James M. Anderson Center for Health Systems Excellence

Evidence-Based Care Guideline

Post-Operative Management of Lateral Patellar Dislocations and Instability

In children and adults aged 8-25 years[1]

Publication Date: January 2015

Target Population

Inclusions:

Children or young adults:

- With a history of lateral patellar dislocation, subluxation or general instability treated surgically with medial patellofemoral ligament (MPFL) repair, reconstruction, or revision (MPFLR)
- Ages 8-25 years
- Who are skeletally immature or mature

Exclusions:

Children and young adults:

- With neuro-developmental conditions associated with patellar instability or dislocation (e.g., Cerebral Palsy, Down Syndrome)
- With patellofemoral re-alignment techniques as part of the surgical procedure (e.g. lateral retinacular release, tibial tubercle re-alignment)
- With lateral patellar instability currently being managed conservatively rather than through surgical intervention

Target Users

Include but are not limited to (in alphabetical order):

- Athletic Trainers
- Coaches
- Nurse Practitioners
- Other healthcare professionals
- Patients and families
- Physical Therapists and Physical Therapy Assistants

[1] Please cite as: Post-Operative Management of Lateral Patellar Dislocations and Instability Team, Cincinnati Children's Hospital Medical Center: Evidence-based clinical care guideline for Post-Operative Management of Lateral Patellar Dislocations and Instability, http://www.cincinnatichildrens.org/service/j/anderson-center/evidence-based-care/recommendations/default/ Post-Operative Management of Lateral Patellar Dislocations and Instability.htm, Guideline 46, pages 1-22, January 2015.

Introduction

References in parentheses ( ) Evidence level in [ ] (See last page for definitions)

Lateral patellar dislocations and instability are relatively common conditions that can cause anterior knee pain, contribute to functional disability, and can eventually lead to degenerative joint changes *(Smith 2010a [1b], Fithian 2004 [2a], Atkin 2000 [3b])*. Conservative management with physical therapy as the primary intervention is often the preferred plan of care for these injuries when there is an absence of predisposing factors, concomitant injuries, or anatomical alignment abnormalities. However, 20-44% of patients who are managed conservatively may experience recurring symptoms of instability or a re-dislocation episode *(Hawkins 1986 [3b], Cofield 1977 [3b], Cash 1988 [4b])*. Thus, when conservative management fails, the next course of management is often a surgical approach *(Shah 2012 [1a], Stefancin 2007 [1b], Hawkins 1986 [3b], Shea 2006 [5b])*. In addition, some cases are treated with surgical management without an initial attempt to manage the injury conservatively *(Hawkins 1986 [3b], Cofield 1977 [3b], Cash 1988 [4b])*. This is particularly common when there is a clear disruption of the MPFL *(Stefancin 2007 [1b], Cofield 1977 [3b], Cash 1988 [4b])*.

Following surgery, patients are often referred to physical therapy. The physical therapy goals are to address pain, range of motion (ROM), strength, neuromuscular control, and functional deficits (e.g., squatting, walking, pivoting) *(Smith 2010a [1b], LocalConcensus 2014 [5], American Physical Therapy 2003 [5a])*. Although a variety of expert commentaries and review articles have been published that provide suggestions for physical therapy interventions for lateral patellar dislocation and instability, higher level studies specifically investigating post-operative rehabilitation strategies are limited *(Smith 2010a [1b])*. The purpose of this guideline is to provide a comprehensive description of evaluation and intervention strategies for rehabilitation following MPFL reconstruction, repair, or revision. For the purposes of this guideline, MPFLR is used to refer to a reconstruction, repair, or revision. However, it is important to note that there may be some subtle variations in outcomes and surgery specific precautions relative to each MPFL surgical technique.

Recommendation statements for this guideline were formulated using the best available evidence. Each article incorporated into the guideline was individually appraised through a systematic, formalized process (described in detail on page 24). Where evidence from the literature was insufficient, recommendation statements were generated through a consensus-based process using a panel of physical therapists. Considerations of the active, passive and static stabilizers of the patellofemoral joint, biomechanical principles relative to joint kinematics and kinetics, and knowledge about the expected healing properties of the surrounding tissues were utilized to help formulate the recommendation statements. The guideline was formally reviewed by orthopaedic surgeons and sports medicine specialists to ensure the recommendations are safe and appropriate for this patient population.

Objectives of this guideline include:

- To guide and promote consistency in the delivery of optimal evidence-based physical therapy services for post-operative management of MPFLR
- To promote long-term joint integrity and maximize healing
- To reduce impairment
- To enhance function
- To maintain and improve patient and family satisfaction and quality of life
- To minimize risk for re-injury

Benefits and Expected Outcomes for the patient after following this guideline:

- Full ROM, both active (AROM) and passive (PROM), of the involved knee
- Ability to participate with self-report of pain less than or equal to 2 out of 10 on Numeric Rating Scale with activities of daily living (ADLs) *(von Baeyer 2009 [4b], Williamson 2005 [5a])*
- Ability to participate with self-report of pain less than or equal to 2 out of 10 *(LocalConcensus 2014 [5])* on Numeric Rating Scale in all age-appropriate gross motor skills *(von Baeyer 2009 [4b], Williamson 2005 [5a])*
- Ability to participate with self-report of pain less than or equal to 2 out of 10 *(LocalConcensus 2014 [5])* on Numeric Rating Scale in all desired recreational activities *(von Baeyer 2009 [4b], Williamson 2005 [5a])*
- A minimum of 4+/5 strength for all trunk, hip and lower extremity musculature bilaterally including hip flexors and extensors, hip abductors and adductors, hip internal and external rotators, knee flexors and extensors, ankle dorsiflexors and plantarflexors, and lateral and medial ankle musculature *(LocalConcensus 2014 [5])*
- Ability to demonstrate safe, proper alignment of trunk, hip, knees and feet while performing walking, lunging, squatting, jumping and running activities *(LocalConcensus 2014 [5])*

Risks and Limitations for the patients if this guideline is applied include:

- Underlying concomitant tissue damage such as chondral lesions or loose bodies may lead to limitations or difficulties with full implementation of these recommendations *(LocalConcensus 2014 [5])*
- Anatomical and structural abnormalities such as patella alta, patellar dysplasia, trochlear dysplasia, significant genu valgum, and hypermobility may reduce a patient's chances for long-term success of the surgical procedure and/or implementation of the rehabilitation recommendations *(Shah 2012 [1a], Stefancin 2007 [1b], Garth 1996 [4b], LocalConcensus 2014 [5])*

Background

Complex and dynamic interactions among static, passive, and active anatomical restraints and healthy biomechanics at the knee provide patellofemoral joint stability *(Balcarek 2010 [4b], von Baeyer 2009 [4b], Senavongse 2005 [4b], Williamson 2005 [5a], Mulford 2007 [5b], Beasley 2004 [5b])*. Therefore, anatomical variations, abnormal biomechanical tendencies, disruption of the passive or active structures in the knee, or a combination of any of these may compromise patellofemoral joint stability.

The MPFL is the primary, passive restraint against lateral forces on the patella and assists with the patella entering the trochlear groove during the first 20-30 degrees of knee flexion *(Philippot 2012 [4b], Amis 2003 [5b])*. With only the MPFL for passive restraint in this range of motion, the most likely position for lateral patellar injury to occur is when the knee is moving within the first 20-30 degrees of knee flexion *(Atkin 2000 [3b], Visuri 2002 [4b], Garth 1996 [4b], Bharam 2002 [5a], Wilk 1998 [5a], Shea 2006 [5b], Hinton 2003 [5b])*. For a more detailed review of the patellofemoral joint and lateral patellar instability in general, please see Evidenced Based Care Guideline for Conservative Management of Lateral Patellar Dislocations and Instability *(CCHMC_LateralPatellarInstabilityManagementTeam 2014 [5])*.

Although conservative management with physical therapy is often the primary approach to treatment for lateral patellar instability, there are a number of reasons a patient may be managed surgically. For example, patients often undergo a surgical procedure when one or more of the following occurs:

- Disrupted MPFL
- Poor outcomes and continued instability following conservative management of lateral patellar instability
- Osteochondral defects are present
- The patella is laterally subluxed on the plain Mercer-Merchant view of the involved limb with

normal alignment of the patella on the uninvolved limb
- One or more predisposing factors for instability are also noted on the uninvolved knee
- The patient is younger than 15 years old and wants to return to sports or activities with high-level physical demands

(Stefancin 2007 [1b], Hawkins 1986 [3b], Cofield 1977 [3b], Visuri 2002 [4b], Cash 1988 [4b], Shea 2006 [5b]).

Prognosis for patients following surgery is usually best when the patient does not have underlying anatomical risk factors that are commonly associated with lateral patellar instability *(Visuri 2002 [4b], Shea 2006 [5b])*. These may include:
- increased tibial tubercle-trochlear groove
- patella alta
- trochlear or patellar dysplasia
- genu valgum
- hypermobility

(Fithian 2004 [2a], Atkin 2000 [3b], Balcarek 2011 [4a], Ward 2007 [4a], Panni 2011 [4b], Balcarek 2010 [4b], Visuri 2002 [4b], Garth 1996 [4b]).

Surgical Techniques:

Surgical management of lateral patellar instability has evolved over the last decade and now includes a large range of techniques and philosophies *(Shah 2012 [1a], Parikh 2011 [4a])*. With a rise in the recognition that the MPFL plays in the range in maintaining stability of the patella, currently one of the most popular operative strategies is reconstruction of the MPFL *(Parikh 2011 [4a])*.

