Age (10 -30 years old)
Female gender
Family history of patella dislocation
Physically active
Increased Q angle
Increased femoral anteversion
Valgus knee deformity
Shallow femoral trochlear groove
Patella alta
Patellar hypermobility
Excessive lateral patellar tilt
Vastus medialis weakness
Contracted Iliotibial band
Hypoplastic lateral condyle
Generalized ligamentous laxity

Fig 1. Risk factors for patella dislocations.

Fig 2. Anterior-posterior and lateral radiographs of the left knee before manual closed reduction of the dislocated patella under general anesthesia at the Ranong Hospital.

of the leg and a series of rehabilitative exercise afterward.^{1,9,10} Many studies report that the risk of redislocation is equal with either surgical or nonsurgical treatment.^{1,6,8,11} Recurrent patella dislocations, especially in the absence of trauma, have a poorer prognosis for stabilization and are further prone to re-dislocation.^{4,5} These injuries should be considered as a subset of patellar dislocations and may require immediate advanced imaging and surgical repair.^{11,12} A thorough examination and diagnosis of this condition, with an emphasis on identification of surgical indications, will increase the likelihood of successful outcomes with conservative methods.^{1,11} Severe damage to the supporting patellar ligaments, especially the medial retinaculum or MPFL, or osteochondral injury which may warrant surgical stabilization should be identified early.^{1,5,12,13}

The purpose of this case study is to describe the management of a patient with a first-time patellar dislocation who received treatment while in Thailand, China, and the United States.

Case Report

A 24-year-old woman was hiking on a remote beach off the coast of Ranong, Thailand, when she lost her footing and fell, spraining her left knee. The patient reported a left knee deformity, an immediate onset of severe pain and swelling, and inability to bear weight. She was transported by boat and taxi to the nearest hospital emergency department in Ranong, Thailand. Anterior-posterior and lateral plain film radiographs identified a laterally dislocated patella (Fig 2). No

further diagnostic imaging was done at the time of the initial emergency department visit. Two and one-half hours after admission to the hospital, the patient was placed under general anesthesia to perform a closed reduction of the patella. Her left leg was then immobilized in a full leg plaster cast (Fig 3). She had no history of prior knee injury or surgery and no history of patellofemoral instability in either knee.

The patient was discharged from the hospital in Thailand the following day with crutches and instructions to stay non-weight-bearing on her left leg. She spent 7 days in the plaster cast before it was removed in Thailand. She was given a simple neoprene knee sleeve without a patella immobilizer to wear however no rehabilitation exercises were prescribed. During the next few weeks she continued to wear the neoprene knee sleeve and use crutches but continued to experience joint discomfort and instability. Because there was little explanation earlier by the health care providers about her condition she experienced considerable kinesiophobia. After 2 weeks, she returned to Wuhan, China, where she consulted with an orthopedist who prescribed a hinged knee immobilizer brace. The knee brace was locked into extension preventing any active range of motion of the knee, and she was restricted to non-weight-bearing using crutches.

After 2 weeks, she continued to experience pain, so she consulted with another physician at the Zhongnan

Fig 3. The left leg was immobilized in a full leg plaster cast for 1 week. (Color version of figure appears online.)

Fig 4. Post reduction sagittal (A) and coronal (B) fat suppressed T2-weighted magnetic resonance images of the knee demonstrates osseous edema (arrows) consistent with contusion within the medial aspect of the patella (A) and also within the lateral femoral condyle (B).

Hospital who scheduled magnetic resonance imaging (MRI) and recommended that she continue to use crutches full time. Magnetic resonance imaging performed at the Zhongnan Hospital of Wuhan University demonstrated no abnormalities involving the cruciate ligaments or menisci. Edema was present within the proximal medial collateral ligament, consistent with grade 1 sprain. There was edema within the medial patella and lateral femoral condyle consistent with osseous contusion (Fig 4). Soft tissue edema was also noted within the soft tissues overlying the medial femoral condyle, suggesting sprain of the MPFL. Axial images were not obtained to confirm MPFL injury. Patella alta and a small joint effusion were also noted. The physician recommended continuing with a non-operative treatment plan. The patient was instructed to continue wearing the hinged knee brace immobilizer for an additional 7 days but was allowed to begin ambulating with weight bearing on her left extremity as tolerated. For the next 14 days she attempted to walk with and without crutches, while still wearing the immobilizer brace. After a call with her father, a chiropractic physician, it was determined that she may have been given the wrong knee brace. A series of stretches and rehabilitative exercises were described and demonstrated along with expectations for her progress and recommendations to manage inflammation and pain with cryotherapy and Ibuprofen as needed. A new patellofemoral brace which allowed knee flexion while also stabilizing the patella was mailed to her.