Most reconstructive techniques can be divided into two categories: suture or tunnel *(Shah 2012 [1a])*. One common reconstructive technique uses a tunnel for graft fixation *(Shah 2012 [1a], Parikh 2011 [4a])*. This procedure can involve one or two tunnels in the patella with varying ranges in diameter. The other common technique is a suture technique, which does not use a tunnel for graft fixation. The suture technique involves placing a lateral fixation of the MPFL graft *(Shah 2012 [1a])*. In addition to these two types, other surgical procedures may be performed at the same time such as lateral release, tibial tubercle realignment, or vastus medialis oblique advancement *(Shah 2012 [1a], Parikh 2011 [4a])*.

Due to the large variety of techniques performed and described in the literature, a comprehensive listing and description of all possible MPFLR approaches is outside the scope and purpose of this guideline. Care providers who will be implementing the recommendations from these guidelines are strongly encouraged to learn about the specific MPFLR approach, other surgical procedures, and specific precautions individual patients receive. In addition, surgeon preferences for post-operative immobilization and bracing are highly variable*(LocalConcensus 2014 [5])*. Therefore, care providers implementing these guidelines are encouraged to communicate with patients' surgeons to determine post-operative immobilization and bracing preferences and plans.

Prognosis:

Success rate reports for minimizing patellar instability after MPFL reconstruction range from 54% to 100% for up to 5.5 years *(Lippacher 2014 [4b], Steiner 2006 [4b])*. In addition, the patients undergoing MPFLR have demonstrated similar return to sport rates compared to other reconstructive and restorative knee surgeries such as articular cartilage repairs, high tibial osteotomies, and anterior cruciate reconstruction (ACLR) *(Lippacher 2014 [4b])*. Median time frames reported for return to sport following MPFLR range from 3-12 months, with younger patients reported better outcomes. Nonetheless, only 53-64% of patients have been noted to resume sports at a preoperative level *(Lippacher 2014 [4b])*.

Complication rates after MPFLR vary widely with rates ranging from 0% to 85% and a mean complication rate of 25% (Shah 2012 [1a]). These rates include minor to major complications such as loss of knee flexion, wound complications, patellar fracture, clinical instability findings post-operatively, and pain *(Shah 2012 [1a], Parikh 2011 [4a], Visuri 2002 [4b])*. Complications arising from MPFLR can stem from a variety of factors including:

- Premature return to impact activities without clearance from a healthcare provider
- Graft placement errors
- Location, size, and geometry of tunnels
- Number of concomitant procedures (e.g. lateral release, chondroplasty)
- Non-adherence to a supervised physical therapy program *(Shah 2012 [1a], Parikh 2011 [4a], LocalConcensus 2014 [5])*.

Guideline Recommendations

General Recommendations

1. It is recommended that patients begin physical therapy within 3-5 days following surgery in order to minimize secondary impairments such as persistent gait abnormalities, ROM deficits, and muscle atrophy that can result from poor gait patterns, immobility and disuse *(Smith 2010b [1b], LocalConcensus 2014 [5])*.
2. It is recommended that throughout the diagnosis and rehabilitation process, physical therapists are in open

communication with the referring physician and any other pertinent health care team members in order to promote the best, most efficient, and optimally effective care *(LocalConcensus 2014 [5], American Physical Therapy 2003 [5a])*.

3. It is recommended that the patient and family members receive thorough education regarding the nature of injury, the surgical procedure, the plan of care, risks for future injury, and any patient-specific concerns regarding prognosis *(LocalConcensus 2014 [5], American Physical Therapy 2003 [5a])*.

4. It is recommended that the referring physician is notified if any of the following red flags/precautions are present during the initial evaluation or at any other time during the rehabilitation process:

- Signs of deep vein thrombosis (DVT) *(Ramzi 2004 [5a])*
- Unchanging or increased irritability in the knee
- Persistent or recurrent effusion *(Stefancin 2007 [1b])*
- Unexpected loss or minimal progression of ROM
- Catching, locking, or persistent pathological end feel with passive ROM *(Stefancin 2007 [1b], Parikh 2011 [4a])*. *(LocalConcensus 2014 [5])*

Initial Examination

5. It is recommended that a thorough review of the operative report is performed with a specific emphasis on the MPFLR surgical protocol that was utilized and any additional procedures that were performed in order to be more prepared to educate the patient and family as well as increasing the awareness of the level and type of complications specific to certain surgical techniques *(LocalConcensus 2014 [5])*.

6. It is recommended that a thorough chart review is performed that includes review of general medical history and imaging studies (e.g., radiograph, CT scan, MR images) with an emphasis on identifying conditions or potential complications that may limit the success of post-operative rehabilitation such as:

- Trochlear dysplasia
- Patellar dysplasia
- Osteochondral defects
- Soft tissue disruptions or abnormalities
- Bone bruises
- Patella alta *(CCHMC_LateralPatellarInstabilityManagementTeam 2014 [5], LocalConcensus 2014 [5], American Physical Therapy 2003 [5a])*.

7. It is recommended that pain is assessed using an appropriate scale *(LocalConcensus 2014 [5])*.

   Note: The Oucher/Faces Pain Scale can be used with children 4-16 years of age *(Beyer 2005 [4a])* or the Numerical Rating Scale (NRS) can be used with children age 6 years and older and adults *(von Baeyer 2009 [4b], Williamson 2005 [5a])*.

8. It is recommended that a thorough history including the following information is obtained from the patient and/or family

- Age
- Sex
- Previous activity level
- Prior history of other musculoskeletal injuries and health conditions
- Patient and family history of patellar dislocation and hypermobility
- Description of mechanism of injury
- Description of treatment prior to surgery
- Complaints of "giving way"/feeling of instability
- Brace use
- Medications
- Weight-bearing status
- Post-operative restrictions/precautions
- Patient/family goals
- Home/school/work environment and goals
- Date of next follow up visit with referring physician *(Stefancin 2007 [1b], LocalConcensus 2014 [5], American Physical Therapy 2003 [5a], Wilk 1998 [5a], Andrish 2008 [5b])*

9. It is recommended that a comprehensive objective physical therapy examination be completed, including the components named in Table 1 *(LocalConcensus 2014 [5], American Physical Therapy 2003 [5a])*.

   Note: It is important to modify guideline recommended tests and examination techniques (e.g., range of motion and weight bearing restrictions) in accordance with any specific post-surgical precautions/restrictions prescribed by the surgeon and any other safety concerns as appropriate.

Table 1: Initial Exam

Initial Exam	
Palpation/ Visual Inspection	Palpate and visually inspect the following: • Global lower extremity for areas of lost/abnormal sensation, signs of Deep Vein Thrombosis (DVT) • Surgical incision sites for signs of poor healing or infection *(LocalConcensus 2014 [5])*.
Girth	Obtain girth measurements via a tape measure to quantify edema and atrophy *(Slaa 2011 [4b])*. Typical placements of measurements may be 15cm above and below the tibial tuberosity to assess for atropy, edema, and assist with identification of DVT *(Ramzi 2004 [5a])*. **Note:** It is common for girth to be smaller around the quadriceps region, indicating quadriceps atrophy, and bigger around joint lines indicating effusion *(LocalConcensus 2014 [5])*.
Range of Motion and Flexibility	Evaluate lower extremity passive ROM (PROM), active ROM (AROM) and flexibility for all lower extremity joints (hip, knee, and ankle) using a fluid filled goniometer or linear goniometer as appropriate *(Rao 2001 [4b], Watkins 1991 [4b])*. • Hip flexion, extension, abduction, adduction, internal rotation and external rotation • Knee flexion and extension • Ankle plantarflexion and dorsiflexion • Any other motions that appear to be functionally limited **Note:** Range of motion for some joints on involved side may not be indicated or appropriate due to positioning concerns. If possible, measurements are to be taken on the uninvolved side for comparison purposes *(LocalConcensus 2014 [5])*.
Muscle Strength and Control	Assess quadriceps activation for the involved limb in supine with a quadriceps set and assisted straight leg raise *(LocalConcensus 2014 [5])*. Perform manual muscle testing or hand-held dynamometry for the uninvolved limb for all of the following: • Hip flexors, extensors, abductors, adductors, internal rotators, external rotators • Knee flexors and extensors • Ankle plantarflexors and dorsiflexors *(LocalConcensus 2014 [5])* **Note**: Strength testing of the involved limb is performed as appropriate and with caution initially following surgery *(LocalConcensus 2014 [5])*.
Special Tests	Assess medial, superior, and inferior patellar glide as appropriate to examine patellar mobility *(LocalConcensus 2014 [5])*. **Note:** Do not assess lateral glide of the involved limb to avoid graft stress *(LocalConcensus 2014 [5])*. Perform intraarticular and extraarticular special tests on the uninvolved limb to establish baseline presentation *(CCHMC_LateralPatellarInstabilityManagementTeam 2014 [5])*.
Gait	Assess patient's ability to ambulate safely on even surfaces with least restrictive assistive device. *(LocalConsensus 2013 [5])*. Evaluate gait for qualitative abnormalities such as: 1. Decreased terminal knee extension during stance and/or quadriceps avoidance gait pattern 2. Decreased push-off during transition from stance to swing phase 3. Decreased knee and hip flexion during swing phase causing circumduction of lower leg 4. Decreased step length 5. Appropriate timing of activation of trunk, hip and lower extremity musculature *(LocalConcensus 2014 [5])*.
Balance	Assess balance as appropriate on the uninvolved limb *(LocalConcensus 2014 [5])*.
Functional Tests	Perform functional assessments as appropriate: • Bed mobility • Transfers • Stair negotiation *(Stefancin 2007 [1b], Smith 2011 [4b], LocalConcensus 2014 [5])*.

10. It is recommended that global joint hypermobility is assessed to determine potential ligamentous laxity as an associated risk factor for a poorer outcome *(LocalConcensus 2014 [5])*.

    Note: Components of the Beighton Scale, which is commonly used to quantify hypermobility, may be assessed (excluding the involved limb) and may be found in Appendix 2 of the conservative guideline *(Smith 2008 [1b], Smits-Engelsman 2011 [3b], Cameron 2010 [3b], VanderGiessen 2001 [4b], CCHMC_LateralPatellarInstabilityManagementTeam 2014 [5])*.

11. It is recommended that knee-specific scales in conjunction with general health instruments are used for a more thorough understanding of the patient's assessment of his or her own knee function and general function following MPFLR, which may include:

    Knee specific Instruments:

- International Knee Documentation Committee (IKDC/Pedi-IKDC) Forms
- Kujala Patellofemoral Disorder Score
- Lysholm Knee Scale
- Tegner Activity Score
- Fulkerson Knee Instability Scale
- General Health Instruments: Short Form 36
- Musculoskeletal Function Assessment, PedsQL *(Smith 2010a [1b], Smith 2008 [1b], Paxton 2003 [2a], Briggs 2009 [3b], LocalConcensus 2014 [5], Lysholm 2007 [5a])*.

Patient and Family Centered Care

12. It is recommended that self-management education and skill building include tailored health education based on individual patient/family needs, risks, and readiness to change *(LocalConcensus 2014 [5])*.

    Note: Self-management is the ability of the client and family to collaborate on and adhere to individualized therapy treatment recommendations and appropriately handle signs/symptoms/difficulties associated with the therapy diagnosis to maximize quality of life and participation in life roles *(LocalConcensus 2014 [5], Lorig 2003 [5b])*.

13. It is recommended that the patient and family's ability to participate in the management of their condition is assessed with regard to:

- Attitudes and beliefs, including confidence and importance about the injury *(Williams 2007 [3a])*
- Readiness to change *(LocalConcensus 2014 [5])*

14. It is recommended that the following patient and family factors are considered in order to develop an individualized and collaborative plan of care:

- understanding of the condition
- self-efficacy, beliefs, and stage of readiness to address the condition
- degree of goal alignment with the health care team's
- dynamics and access to resources to follow the health care professionals' recommendations regarding the condition
- potential barriers to being able to optimally attend physical therapy sessions and perform a home exercise program (HEP) *(LocalConcensus 2014 [5], Ryan 2009 [5a], Holman 2004 [5b])*

Physical Therapy Assessment and Diagnosis

15. It is recommended that clinicians synthesize subjective, objective, and self-management information from the physical therapy examination to establish a physical therapy diagnosis and individualized plan of care *(American Physical Therapy 2003 [5a])*.

Re-Assessment

16. It is recommended that quantitative and qualitative measures relative to the goals for each phase of treatment be re-assessed at least every two weeks and/or whenever the patient experiences a significant change in status*(LocalConcensus 2014 [5])*.

    Note: To ensure proper ROM progression, re-assessments for knee ROM may be appropriate at every session during the early phases of rehabilitation *(LocalConcensus 2014 [5])*

Management Recommendations

17. It is recommended that dosage of physical therapy be approximately 2-3 times per week with a supplemental HEP with modifications made as determined to be appropriate based upon the patients' needs, preferences, and specific impairments *(Friedrich 1996 [2b], LocalConcensus 2014 [5], Bailes 2008 [5a])*.

    Note: Patients who participate in supervised clinical visits demonstrate greater gains in muscle strength, functional mobility, gait speed, and quality of exercise performance than those who receive a HEP alone or no instruction at all *(Friedrich 1996 [2b])*.

18. It is recommended that a functional-based goal progression model of advancement through the phases of rehabilitation be followed rather than a time-based progression model *(LocalConcensus 2014 [5])*.

    Note: All recommended milestones/goals may not be appropriate for every individual. Rehabilitation progression relies on sound clinical judgment, a good understanding of the patient's pre-injury level of function, and personal activity goals *(LocalConcensus 2014 [5])*.

Guideline Recommendations

Phases of Rehabilitation

General Interventions for All Phases

Pain

19. It is recommended that the following are performed for pain management as appropriate:

- Cryotherapy *(Rice 2009 [2a], Hopkins 2006 [2a], Singh 2001 [2a], Bolgla 2000 [5b])*
- Electrical stimulation and transcutaneous electrical nerve stimulation per clinician discretion *(LocalConcensus 2014 [5], Palmieri-Smith 2008 [5a])*
- Medications as recommended by physicians. *(LocalConcensus 2014 [5])*.

Effusion

20. It is recommended that the following are used to help decrease effusion as appropriate:

- Cryotherapy *(Rice 2009 [2a], Hopkins 2006 [2a], Singh 2001 [2a], Bolgla 2000 [5b])*
- Vasopneumatic device *(Holwerda 2012 [3b])*
- Elastic compression wrap before and after therapy sessions *(Janwantanakul 2006 [4b], LocalConcensus 2014 [5])*

Initial Phase

This phase is designed to help patients prepare to engage in activities that will restore knee motion, minimize edema, improve tolerance for weight bearing, and initiate local muscle activation while protecting the surgical site. It is important to note that patients that required other surgical interventions in conjunction with MPFLR may require extra precautions such as specific ROM or weight bearing restrictions. Patients with extra precautions may need to spend extra time in the initial phases of this guideline *(LocalConcensus 2014 [5])*. See Table 2 for Initial Phase goals.

Table 2 Goals for Initial Phase

Impairment	Goals
Pain	≤ 2out of 10 on NRS or little to no indication of pain with other scales during ambulation with or without an assistive device as appropriate
Effusion	Minimal to none
Range of Motion and Flexibility	• Achieve 0° knee extension AROM • Achieve ≥ 90° knee flexion PROM by 4 weeks post-operation • Achieve ≥ 120º by 6 weeks post-operation
Muscle Strength and Control	• Achieve a visible or palpable contraction of the quadriceps muscle group by the end of the 1st week post-operation • Demonstrate visible activation of quadriceps femoris muscle group by performing a straight leg raise with less than or equal to 10 degrees of extensor lag by the end of the initial phase • Achieve a MMT score of at least 4/5 for abdominal musculature and all lower extremity musculature in the uninvolved leg by the end of the initial phase
Balance	Demonstrate symmetrical weight bearing in double limb stance with minimal to no assist
Gait	Demonstrate independent, safe, and symmetrical walking mechanics with appropriate use of assistive device as needed
Functional Tests	Demonstrate safe and independent transfers, bed mobility and stair navigation with an assistive device as needed

(LocalConcensus 2014 [5])

<u>Initial Phase - ROM/Flexibility</u>

21. It is recommended that passive static stretches, AROM exercises, and active assisted range of motion (AAROM) exercises for lower extremity musculature and joints are utilized to assist with gains in ROM and flexibility *(Moseley 2005 [2a], Bandy 1998 [2a], Davis 2005 [2b], LocalConcensus 2014 [5])*. Example exercises are provided in Appendix 1a.

    Note 1: Gradual progression of ROM will help minimize the negative side effects of increased pain, muscle guarding, and joint inflammation *(LocalConcensus 2014 [5])*.

    Note 2: AROM and AAROM may be helpful if the patient is muscle guarding due to pain or unable to achieve end range of motion with static stretch. AROM and AAROM can also be used to help maintain new gains in motion *(Bandy 1998 [2a], Depino 2000 [2b], LocalConcensus 2014 [5])*.

22. It is recommended that stretching applied to graft-source musculature is applied gently and progressed slowly to allow the tissue to heal properly *(LocalConcensus 2014 [5])*.
23. It is recommended that light mobilizations of the patella in the superior, inferior and medial directions (not lateral) and scar massage are initiated to promote patellar and skin mobility and minimize scarring toward the end of the initial phase *(LocalConcensus 2014 [5])*.
24. It is recommended that AROM and AAROM continue to be performed following stretching to maintain new gains in motion *(Depino 2000 [2b])*.

<u>Initial Phase - Muscle Strengthening and Control</u>

25. It is recommended that strengthening exercises for this phase begin with isometric and isotonic exercises targeting hip and knee musculature in gravity-mitigated positions with progression to isotonic exercises against gravity as tolerated by patient *(LocalConcensus 2014 [5])*. Example exercises are provided in Appendix 1a.
26. It is recommended that strengthening exercises are initiated in2 sets of 10-15 repetitions of exercises as appropriate, with progression to 3 sets of each exercise as tolerated *(Rhea 2002 [2b], Faigenbaum 1996 [4b], LocalConcensus 2014 [5])*.

    Note 1: This recommendation applies for all strengthening exercises for all phases of rehabilitation *(LocalConcensus 2014 [5])*.

    Note 2: If the patient is unable to perform 2 sets of 10 repetitions of an exercise, the intensity of the exercise can be modified per clinical judgment *(LocalConcensus 2014 [5])*.

27. It is recommended that isometric holds in varying degrees of hip flexion, hip abduction, and hip extension with the knee in full extension are utilized to target key muscles while minimizing

patellofemoral forces and pain *(LocalConcensus 2014 [5])*.

Note: The addition of resistance to exercises and integration of eccentric-specific exercises may be appropriate for certain muscle groups and/or positions based on clinical judgment *(LocalConcensus 2014 [5])*.

28. It is recommended that isokinetic exercises are avoided during this phase of treatment to minimize pain and reduce stress to the surgical site *(LocalConcensus 2014 [5])*.
29. It is recommended that short arc quadriceps exercises (knee extension from 30° to 0°) and long arc quadriceps exercises in the terminal range of 30° to 0° are avoided to minimize stress to the reconstructed medial patellofemoral ligament *(LocalConcensus 2014 [5])*.
30. It is recommended that visual, tactile and verbal feedback cues are provided as needed to ensure optimal performance. *(LocalConcensus 2014 [5])*.