After discontinued the use of crutches, she continued to experience pain and swelling and was unable to walk comfortably. She consulted with another physician who told her she had an infection in her knee and he applied a topical paste for 3 days to eliminate the infection.

Shortly afterward, she saw another physician who aspirated 2 large syringes full of sanguineous fluid from the medial side of her knee. There was a translator present with limited English skills. She was advised to return for 2 additional procedures and acupuncture treatments. She declined because the procedure was very painful and she felt the clinic was unsanitary. She continued to experience pain and swelling in the knee, therefore she consulted with another physician who did not treat her but recommended she walk more to reduce the swelling. She continued to experience pain, lack of motion and kinesiophobia the remainder of her time in Wuhan.

Upon her return to the United States, 4 months after the date of injury, she was examined by a chiropractic physician. Compared to the uninjured side, there was a loss of range of motion (ROM) in knee flexion and extension, muscle weakness in the quadriceps and hamstrings without noticeable muscular atrophy, and mild sub patellar effusion. The patient still had difficulty walking and reported mild amount of pain and tenderness surrounding the patella as well as kinesiophobia. The patient's knee was stabilized with taping and she was then referred to the Logan University Department of Radiology for consultation and review of her imaging studies from Thailand and China. A diagnostic ultrasound was then performed. The ultrasound examination confirmed injury to the patellar and femoral insertions of the MPFL as demonstrated by ligament thickening, hypoechogenicity, and adjacent bony cortical irregularity (Fig 5). Power doppler examination at the sites also demonstrated active hyperemia. The grade 1 injury of the medial collateral ligament was also confirmed. Measurements of the patella to patellar tendon ratio confirmed patella alta. The trochlear groove angle measured 144° with 145° being the upper limit of normal. A persistent suprapatellar effusion was also noted. The MPFL is the patella's primary medial soft

Fig 6. Illustration of a lateral dislocation of the patella with a sprained MPFL. Original anatomical artwork by Frank Scali, DC.

tissue restraint and is often torn during a patellar dislocation (Fig 6).^{7,13} Since axial MRI views were either not performed in Wuhan or provided, the extent of the patient's MPFL damage was not fully identified before ultrasound imaging.

The patient was then referred for physical therapy for strength and rehabilitation training. At 4 months post injury, she demonstrated quadriceps and hamstring weakness, without atrophy and complained of patellofemoral pain and difficulty with ambulating long distances, using stairs, and running. Upon assessment, her hamstrings, iliotibial band, and rectus femoris showed no signs of adaptive shortening. While her passive ROM was within normal limits, she com-

Fig 5. Long-axis ultrasound image of the MPFL (arrowheads) demonstrates thickening and hypoechogenicity within the patellofemoral ligament at the patellar and femoral insertions along with adjacent bony cortical irregularity (arrows).

plained of discomfort at end-range knee flexion and lacked the strength to perform full active knee flexion in both standing and supine positions. also had visible signs of patella alta which was confirmed on both previous MRI and ultrasound imaging. The patient was issued written instructions to perform a home exercise program 2 to 3 times a day focusing on closed kinetic chain quadriceps strengthening exercises such as mini-squats (knee flexion no more than 45°) and step-ups.^{14,15} The exercise program addressed hamstring weakness and range of motion deficits by including prone knee active flexion with manually applied overpressure and seated hamstring curls with a resistive exercise band.^{14,15}

The knee flexion kinesiophobia decreased after examination and treatment in the United States. After 1 year, she had recovered much of her normal motion and strength, although some residual pain persisted. Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

Discussion

Acute patellar dislocations are a common orthopedic condition with injuries ranging from mild to severe sprain strains to osteochondral fractures. The presence of hemarthrosis in the joint is a strong indicator of osteochondral fracture and should be evaluated with MRI. A closed reduction technique followed by acute stabilization then rehabilitation focused on strengthening the quadriceps muscles and increasing joint range of motion is the preferred treatment option for dislocations without osteochondral fracture.