    Note: Individuals who receive regular positive feedback from a physical therapist are more likely to be adherent with a supplemental home exercise program *(Sluijs 1993 [4b])*.
31. It is recommended that Neuromuscular Electrical Stimulation (NMES) is used in conjunction with exercise to facilitate quadriceps activation and strength *(Fithian 2004 [2a], Snyder-Mackler 1995 [2a], LocalConcensus 2014 [5])*.
32. It is recommended that additional isometric and isotonic strengthening exercises are implemented to target bilateral core and hip musculature *(Powers 2010 [5a], Reinold 2006 [5a])*.

Initial Phase - Balance

33. It is recommended that balance exercises for this phase begin with an emphasis on symmetrical weight bearing in double limb stance with minimal to no assist and progressed to good control with weight-shifting in Anterior-Posterior and Medial-Lateral directions *(LocalConcensus 2014 [5])*.

    Note: Weight shifting in the anterior-posterior and medial-lateral directions in this phase of rehabilitation may help to prepare the patient to progress away from dependence on an assistive device and progress to single leg balance in the next rehabilitation phase *(LocalConcensus 2014 [5])*.

Initial Phase - Gait

34. It is recommended that patient-specific ambulation exercises are implemented to improve the patient's ability to:

- Weight bear as tolerated and appropriate per physician recommendation
- Demonstrate adequate ROM in hip, knee and ankle at each phase of the gait cycle
- Maintain good quadriceps control, particularly during stance phase
- Decrease dependence on assistive device while maintaining proper gait mechanics *(LocalConcensus 2014 [5])*

Initial Phase - Functional Tasks

35. It is recommended that patients are provided training and education in bed mobility, transfers, and safe stair navigation with progression toward minimal use of assistive device as appropriate *(LocalConcensus 2014 [5])*.

Restoring Basic Function Phase

The purpose of this phase is to ensure that the patient is able to perform all basic functional tasks (e.g., walking longer distances, stooping, stair navigation) associated with typical ADLs while still maintaining any precautions that may need to be followed due to the procedure performed, or any concomitant issues *(LocalConcensus 2014 [5])*. See Table 3 for Restoring Basic Function goals.

Table 3: Goals for Restoring Basic Function

Impairment	Goals
Pain	≤ 2 out of 10 on NRS or little to no indication of pain with other scales during all basic functional tasks
Effusion	Intermittent to minimal
Range of Motion and Flexibility	Achieve ≥ 120º or 75% of uninvolved limb for knee flexion
Muscle Strength and Control	• Maintain an unassisted straight leg raise without an extensor lag for 10 seconds • Achieve a MMT of at least 4-/5 for involved limb hip, knee, and ankle musculature or 60-65% of isometric dynamometer comparison to uninvolved • Achieve a MMT strength of at least 4+/5 for core muscles and uninvolved hip, knee and ankle musculature • Demonstrate a double leg squat with proper alignment with minimal visual, tactile or verbal cues
Balance	Perform single leg balance on involved limb at 90% timed performance of uninvolved limb on stable surface.
Gait	Demonstrate normal walking mechanics without the use of assistive device on even and uneven surfaces
Functional Tests	• Demonstrate safe and independent transfers, bed mobility, and stair navigation without the use of an assistive device • Demonstrate quick, unanticipated change of direction while ambulating
Cardiovascular	Tolerate 5 minutes of minimal intensity activity such as walking or low resistance stationary cycling
Patient Reported Outcome Measure	Achieve a score of 60% of goal target on a Patient Reported Outcome Measure (e.g. IKDC, Kujala, Peds QL)

(LocalConcensus 2014 [5])

Restoring Basic Function Phase - ROM/Flexibility

36. It is recommended that passive static stretches for lower extremity musculature continue to be utilized to assist with gains in ROM and flexibility *(Moseley 2005 [2a], Bandy 1998 [2a], Davis 2005 [2b], LocalConcensus 2014 [5])*. Example exercises include:

- Standing or prone quadriceps stretch
- Long-sitting, or supine 90/90 hamstring stretch
- Standing gastroc/soleus stretch on floor or slantboard

Note: Dynamic ROM *(Bandy 1998 [2a])* may be beneficial if the patient is muscle guarding due to pain and unable to achieve end range motion with static stretch *(LocalConcensus 2014 [5])*. For example exercises see Appendix 1b.

Restoring Basic Function Phase - Muscle Strength and Control

37. It is recommended that strengthening exercises include resisted isometric and isotonic strengthening (concentric and eccentric) specifically targeting the hip, knee and ankle musculature of the involved limb with the addition of resistance as appropriate *(LocalConcensus 2014 [5], Powers 2010 [5a], Reinold 2006 [5a], Bolgla 2000 [5b])*. For example exercises see Appendix 1b.

    Note 1: It may be necessary to begin these exercises with lighter resistance (partial to body weight only with progression to increased resistance per clinical judgment *(LocalConcensus 2014 [5], Bolgla 2000 [5b])*.

    Note 2: Isokinetic exercises may be appropriate to integrate in the later stages of this phase *(LocalConcensus 2014 [5])*.

38. It is recommended that Neuromuscular Electrical Stimulation (NMES) continue to be used as needed in conjunction with exercise to facilitate quadriceps activation and strength *(Fithian 2004 [2a], Snyder-Mackler 1995 [2a], LocalConcensus 2014 [5])*.

39. It is recommended that Open Kinetic Chain Exercises (OKCE) are incorporated into the strength training exercises for the involved limb such as knee flexion and extension, hip flexion, extension, abduction, adduction, ankle plantar flexion, dorsiflexion, eversion, and inversion *(Escamilla 1998 [4b], LocalConcensus 2014 [5])*.

    Note: It may be helpful to perform OKCE for knee flexion/extension initially only from 90°-30° for the involved limb to allow for enhanced osseous stability with progressions working toward exercises that work through the entire ROM *(Escamilla 1998 [4b], LocalConcensus 2014 [5])*.

40. It is recommended that isotonic Closed Kinetic Chain Exercises (CKCE) are initiated using a double limb stance with a focus on neuromuscular control of the pelvis, femur, tibia, and patella during knee flexion ROM to encourage optimal alignment of all joints during movements *(LocalConcensus 2014 [5])*.

41. It is recommended that a continued emphasis is placed on targeting hip, knee and ankle musculature of the uninvolved limb and any other muscle groups (e.g., core and trunk musculature) where significant strength deficits remain present *(LocalConcensus 2014 [5], Powers 2010 [5a], Reinold 2006 [5a], Bolgla 2000 [5b])*.

Restoring Basic Function Phase - Balance

42. It is recommended that balance exercises for this phase include double limb stance challenges on dynamic surfaces and other external perturbations with an emphasis on transitioning to a safe ability to balance independently on a single leg *(LocalConcensus 2014 [5])*.

    Note: Patients at this stage may also be ready to begin more advanced challenging single leg balance challenges that include unstable surfaces and external perturbations *(LocalConcensus 2014 [5])*.

Restoring Basic Function Phase - Gait

43. It is recommended that the remaining deficits in the gait cycle (e.g., quadriceps avoidance) continue to be emphasized to progress the patient off any assistive devices and normalize gait patterns on even and uneven surfaces *(LocalConcensus 2014 [5])*.

Restoring Basic Function Phase - Functional Tasks

44. It is recommended that advanced training exercises be incorporated for ADLs such as repeated chair squats, reciprocal stair climbing, single leg balance with floor touches or object pick-ups, obstacle avoidance, and quick changes/pivots in direction while ambulating *(LocalConcensus 2014 [5])*.

Restoring Basic Function Phase - Cardiovascular

45. It is recommended that minimal intensity cardiovascular exercise be performed at a Rate of Perceived Exertion (RPE) of 9-11 on the 6-20 Borg Scale or 3-4 on the Pictorial Children's Effort Rating Table (PCERT) *(Roemmich 2006 [4a], Dunbar 1992 [4b], LocalConcensus 2014 [5], Groslambert 2006 [5a])*.

    Note: RPE has been shown to be a valid and reliable measurement of exertion and correlated with heart rate produced during physical activity *(Dunbar 1992 [4b], Groslambert 2006 [5a])*.

Restoring Advanced Function Phase

The purpose of this phase is to fully restore the patient's ability to engage in pre-surgical level of age-appropriate functional activities and build symmetry between involved and uninvolved limbs. By the end of this phase, patients will be able to meet the Center for Disease Control recommended guidelines for physical activity, with the ability to participate in all activities expected for healthy, typically-developing children. Healthy guidelines include: full participation in physical activity classes, and at least 60 minutes of activity a day including moderate intensity (e.g. brisk walking) and vigorous intensity (e.g. running) *(LocalConcensus 2014 [5], DHHS 2008 [5a])*. See Table 4 for Restoring Advanced Function goals.

Table 4: Goals for Restoring Advanced Function

Goal	Expected Outcome
Pain	Resolved for all basic functional activities and ≤ 2 out of 10 on NRS or little to no indication of pain with other scales during all advanced functional tasks
Effusion	Resolved for all basic functional activities and minimal to intermittent following more advanced functional activities
ROM / Flexibility	Demonstrate ROM and flexibility equal to uninvolved limb for all lower extremity joints and musculature
Muscle Strength and Control	• Achieve a MMT score of at least 4+/5 for involved limb hip, knee, and ankle musculature (or at least 85% of dynamometer comparison to uninvolved) • Achieve a MMT strength of 5/5 for core muscles and uninvolved hip, knee and ankle musculature • Demonstrate double leg squat to 90 degrees of knee flexion with proper form and technique for 10 seconds • Demonstrate single squat to 60 degrees of knee flexion with proper form and technique for 10 seconds • Perform planks/modified plank for 60 seconds • Perform side planks/modified side planks for 60 seconds • Perform Sorenson test for 60 seconds • Perform V-sit hold for 60 seconds
Balance	• Demonstrate single leg balance equal to uninvolved limb for time • Demonstrate single leg balance quality equal to uninvolved leg on unstable surfaces • Demonstrate proper ability to balance on a single leg with internally derived perturbations (e.g. reaching for an object or tossing a ball) and externally derived perturbations (e.g., perturbations applied to wobble board by clinician) bilaterally
Gait	Demonstrate good, symmetrical mechanics while running short distances at a minimum intensity level of 75% of pre-injury abilities for a minimum distance of 50'
Functional Tasks	Demonstrate: • safe climbing/navigation of varying step heights or playground-type pieces of equipment • proper mechanics while stooping, kneeling, lifting heavy objects • proper mechanics while performing basic-level hopping, skipping, jumping, and jogging activities per age-appropriate activity-level needs

Goal	Expected Outcome
	• double leg jumping in place on static surfaces with proper technique 100% of the time for 10 jumps • Limb Symmetry index of ≥ 85 on all single leg hop tests
Cardiovascular	Participate in cardiovascular activity without increased pain or adverse event (such as early onset of fatigue with regards to age and activity, syncope) greater than or equal to 90% intensity and duration of pre-injury level.
Patient Reported Outcome Measure	Achieve a patient reported outcome measure (e.g. IKDC, Kujala, Peds QL) of ≥ 85% of target goal.

(LocalConcensus 2014 [5])

Restoring Advanced Function Phase - ROM/Flexibility

46. It is recommended that passive static stretches for lower extremity musculature continue to be utilized to assist with gains and/or maintenance of ROM and flexibility *(Moseley 2005 [2a], Bandy 1998 [2a], Davis 2005 [2b], LocalConcensus 2014 [5])*.

47. It is recommended that manual therapy techniques such as more aggressive manual stretching and joint mobilizations are utilized if ROM deficits continue to be present in the involved knee *(LocalConcensus 2014 [5])*.

Restoring Advanced Function Phase - Muscle Strength and Control

48. It is recommended that isotonic and isokinetic resistance exercises targeting the knee, hip and ankle musculature of the involved knee are fully integrated into therapeutic exercises by this phase *(LocalConcensus 2014 [5])*. For example exercises see Appendix 1c.

    Note: It is appropriate at this stage to increase resistance and work through increasing ROM for both OKCE and CKCE as tolerated by the patient and within the patient's ability to maintain proper core, hip, knee and foot alignment *(LocalConcensus 2014 [5])*.

49. It is recommended that a continued emphasis is placed on good control, alignment and appropriate muscle recruitment for double leg and single leg activities *(LocalConcensus 2014 [5])*.

    Note 1: At this stage, it is appropriate to integrate more exercises that emphasize full-body dynamic movements in multiple planes of motion that incorporate strength and endurance building for core musculature and trunk stability *(Powers 2010 [5a], Reinold 2006 [5a], Greiwe 2010 [5b])* and strengthening activities performed on both static and dynamic surfaces *(LocalConcensus 2014 [5], Reinold 2006 [5a], Greiwe 2010 [5b], Bolgla 2000 [5b])*.

Restoring Advanced Function Phase - Balance

50. It is recommended that balance training activities include more advanced activities for single leg balance with perturbations on unstable surfaces *(LocalConcensus 2014 [5])*.

Restoring Advanced Function Phase - Gait

51. It is recommended that exercise interventions that emphasize proper, symmetrical, and safe gait patterns for jogging and running are integrated in this phase *(LocalConcensus 2014 [5])*.

    Note: Even if a patient did not engage in running activities regularly prior to injury, it is likely he or she may be expected to participate in at least low-level running activities for physical education classes or for participation at recess with classmates. It is important to ensure the patient is able to run at least short distances safely using proper form *(LocalConcensus 2014 [5])*.

Restoring Advanced Function Phase - Functional Tasks

52. It is recommended that, when strength and neuromuscular control are adequate for safety purposes, exercises that emphasize the following are introduced:
    - Quick changes in direction on stable and unstable surfaces and even and uneven step-heights
    - Increased intensity and dynamic motions associated with ADLs or work/play related tasks (e.g., squatting or lunging quickly with heavier weight to replicate lifting heavier boxes/object from the floor) emphasizing mechanics
    - Age-appropriate activities such as skipping, double leg hopping, single leg hopping, and jogging per patient and family goals and to return to desired physical activity. *(LocalConcensus 2014 [5])*

    Note: These exercises will help improve the patient's ability to fully participate in physical education class and/or in recreational activities and can be designed to be task or sport-specific, such as being able to navigate the playground, participate in physical education classes or engage in the work environment safely *(LocalConcensus 2014 [5])*.

Restoring Advanced Function Phase - Cardiovascular

53. It is recommended that moderate intensity cardiovascular exercise is integrated with a RPE of 12-14 on the 6-20 Borg Scale or 5-6 on the PCERT, and vigorous intensity exercise is performed with a

RPE of 15-17 or 7-8 on the PCERT *(Roemmich 2006 [4a], Dunbar 1992 [4b], LocalConcensus 2014 [5], Groslambert 2006 [5a])*.

Return-to-Activity Phase

Successful attainment of the goals for the Restoring Advanced Function Phase is used as indication of the individual's readiness to reintegrate into higher level activities. If the patient's highest level of personal functional goals have been met at this time, and clinical judgment dictates the patient is able to perform all age-appropriate types of activities (e.g., full participation in physical education classes), it may be appropriate to discharge patient at this time. If the patient's goals include full return to high-level sports or recreational activities, additional sport/activity-specific training could be critical for minimizing risk for re-injury or other injuries as well as returning to pre-injury performance levels.

54. It is recommended that progressive reintegration into activities be conducted according to the Evidence-based Care Guideline for Return-to-activity After Lower Extremity Injury *(LocalConcensus 2014 [5])*. For example exercises see Appendix 1d.

Discharge Criteria

55. It is recommended that discharge from therapy be based on clinical judgment, attainment of goals, and successful participation in desired activities *(LocalConcensus 2014 [5])*.

Future Research Agenda

Due to limited evidence in the current literature, many of the recommendations in this guideline were based on low-level evidence and/or consensus statements developed by the authorship team. Suggestions for future research that could help improve post-operative management of lateral patellar dislocations and instability includes:

- Outcome studies that consider pre-disposing risk factors (e.g., anatomic abnormalities), activity levels, maturational levels and gender
- Studies regarding the tissue healing properties of grafts for the MPFL
- Creation and validation of a patellar instability scale appropriate for children and adolescents
- Outcome studies that track the typical recovery patterns for ROM, strength, and performance of functional tasks

Comparative effectiveness studies that evaluate various modes, dosage, and discharge criteria for physical therapy interventions

Appendix 1a: Intervention Examples for the Initial Phase *(LocalConcensus 2014 [5])*

ROM/Flexibility	Muscle Strength, Neuromuscular Control and Gait	Cardiovascular	Other
1. Partial to full revolutions on stationary bike to improve ROM 2. Knee flexion stretches (supine wall slide with feet on wall, AAROM towel pulls) 3. Knee extension stretches (place bolster/towel underneath heel to promote knee extension) 4. Gastrocnemius and soleus stretches 5. Hamstring stretches 6. Mobilization of patella all directions **except lateral** 7. Scar massage	1. Quadriceps isometric sets 2. Gluteal isometric sets 3. Straight leg raises for hip flexion, abduction, adduction and extension 4. Clamshells 5. Mini squats with hip hinge emphasis 6. Double leg bridges 7. Theraband exercises for involved ankle 8. Double leg anterior-posterior weight shifts 9. Double leg medial-lateral weight shifts 10. Double leg calf raises	1. Walking for increased distances as tolerated and appropriate **2.** Upper body ergometer as tolerated	1. Electrical stimulation to control pain and effusion 2. Cryotherapy to control pain and effusion 3. Medications to minimize pain and effusion at recommendation of physician 4. Vasopneumatic device and/or compression wraps to decrease effusion 5. Neuromuscular Electrical Stimulation (NMES) to facilitate quadriceps activation 6. Training in bed mobility, transfers, and safe stair navigation

Appendix 1b: Intervention Examples for Restoring Basic Function Phase *(LocalConcensus 2014 [5])*

ROM/Flexibility	Muscle Strength, Neuromuscular Control and Gait	Cardiovascular	Other
1. Full revolutions on stationary bike to maintain/improve ROM 2. Knee flexion stretch 3. Knee extension stretch 4. Gastrocnemius and soleus stretches (slant board) 5. Mobilization of patella all directions including mild lateral glides 6. Standing/prone quadriceps stretch 7. Supine 90/90 hamstring stretch 8. Dynamic ROM exercises (standing marches, lunges, "bicycle walks," heel tap to buttocks walk)	1. Straight leg raises for hip flexion, abduction, adduction, and extension with added resistance and isometric holds as tolerated and appropriate 2. Double leg squats 3. Forward step-ups 4. Lateral step-ups 5. Retro/Reverse step-ups 6. Wall squats and leg press beginning at 45 degrees of knee flexion and progressively working into the higher and lower levels of flexion 7. Hamstring curls against gravity with slow progression to higher levels of resistance 8. Sidesteps 9. Quadruped alternating upper extremity/lower extremity 10. Single leg calf raises 11. Double leg dynamic balance (unstable surfaces, rocker board, ball toss) 12. Single leg balance on firm surface 13. Prone planks 14. Side planks 15. Stability ball roll-outs 16. Stability ball skier 17. Stability ball knee-up 18. Double limb stand on dynamic surfaces	1. Upper body ergometer 2. Stationary biking for conditioning; increasing resistance as tolerated and appropriate 3. Marches in pool 4. Forward, retro, lateral stepping in pool 5. Swimming	1. Electrical stimulation to control pain and effusion 2. Cryotherapy to control pain and effusion 3. Medications to minimize pain and effusion at recommendation of physician 4. Vasopneumatic device and/or compression wraps to decrease effusion 5. NMES to facilitate quadriceps activation