While lateral patellar dislocations are a common injury, they may present with a range of damage to soft tissue, bone and cartilage. Varying degrees of damage to the MPFL is common and can be assessed with diagnostic ultrasound. Large amounts of subpatellar hemarthrosis may indicate an osteochondral fracture and should be imaged with MRI to confirm this. Patients without osteochondral fracture may be successfully managed with manual closed reduction of the patella, casting or splinting of the leg followed by rehabilitation exercises focused on increasing range of motion and quadriceps muscle strengthening. The case study presented highlights the importance of a thorough examination, a proper regiment of care and patient counseling to insure a full recovery and minimize the chance of re-injury.

Clinical decisions on the proper management of patellar dislocations are dependent on the amount of ligament injury, the presence of osteochondral fractures, and the number of previous dislocations.^{3–6,11,12} Multiple randomized control studies and one systematic review have addressed operative vs nonoperative treatment in first-time traumatic patellar dislocations.^{1,10,12,16} The area and degree of injury to the MPFL, ligament hyperlaxity, medial retinacular injury, sub-patellar effusion and fractures to bone or cartilage are factors in deciding on surgical management of the dislocated patella.^{3,11,13} Some defects may be obvious on examination, however evaluation of the supporting structures of the knee by MRI or computed tomography is important to verify the patency of supporting ligaments and presence of osteochondral fractures.^{1,9,10} Re-dislocation of the patella is a strong indicator for surgical intervention.^{5,11–13}

Operative vs Nonoperative Care

There is no substantial difference in long-term outcomes between the surgically and conservatively treated patients in regard to redislocation rates, level of activity, or functional and subjective outcomes.^{2,3,8,11,16} A randomized study by Nikku et al compared operative vs closed treatment in 125 patients with patellar dislocations without tibiofemoral ligament or osteochondral fractures that necessitated surgical stabilization, with a 2-year follow-up.² The results concluded that both treatments gave almost identical outcomes after 2 years in terms of a subjective score, recurrent instability, and function. However major complications occurred only after operative treatment.² After a 7-year follow-up of this group of subjects, 81 % of the nonsurgical treatment group still reported having excellent or good outcomes compared to 67% of the surgical group.⁶ A Cochrane systematic review reported equal outcomes with surgical and nonsurgical interventions for patellar dislocations.¹ However considering the surgical related adverse events, non-surgical treatments for patellar dislocations should be utilized.¹ Another meta-analysis by Zheng showed that surgical management of patellar dislocations decreases the chance of reoccurrence.⁹ However, in a review of 12 studies by van Gemert, only 1 study reported lower redislocation rates after surgical repair.¹⁶ While there are risks associated with surgical intervention, Cheng reported a lower incidence of redislocation compared to nonsurgical therapies.¹⁰ This decreased dislocation rate of more than 50% over nonsurgical treatments may be due to the inclusion of cases with ligament and cartilage

damage in the nonoperative group.¹⁰ Therefore patients with severe damage to the medial retinaculum and MPFL may require surgical stabilization.^{1,9,11–13,17} Results vary with the surgical procedure; however, arthroscopic techniques can reduce risk of vascular and nerve damage and allow easy removal of loose osteochondral bodies or meniscus and repair of damaged ligaments.¹⁷

Bracing

The goal of immobilization of the post dislocated patella is patella alignment, restoration of normal patellar tracking and joint mechanics, and reduction of patellofemoral pain.^{3,11,16} Immobilization of the patella can be accomplished with the use of a neoprene brace, a posterior splint, or a cylinder plaster cast.¹⁶ The use of different braces has varying re-dislocation rates, ranging for between 6–54% (neoprene braces), 4% to 53% (splints), and 0% to 38% (cylinder plaster casts).¹⁶ Because of the low redislocation rates, the use of posterior splinting has been recommended, however this is based on a small number of studies and these recommendations should be cautiously interpreted.¹⁶ Taping of the patella has been shown to be of value for cases involving patellofemoral pain syndrome.^{18–20} A small randomized trial of 18 participants showed immobilization of the patella with tape to be superior to cylinder casting for functionality and re-dislocation rates after 1 and 5 years.²¹ One study showed elastic tape to be equally effective as the McConnell technique of taping for pain reduction.²²