Appendix 1c: Intervention Examples for Restoring Advanced Function Phase *(LocalConcensus 2014 [5])*

ROM/Flexibility	Muscle Strength, Neuromuscular Control and Gait	Cardiovascular
1. Stretches as needed to maintain ROM and flexibility	1. Forward step up (high) 2. Lateral step up (high) 3. Reverse step up (high) 4. Wall squat 5. Single leg squat 0°-45° 6. Side plank + hip abduction 7. Front plank + hip extension 8. Single leg balance + hip abduction 9. Single leg deadlifts 10. Single leg bridge 11. Side stepping 12. Transverse lunges 13. Resisted diagonal stepping 14. Quadruped alternating upper extremity/lower extremity 15. Forward lunge + trunk rotation as appropriate to challenge stability 16. Retro lunge 17. Stability ball pike up 18. Stability ball roll-out + hip extension 19. Stability ball skier 20. Stability ball knee up 21. Anterior step down 22. Prone and lateral planks 23. Dynamic balancing double leg and single leg (reactive and anticipatory) 24. Double leg ankle hops (vertical, medial/lateral, anterior/posterior, diagonal), increasing height and distance as appropriate 25. Double leg mini squat and lunge jumps (focusing on form and increasing depth, height and distance as appropriate) 26. Low-level single leg hops 27. Agility ladder drills	1. Stationary biking or elliptical trainer at progressively harder levels of intensity and longer periods of time 2. Swimming-start with pulling and advance to using lower extremity at progressively harder levels of intensity and longer periods of time 3. Run/walk program with progression to running at desired intensity level as appropriate 4. Skipping/jumping

Appendix 1d: Intervention Examples for Return-to-Activity Phase *(LocalConcensus 2014 [5])*

ROM / Flexibility	Muscle Strength, Neuromuscular Control and Gait	Cardiovascular
1. Stretches as needed to maintain ROM and flexibility	1. Single leg squat 0°-45° on dynamic surfaces 2. Side plank + hip abduction 3. Front plank + hip abduction 4. Front plank + hip extension 5. Single leg deadlift 6. Transverse lunge 7. Multi planar lunges 8. Stability ball pike up 9. Progressing previous exercises with increased holds, repetitions, or intensity as appropriate 10. Box drops 11. Box jump with rebound 12. Single leg plyojumps in various directions (increasing height and quickness as appropriate) 13. Single leg static bounding, rotational, and repetitive jumps 14. Sport specific drills and activities	1. Elliptical Trainer 2. Jogging and/or running 3. Sprinting 4. Plyometrics, cutting and pivoting activities

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All of the staff listed above has signed a conflict of interest declaration and none were found. The guideline was developed without external funding.

Development Process

The process by which this guideline was developed is documented in the Guideline Development Process Manual; relevant development materials are kept electronically. The recommendations contained in this guideline were formulated by an interdisciplinary working group which performed systematic search and critical appraisal of the literature, using the Table of Evidence Levels described following the references, and examined current local clinical practices. The recommendation statements were formally reviewed by other physical therapists, physicians and athletic trainers. In addition, specific feedback regarding patient and family needs and preferences were obtained through a review process with former patients and family members who have undergone conservative management of lateral patellar instability.

Tools to assist in the effective dissemination and implementation of the guideline are available online at http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/ev-based/default.htm .

Once the guideline has been in place for five years, the development team reconvenes to explore the continued validity of the guideline. This phase can be initiated at any point that evidence indicates a critical change is needed.

Recommendations have been formulated by a consensus process directed by best evidence, patient and family preference and clinical expertise. During formulation of these recommendations, the team members have remained cognizant of controversies and disagreements over the management of these patients. They have tried to resolve controversial issues by consensus where possible and, when not possible, to offer optional approaches to care in the form of information that includes best supporting evidence of efficacy for alternative choices.

The guideline has been reviewed and approved by clinical experts not involved in the development process, distributed to senior management, and other parties as appropriate to their intended purposes.

Copies of this Evidence-based Care Guideline (EBCG) and any available implementation tools are available online and may be distributed by any organization for the global purpose of improving child health outcomes. Website address: http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/ev-based/default.htm. Examples of approved uses of the EBCG include the following:

- copies may be provided to anyone involved in the organization's process for developing and implementing evidence based care guidelines
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NOTE: These recommendations result from review of literature and practices current at the time of their formulations. This guideline does not preclude using care modalities proven efficacious in studies published subsequent to the current revision of this document. This document is not intended to impose standards of care preventing selective variances from the recommendations to meet the specific and unique requirements of individual patients. Adherence to this guideline is voluntary. The clinician in light of individual circumstances presented by the

patient must make the ultimate clinical judgment regarding the implementation and priority of any specific procedure.

For more information about this guideline, its' supporting evidences and the guideline development process, contact the James M. Anderson Center for Health Systems Excellence office at EBDMInfo@cchmc.org .

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Note: When using the electronic version of this document, ☜ indicates a hyperlink to the PubMed abstract. A hyperlink following this symbol goes to the article PDF when the user is within the CCHMC network.

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Note: Full tables of evidence grading system available in separate document:

- Table of Evidence Levels of Individual Studies by Domain, Study Design, & Quality (abbreviated table below)
- Grading a Body of Evidence to Answer a Clinical Question
- Judging the Strength of a Recommendation (abbreviated table below)

Table of Evidence Levels (see note above)

Quality level	***Definition***
1a† or 1b†	Systematic review, meta-analysis, or meta-synthesis of multiple studies
2a or 2b	Best study design for domain
3a or 3b	Fair study design for domain
4a or 4b	Weak study design for domain
5, 5a or 5b	Other: General review, expert opinion, case report, consensus report, or guideline

†a = good quality study; b = lesser quality study

Table of Recommendation Strength (see note above)

Strength	***Definition***
"Strongly recommended"	There is consensus that benefits clearly outweigh risks and burdens (or visa-versa for negative recommendations).
"Recommended"	There is consensus that benefits are closely balanced with risks and burdens.
No recommendation made	There is lack of consensus to direct development of a recommendation.

Dimensions: In determining the strength of a recommendation, the development group makes a considered judgment in a consensus process that incorporates critically appraised evidence, clinical experience, and other dimensions as listed below.

1. Grade of the Body of Evidence (see note above)
2. Safety/Harm
3. Health benefit to patient *(direct benefit)*
4. Burden to patient of adherence to recommendation *(cost, hassle, discomfort, pain, motivation, ability to adhere, time)*
5. Cost-effectiveness to healthcare system *(balance of cost/savings of resources, staff time, and supplies based on published studies or onsite analysis)*
6. Directness *(the extent to which the body of evidence directly answers the clinical question [population/problem, intervention, comparison, outcome])*
7. Impact on morbidity/mortality or quality of life

Appendix
Evidence Search Strategy and Results

Criteria for considering studies for this review

Types of Studies
All types of studies were considered for inclusion in the systematic review

Types of Participants
Patients who had undergone surgical intervention for patellar instability made up the target population for this review.

Types of Interventions
All types of Physical Therapy interventions were included in the systematic review

Types of Outcomes
The types of outcomes considered for this review included:

- Pain
- Effusion
- Range-of-Motion
- Gait
- Neuromuscular Control
- Strength
- Return-to-previous level of function
- Re-injury or dislocation
- Feelings of instability

Exclusion Criteria, if any
Studies that reported on surgical procedures which did not include MPFL reconstruction or repair as part of the surgical protocol were excluded.

Search Strategy

Search Methods

To select evidence for critical appraisal by the group for this guideline, the databases below were searched using search terms, limits, filters, and date parameters to generate an unrefined, "combined evidence" database. This search strategy focused on answering clinical questions relevant to condition and employing a combination of Boolean searching and "natural language" searching on human-indexed thesaurus terms as well as "natural language" searching on words in the title, abstract, and indexing terms.

Search Databases	Search Terms	Limits, Filters, & Search Date Parameters
☒ MedLine via PubMed or Ovid	• "Patellar Instability "[All Fields] OR "Patella Instability "[All Fields] OR "Patellar Dislocation "[All Fields] OR "Patella Dislocation "[All Fields] OR "Medial Patellofemoral Ligament "[All Fields] OR "MPFL"[All Fields] OR "Patellar Subluxation "[All Fields] OR "Patella Subluxation "[All Fields] AND ("humans "[MeSH Terms] AND English [lang])	Publication Dates or Search Dates: 1/2000 to 10/2014 ☒ English Language
☒ CINAHL Plus	• "Patellar Instability" OR Patella Instability" OR "Patellar Dislocation" OR "Patella Dislocation" OR Medial Patellofemoral Ligament" OR "MPFL" OR "Patellar Subluxation" OR "Patella Subluxation"	Publication Dates or Search Dates: • 1/2000 to 10/2014 ☒ English Language
☒ Other: SPORTDiscus, PEDRO	• "Patellar Instability" OR Patella Instability" OR "Patellar Dislocation" OR "Patella Dislocation" OR Medial Patellofemoral Ligament" OR "MPFL" OR "Patellar Subluxation" OR "Patella Subluxation"	Publication Dates or Search Dates: • 1/2000 to 10/2014 ☒ English Language

Search Results

The citations were reduced by: eliminating duplicates, review articles, non-English articles, and adult articles (e.g., limits/filters above). The resulting abstracts and full text articles were reviewed by a methodologist to eliminate low quality and irrelevant citations or articles. During the course of the guideline development, additional articles were identified from subsequent refining searches for evidence, clinical questions added to the guideline and subjected to the search process, and hand searching of reference lists. The dates of the most recent searches are provided above. The initial search for evidence identified 1,053 articles. Seventy-four articles met the inclusion criteria above.