Commonly, once a laterally displaced patella is reduced, a 2- to 6-week period of immobilization is preferred using either a plaster cast, a posterior splint, or a hinged knee brace.^{16,23} A study by Maenpaa and Lehto suggested limiting the period of immobilization to 3 weeks to avoid muscle atrophy, knee joint restrictions, and retropatellar crepitation.²³ This allows sufficient time for the medial structures such as the MPFL to heal as well as to protect the injured joint.²³ In their study of 100 acute dislocations, the posterior splint group showed fewer incidents of redislocation per follow-up year and subsequent problems at final follow-up (patellar subluxations, knee joint restriction, chondromalacia patellae and patellofemoral pain).²³

In this case, without proper counseling on post reduction rehabilitation, the patient spent an extended time non-weight-bearing on the injured limb and with limited knee ROM allowed and experienced unnecessary kinesiophobia. She spent a week in a plaster cast, followed by 1 week in a neoprene non-hinged sleeve,

and then 3 weeks in a locked hinged knee brace. This 5-week period exceeded the recommend time for immobilization of the knee.

Patellofemoral Joint Biomechanics

Biomechanically, the patella functions to increase the moment arm of the quadriceps muscle, effectively decreasing the force requirements of the knee.^{24–27} The normal compressive force at the patellofemoral joint is one-half body weight during walking and 3 times the body weight while climbing stairs.^{25,27} The angle of the knee determines the mechanical advantage generated by the quadriceps muscle, with 90° being the optimal angle for force production.^{24,25,27} Tibiofemoral contact also changes throughout the knee's ROM with the resultant forces dependent on the angle of the knee.^{24–26} The MPFL provides 60% of restraint to lateral patellar translation to 20° of flexion.²⁴ To maximize the greatest amount of patellofemoral contact area and minimize patellofemoral stresses and pain, specific ROM limits have been established for a series of both open and closed chain kinetic exercises.^{24,26} Open kinetic chain knee exercises can be done without inducing excessive patellofemoral joint stress by limiting the knee joint excursion to 45° extension.²⁴ Closed kinetic chain knee exercises can be safely done by limiting the joint excursion from full extension to approximately 45° of flexion.²⁴ As patient symptoms subside, greater ranges of motion can be performed increasing muscle strength.²⁴

Rehabilitation of Patellofemoral Disorders

Following immobilization, rehabilitation normally begins to address any remaining functional deficits.^{3,12,13,15} It is important to identify anything that might affect normal patellar glide between the femoral condyles as well as any functional difficulties the patient may be experiencing. Issues such as quadriceps strength, hamstring/quad strength ratio, rectus femoris and iliotibial band adaptive shortening, knee ROM, and patellar mobility need to be addressed.^{3,11,15} Passive range of motion (ROM) which glides the leg in flexion/extension until the knee reaches extension will counter the effects of immobilization.^{11,28} Typical rehabilitation protocols show return to full activity 8–12 weeks from the time of injury.^{11,14–16} While current research has not demonstrated the ability to selectively recruit the vastus medialis obliquus (VMO), strengthening the entire quadriceps muscle group as a unit is beneficial to restore knee function.^{19,27,29,30} The use of closed kinetic chain

exercises can increase activation of the VMO and the vastus lateralis, as well as decrease the overall anterior shear and reaction forces on the patellofemoral joint.^{19,26,27,29,30} Manipulation and mobilization of the lumbar spine and sacroiliac joints has been shown to decrease pain and increase muscle activation in the quadriceps muscles.^{31,32} After bracing is removed, a common exercise prescription might begin with passive ROM exercises, followed by active heel slides for knee flexion/extension, and non-weight-bearing hamstring stretches, for 3 to 4 weeks.^{14–16,30} After 6 to 8 weeks, stretching and weight-bearing exercises including gastrocnemius/soleus stretching, toe raises, hamstring curls, and leg presses can begin.^{14–16} Attention should be paid to balancing musculature of the Quads/VMO to insure proper patellar tracking. Proprioceptive neuromuscular retraining with rocker or wobble boards and gait retraining if necessary should also be employed.^{14–16} After exercises, cryotherapy may be applied locally to aid in reducing inflammation. The application of tape using the McConnell method around the patellofemoral joint may stretch surrounding soft tissues, unloading the stresses on the joint.^{14–16,21,30} Education is an important aspect of managing the rehabilitative process.^{4,28} Patients should be provided information on the expectations of their rehabilitation along with Instructions on the use of crutches to maintain partial weight bearing.^{14,28} Four to 6 months post injury, patients can progress to closed-kinetic chain weight bearing exercises, jogging or pool resistance exercises.^{15,28}