Citation	Purpose	Research Design and Study Sample	Results / Conclusions	Evidence Level
Amis (2003)	To describe the anatomy and biomechanics of the MPFL.	Review and expert opinion.	The MPFL is overlaid by the distal part of the vastus medialis obliquus (VMO) and has a mean tensile strength of 208 Newtons. The MPFL is a primary passive restraint for lateral patellar displacement.	5b
Andrish (2008)	To describe an approach to the treatment of recurrent patellar instability that considers the unique features and expectations of the patient rather than using a generic algorithm.	Research review of both static and dynamic tests, expert opinion. Describes individual tests which can be conducted to determine what has caused this individual's patellar dislocation.	Rehabilitation should include an emphasis on core stabilization of the hip, abdomen and back as well as progressive resistance exercises to protect against excessive excessive medial femoral rotation and knee valgus. Although the VMO is an important component of patellar stability, its role as the main dynamic stabilizer has been overstated.	5b
Atkin (2000)	To determine the characteristics of patients at risk for primary patellar dislocation, the course of early recovery, and the risk of late disability and recurrence.	Prospective study of the characteristics of patients who had acute first-time lateral patellar dislocation. The recovery program used standard rehabilitation, emphasizing ROM, strength, and return to function. Patients returned to stressful activity as tolerated when they regained passive ROM, had no effusion, and when quadriceps muscle strength. N=74(37male). Average age 19.9 years (range, 11-56) was at least 80% compared with non-injured limb.	Risk of patellar dislocation greatest in 2nd decade of life. Injury rate higher for girls in 2nd decade and boys in 3rd decade. 16.5% patients had quadriceps angle greater than 20 degrees. Patella alta present in half of patients. 29% showed abnormal sulcus angle. Positive Laurin angle in 44% of injured knees (28% of non-injured). Lateral patellar overhang significantly greater in injured knees. Patients demonstrated a significant decline in sports activities after 6 months (P=0.015). Found no correlation between signs of dislocation and return of strength or motion.	3b
Bailes (2008)	To describe guidelines for frequency of therapy services that were developed to help physical therapists and occupational therapists determine appropriate utilization of therapy services in a pediatric medical setting.	Evidence-based guideline describing factors for consideration when determining dosing recommendations for therapy services.	Four modes of delivery service are described: Intensive (3 to 11 times a week), weekly or bi-monthly (1 to 2 times per week to every other week), periodic (monthly or less often but at regularly scheduled intervals), and consultative (episodic or as needed).	5a
Balcarek (2010)	To identify differences between the sexes in the anatomy of lateral patellar instability.	Case control study: 100 patients with lateral patellar instability and 157 controls. Using 2-way analyses of variance, the influence of patellar dislocation, gender, and their interaction were analyzed with regard to sulcus angle, trochlear depth, trochlear asymmetry, patellar height, and the tibial tubercle–trochlear groove (TT-TG) distance. Mechanisms of injury of first-time dislocations were divided into high-risk, low-risk, and no-risk pivoting activities and direct hits.	The data from this study indicate that trochlear dysplasia and the TT-TG distance is more prominent in women who dislocate the patella. Both factors might contribute to an increased risk of lateral patellar instability in the female patient as illustrated by the fact that dislocations occurred most often during low-risk or no-risk pivoting activities in women.	3

Balcarek (2011)	Toanalyze MPFL injury patterns in children and adolescents after first time LPD in comparison with the injury patterns in adults And to evaluate the trochlear groove anatomy at different developmental stages of the growing knee joint	Case-control study: Knee magnetic resonance images were collected from 22 patients after first time patellar dislocations. Controls consisted of 21 adult patients with first time lateral patellar dislocation. The injury patterns were compared with regards to MPFL ligament and trochlear dysplasia.	After patellar dislocation, injury to the medial patellofemoral ligament was found in 90.2% of the children and in 100% of the adult patients. Injury patterns of the medial patellofemoral ligament were similar between the study group and the control group with regard to injury at the patellar attachment site.	4a
Bandy (1998)	To compare the effects of dynamic range of motion (DROM) and static stretching of the hamstring muscles with a control group on increasing hamstring flexibility as measured by knee extension ROM.	Randomized Control Trial (RCT) with 58 subjects, aged 21 to 41, with limited hamstring flexibility were split into 3 groups: DROM, static stretching and no stretching. They were analyzed for flexibility after a 6 week period.	There was a significant difference the types of stretching, with the static stretch being twice as effective as DROM. Stretching was significantly better than not stretching, regardless of type.	2a
Beasley (2004)	To review risk factors that predispose children to recurrent dislocation and how they can be managed. Also, looking into the results of surgical interventions.	Review of the anatomy and biomechanics related to patellar dislocation.	Risk factors for recurrent dislocation may include various skeletal abnormalities, increased quadriceps angle, generalized ligamentous laxity, and family history. Recent anatomic and biomechanical studies have demonstrated that the medial patellofemoral ligament and the vastus medialis obliquus are the primary restraints to lateral translation and ultimately dislocation of the patella. Management should therefore be directed both at correcting anatomic abnormalities when indicated and at reconstruction of medial restraints to patellar tracking.	5b
Beyer (2005)	The purpose of this investigation was to determine the adequacy of the alternate forms reliability of the reduced- size versions of the Oucher Pain Scale.	Reliability study of the Oucher Pain Scale: A group of 3- to 12-year-old children who underwent surgical or dental procedures (n = 137), scores were obtained after the procedure on small and large versions of the Oucher. The order of presentation of the two different Ouchers was randomized.	Findings revealed that correlation coefficients between the scores provided for the small and large versions of the Oucher were strong, positive, and significant for the Caucasian, African-American, and Hispanic versions in 3- to 12-year-old children.	4a
Bharam (2002)	The evaluation and management of tibial plateau fractures, distal femur fractures, patella fractures, osteochondral fractures with acute patella dislocation, and knee fractures of the adolescent athlete will be discussed in this	Literature review and clinical commentary for knee injuries in the adolescent athlete including acute patella dislocation.	Early recommendations following acute patella dislocation include bracing, early range of motion and working toward 80% quadriceps strength compared with the non-injured limb.	5a

	article. Return to sports criteria and implant removal will also be addressed.			
Bolgla (2000)	To summarize information on previous research aimed at explaining the physiological relationship among knee effusion, quadriceps inhibition, and knee function.	Review of peer-reviewed publications from 1965-1997 that investigated the effect of knee effusion on quadriceps strength using active motion, EMG, and isokinetics.	Most studies reported that a knee effusion resulted in quadriceps inhibition and inferred that quadriceps inhibition would impair knee function.	5b
Briggs (2009)	To establish a normal knee data set for the Lysholm and Tegner rating systems, as well as to show how these scores are affected by age and gender.	A cross-sectional study that included both the Lysholm score and Tegner activity grading scales was completed by 488 subjects in the community who considered their knee function normal. Any subject reporting a history of injury or surgery was excluded from the study. The average age was 41 years (range, 18-85), with 244 men and 244 women qualifying for statistical analysis.	Average Lysholm score was 94 and average Tegner activity level was 5.7. The Lysholm score and age demonstrated no correlation. The Tegner activity level was inversely correlated with age. The average Tegner activity level for men was 6.0 and for women was 5.4. There was no significant difference in the Lysholm score between men and women. These data acquired from a normal, healthy population provide a standard point of reference for the injured or postsurgical knee.	3b
Cameron (2010)	To examine the relationship among sex, generalized joint hypermobility scores, and a history of glenohumeral joint instability within a young, physically active cohort and to describe the incidence of generalized joint hypermobility within this population.	Cross sectional cohort study with 1050 participants. A prospective cohort study to identify modifiable and non-modifiable risk factors for glenohumeral joint instability in a young, healthy, and physically active population. This project represents the cross-sectional analysis of a subset of the baseline data from a broader longitudinal cohort study. The institutional review board at our institution reviewed and approved this study before it began.	Most participants (78%) had no signs of generalized joint hypermobility. Logistic regression analysis revealed a relationship between generalized joint hypermobility and a history of glenohumeral joint instability (P = .023), those with a total Beighton Scale score of >:2 were nearly 2.5 times as likely) to have reported a history of glenohumeral joint instability. Women had a higher Beighton score, but race and sex are not related to glenohumeral joint instability.	3b
Cash (1988)	Determine the effectiveness of non-operative and operative treatment of initial acute patellar dislocation.	A retrospective cohort study for 103 knees in 100 patients. 70 male and 30 female who had knee dislocations. Patients were evaluated and treated by 1) immobilization and exercise, 2) arthroscopy, or 3) surgical repair. Patients' knees remained in an immobilizer for up to 6 weeks. If the knee was stable and minimally tender on interval examination, the immobilizer was discontinued and physical therapy continued until normal strength and stability were obtained. 13 knees were treated with arthroscopic surgery and 16 knees underwent surgical repair.	Acute dislocations occurred more frequently in males than females. Recurrence was rarer in patients whose initial dislocation had occurred when they were over 15 years old. Initial evaluation should include examination of the uninvolved knee which, if found to have signs of congenital abnormality, would indicate a worse prognosis. The most common mechanisms of injury were twisting, valgus stress, or a direct blow to the knee.	4b
Cofield (1977)	To better define the results of nonoperative,	Cohort study of 48 primary, acute lateral patellar dislocations that were initially treated at the Mayo	The data suggests that immediate operative repair should be done in patients with anatomic variations that would contribute to recurrence, in	3b