In this case, the orthopedic physician in China did not recommend or refer the patient to any rehab specialist. No instructions were given on when to initiate knee movement or any early stage strengthening. Once her MRI report ruled out the need for surgical intervention, the patient was discharged from his care with instructions to keep the knee immobilized for another week. The addition of multiple visits to different physicians with different recommendations added to the patient's stress. After a short stay in the United States that summer, the patient returned to Wuhan China, therefore, direct patient follow-up was not possible. Her progress was monitored by Skype calls. The patient's knee ROM and pain continued to improve when she was diligent about performing the home exercise program. Her decreased fear of movement seemed to correspond with her improved knee ROM.

Language Barriers to Care

Problems in obtaining medical reports in English or radiographic studies made early diagnosis and patient

progress difficult to assess from a distance. Initially, after being released from the hospital in Ranong Thailand, the patient was unable to describe her condition. She was unsure whether she had dislocated her patella or had a more complex femoral tibial injury. Lack of understanding by the patient of her medical reports limited her ability to accurately convey the information to others. This case study highlights the challenges of telemedicine in coordinating care with patients in other countries. Differing standards of care, language barriers, and traditional medicine practices influence the physician's ability to make informed decisions about patients. The difficulty in accessing patient care from a distance is reflected in the lack of some information such as pain levels and range of motion that we did not have access to. In this case, medical reports in Mandarin Chinese and Tai-Kadai Taiwanese, an incomplete MRI series, incorrect knee bracing, and lack of rehabilitation counseling caused a delay in this patient's recovery.

Limitations

This case report describes a single patient's experience in the diagnosis and treatment of a common orthopedic condition in 3 countries. The variations in care described are not inferred to exist in all instances and cannot be generalized to other situations.

Conclusion

Receipt of care when abroad can be challenging. The patient's knee ROM and pain continued to improve when she was diligent about performing the home exercise program. This case highlights the importance of a thorough examination, a proper regiment of care and patient counseling to insure a full recovery and minimize the chance of re-injury.

Funding Sources and Conflicts of Interest

No funding sources were reported for this study. The authors declare that the patient was the daughter of the first author.

References

1. Hing CB, Smith TO, Donell S, Song F. Surgical versus non-surgical interventions for treating patellar dislocation. *Cochrane Database Syst Rev* 2011(Issue 11), <http://dx.doi.org/10.1002/14651858.CD008106.pub2> [Art. No.: CD008106].

2. Nikku R, Nietosvaara Y, Kallio PE, Aalto K, Michelsson JE. Operative versus closed treatment of primary dislocation of the patella: similar 2-year results in 125 randomized patients. *Acta Orthop Scand* 1997;68:419–23.
3. Geary M, Schepsis A. Management of first-time patellar dislocations. *Orthopedics* 2004;27(10):1058–62.
4. Jain NP, Khan N, Fithian DC. A treatment algorithm for primary patellar dislocations. *Sports Health* 2011;3:170.
5. Fithian D, Paxton E, Stone M, et al. Epidemiology and natural history of acute patellar dislocation. *Am J Sports Med* 2004;32:1114–21.
6. Nikku R, Nietosvaara Y, Aalto K, Kallio PE. Operative treatment of primary patellar dislocation does not improve medium-term outcome, a 7-year follow-up report and risk analysis of 127 randomized patients. *Acta Orthop* 2005;76(5):699–704.
7. Owens D, Jordan C, Ross A, et al. Surgical treatment of acute patella dislocations: Review of 13 consecutive cases from Keller Army Hospital. *Open Sports Med J* 2008;2:82–4.
8. Buchner M, Baudendistel B, Sabo D, Schmitt H. Acute traumatic primary patellar dislocation: long-term results comparing conservative and surgical treatment. *Clin J Sport Med* 2005;15(2):62–6.
9. Zheng X, Kang K, Li T, Lu B, Dong J, Gao S. Surgical versus non-surgical management for primary patellar dislocations: an up-to-date meta-analysis. *Eur J Orthop Surg Traumatol* 2014;24:1513–23.
10. Cheng B, Wu X, Ge H, Sun Y, Zhang Q. Operative versus conservative treatment for patellar dislocation: a meta-analysis of 7 randomized controlled trials. *Diagn Pathol* 2014;9:60.
11. Sillanpää PJ, Maenpää HM. First-time patellar dislocation: surgery or conservative treatment? *Sports Med Arthrosc* 2012;20(3):128–35.
12. Stefancin J, Parker R. First-time traumatic patellar dislocation: a systematic review. *Clin Orthop Relat Res* 2007;455:93–101.
13. Bitar A, Demange M, D'Elia C, et al. Traumatic patellar dislocation: nonoperative treatment compared with MPFL reconstruction using patellar tendon. *Am J Sports Med* 2012;40(1):114–22.
14. Powers CM, Ward SR, Fredericson M, Guillet M, Shellock FG. Patellofemoral kinematics during weight-bearing and non-weight-bearing knee extension in persons with lateral subluxation of the patella: A preliminary study. *J Orthop Sports Phys Ther* 2003;33:11.
15. Crossley K, Bennell K, Green S, Cowan S, McConnell J. Physical therapy for patellofemoral pain, a randomized, double-blinded, placebo-controlled trial. *Am J Sports Med* 2002(6):857–65.
16. Van Gemert J, De Vree L, Hessels R, Gaakeer M. Patellar dislocation: cylinder cast, splint, or brace? An evidence-based review of the literature. *Int J Emerg Med* 2012;5(1):45.
17. Sillanpää PJ, Mäenpää HM, Mattila VM, Visuri T, Pihlajamäki H. Arthroscopic surgery for primary traumatic patellar dislocation. *Am J Sports Med* 2008;36(12):2301–9.
18. Crossley K, Cowan SM, Bennell KL, McConnell J. Patellar taping: is clinical success supported by scientific evidence. *Man Ther* 2000;5(3):142–50.
19. Gilleard W, McConnell J, Parsons D. The effect of patellar taping on the onset of vastus medialis obliquus and vastus lateralis muscle activity in persons with patellofemoral pain. *Phys Ther* 1998;78(1):25–32.
20. Osterhues DJ. The use of Kinesio taping in the management of traumatic patella dislocation. A case study. *Physiother Theory Pract* 2004;20:267–70.
21. Rood A, Boons H, Ploegmakers J, van der Stappen W, Koëter S. Tape versus cast for non-operative treatment of primary patellar dislocation: a randomized controlled trial. *Arch Orthop Trauma Surg* 2012;132:1199–203.
22. Campolo M, Babu J, Dmochowska K, Scariah S, Varughese J. A comparison of two taping techniques (Kinesio and McConnell) and their effect on anterior knee pain during functional activities. *Int J Sports Phys Ther* 2013;8(2):105–10.
23. Maenpää H, Lehto MU. Patellar dislocation. The long-term results of nonoperative management in 100 patients. *Am J Sports Med* 1997;25:213–7.
24. Steinkamp LA, Dillingham MF, Markel MD, Hill JA, Kaufman KR. Biomechanical considerations in patellofemoral joint rehabilitation. *Am J Sports Med* 1993;21(3):438–44.
25. Brinckmann P, Frobin W, Leivseth G. Musculoskeletal biomechanics. Georg Thieme Verlag 3131300515; 2002.
26. McGinty G, Irrgang JJ, Pezzullo D. Biomechanical considerations for rehabilitation of the knee. *Clin Biomech* 2000;15:160–6.
27. Huberti HH, Hayes WC, Stone JL, Shybut GT. Force ratios in the quadriceps tendon and ligamentum patella. *J Orthop Res* 1984;2:49–54.
28. Arendt EA, Fithian DC, Cohen E. Current concepts of lateral patella dislocation. *Clin Sports Med* 2002;21:499–519.
29. Earl J, Schmitz R, Arnold B. Activation of the VMO and VL during dynamic mini-squat exercises with and without isometric hip adduction. *J Electromyogr Kinesiol* 2001;11(6):381–6.
30. Neptune R, Wright I, Van Den Bogart A. The influence of orthotic devices and vastus medialis strength and timing on patellofemoral loads during running. *Clin Biomech* 2000;15:611–8.
31. Grindstaff TL, Hertel J, Beazell JR, et al. Lumbopelvic joint manipulation and quadriceps activation of people with patellofemoral pain syndrome. *J Athl Train* 2012;47(1):24–31.
32. Pickar JG. Neurophysiological effects of spinal manipulation. *Spine J* 2002;2:357–71.