	conservative treatment of the acute lateral patellar dislocation.	Clinic during the 15-year period of 1955-1969 were analyzed with the use of patient records and roentgenograms. The operative group included all surgeries except MPFL reconstruction.	athletes, and in patients with displaced intra-articular fractures, exclusive of the medial patellar border.	
Davis (2005)	To compare static stretching, PNF-R (agonist contraction), and active self-stretching in a randomized controlled trial by using the same stretching parameters during a 2- and 4- week training program.	A randomized control trial with inclusion criterion of tight hamstrings as defined by a knee extension angle greater than 20° while supine with the hip flexed 90°. The participants were randomly assigned to self-stretch, static stretching, PNF-R or as a control. Each group received the same stretching dose of a single 80-second stretch 3 days per week for 4 weeks. Knee extension angle was measured before the start of the stretching program, at 2 weeks, and at 4 weeks.	Statistical analysis ($p \leq 0.05$) revealed a significant interaction of stretching technique and duration of stretch. Post hoc analysis showed that all 3 stretching techniques increase hamstring length from the baseline value during a 4-week training program; however, only group 2 (static stretching) was found to be significantly greater than the control at 4 weeks	2b
Depino (2000)	To determine the duration of hamstring flexibility gains, as measured by an active knee-extension test, after cessation of an acute static stretching protocol.	Randomized control trial with warm-up knee extensions serving as the baseline comparison measurement (age = 19.8 + 5.1 years, ht = 179.4 ± 18.7 cm, wt = 78.5 ± 26.9 kg).	Tukey post hoc analysis indicated significant improvement of knee-extension range of motion in the experimental group that lasted 3 minutes after cessation of the static stretching protocol. Subsequent measurements after 3 minutes were not statistically different from baseline. A dependent t test revealed a significant increase in knee-extension range of motion when comparing the first to the sixth active warm-up repetition.	2b
DHHS (2008)	To provide a guideline for health professionals and policymakers regarding the health benefits of physical activity and how to help others be more physically active.	Evidence-based guideline developed as a joint effort by the U.S. Department of Health and Human Services.	Regular physical activity can produce long-term health benefits. Most health benefits occur with at least 150 minutes a week of moderate intensity physical activity such as brisk walking. Children and adolescents should do 60 minutes or more of physical activity daily. As part of their 60 or more minutes, muscle strengthening and bone-strengthening activities should be included.	5a
Dunbar (1992)	To examine the regulation of exercise intensity by using RPE in comparison to targeted heart rate.	Experimental design with 17 males ages 17-35 years. Each subject underwent one familiarization, two estimation, and four production trials. The estimation trials were presented in counter-balanced sequence and were undertaken prior to the production trials. The production trials were presented in randomized order. A minimum of 48 hours separated each trial.	There were no significant differences in any of the trials when attempting to determine validity of the RPE scale during strenuous exercise. Present findings indicate that RPE provides a simple and physiologically valid method of regulating exercise intensity. The principle underlying an exercise prescription is to identify training intensity that elicits a predetermined total body VO_2.	4b
Escamilla (1998)	The purpose was to quantify knee forces and muscle activity in CKCE (squat and leg press) and OCKE (knee extension).	Observational study with ten male subjects performed three repetitions of each exercise at their 12-repetition maximum. Kinematic, kinetic, and electromyographic data were calculated using video cameras (60 Hz), force transducers (960 Hz), and EMG(960 Hz).	Overall, the squat generated approximately twice as much hamstring activity as the leg press and knee extensions. Quadriceps muscle activity was greatest in CKCE when the knee was near full flexion and in OKCE when the knee was near full extension. OKCE produced more rectus femoris activity while CKCE produced more vasti muscle activity. Tibiofemoral compressive force	4b

		Mathematical muscle modeling and optimization techniques were employed to estimate internal muscle forces.	was greatest in CKCE near full flexion and in OKCE near full extension. Patellofemoral compressive force was greatest in CKCE near full flexion and in the mid-range of the knee extending phase in OKCE.	
Faigenbaum (1996)	To evaluate the effects of 8 weeks of strength training and detraining on voluntary strength, flexibility, and vertical jump in children, and to investigate the time course for strength adaptations and retrogressions.	Cross-sectional comparison study with 11 boys and 4 girls, ages 7 to 12 years. Three boys and 6 girls matched for age and level of maturity served as controls. Progressive strength training was performed twice a week on child-size equipment. Subjects were tested on the following measures: 6 repetition maximum (RIM) leg extension, 6-RM chest press, vertical jump, and flexibility.	At 8 weeks experimental group showed increased strength in 6 RM for leg extension (53.5%) and chest press (41.1%). At 8 weeks of detraining experimental group had losses of leg extension (-28.1%) and chest press (-19.3%), control group had gains of 6.4% and 9.5% respectively. Following 8 week detraining period, chest press strength was still significantly greater than control, but there was no difference in leg extension strength.	4b
Fithian (2004)	This study had 3 specific goals. The first goal was to define the epidemiology of acute patellar dislocation. The second aim was to determine the risk of recurrent patellar instability, either patellar subluxation or dislocation. The third goal was to determine what epidemiological factors are associated with risk of subsequent instability.	Prospective cohort study. The authors prospectively followed 189 patients for a period of 2 to 5 years. Historical data, injury mechanisms, and physical and radiographic measurements were recorded to identify potential risk factors for poor outcomes.	Patellar dislocations who present with a history of patellofemoral instability are more likely to be female, are older, and have greater risk of subsequent patellar instability episodes than first-time patellar dislocations. Risk of recurrent patellar instability episodes in either knee is much higher in this group than in first-time dislocations.	2a
Friedrich (1996)	The purpose of this study was to investigate whether the mode of teaching exercises (use of brochures versus therapist teaching) affects whether patients correctly perform the exercises and changes in impairment.	Randomized control trial with 87 patients (33 women, 54 men) with neck pain and low back pain were examined. The average age was 48 years (SD=12.7, range=21–67). Two groups of patients were analyzed, with one being supervised by PTs and the other merely receiving a brochure A rating scale was used to assess the correctness of exercise performance.	On the rating scale evaluating the correctness of exercise performance at follow-up, the patients in the supervised group performed better than the patients in the brochure group. In addition, there was a strong correlation between the quality of exercise performance and decrease in pain.	2b
Garth (1996)	To determine outcome a minimum of 2 years after this immediate functional rehabilitation program and to gain insight into the natural history of patellofemoral instability treated in	Cohort study with 58 athletes that added up to 69 knees with patellar dislocations were evaluated at an average of 46.2 months.	Good or excellent results occurred in 39 (66%) knees treated after an initial patellar dislocation and in 15 (50%) knees with a chronic history of patellar instability. Twenty-six percent of the 69 knees had experienced recurrent patellar instability at follow-up. Overall, 42 patients (73%) were satisfied with their knees after this nonsurgical management. Anatomic predisposition and onset of bilateral instability at an early age were found to be significant factors	4b

	this fashion.		associated with a less favorable outcome.	
Greiwe (2010)	To understand the functional anatomy and biomechanics of the patellofemoral joint to enhance evaluation and treatment of patellar instability.	Clinical commentary and review of literature covering the pathomechanics of primary patellar dislocations, dynamic and positional lower extremity alignment, articular geometry, dynamic stability and static stability.	Patella alta is associated with recurrent dislocation. Trochlear dysplasia can be indirectly assessed by a sulcus angle measurement, which is inversely related to patellar mobility. The MPFL is taut from 0-30 degrees of knee flexion and slackens with increasing knee flexion. Non-operative treatment now attempts to enhance dynamic neuromuscular control of the lower extremity.	5b
Groslambert (2006)	To review key findings from the published literature related to rating perceived exertion in relation to patient developmental levels.	Literature review that presents the results of studies related to different developmental periods and rating of perceived exertion.	RPE appears to be a cognitive function that reflects a long and progressive developmental process from 4 years of age to adult. Before 4 years, patients cannot rate their perceived exertion with a high degree of accuracy, but at age 4 and 5 patients begin to use peripheral cues and cardiorespiratory factors, respectively.	5a
Hawkins (1986)	To analyze a group of patients who have undergone conservative non operative treatment for primary patellar dislocation and compare to a group of surgically treated patients.	Retrospective cohort study with 27 patients, 20 of whom were treated with immobilization and physical therapy and 7 of whom were treated with immediate surgical stabilization and lateral release. Data was obtained by questionnaire, patient examination, and radiographic evaluation.	It is likely that 20-30% will go on to experince symptoms of instability (treated operatively or non-operatively). Osteochondral fractures were found in 14 of the 27 pts. The incidence of redislocation in conservatively treated pts is greater in the presence of predisposing factors.	3b
Hinton (2003)	This article focuses on describing agent, and environmental risk factors that contribute to patellofemoral instability with a focus on age-specific information.	Literature review and expert opinion that discusses the anatomy, biomechanics, risk factors, classification, history, physical examination, patellofemoral imaging non-operative and operative management of patellar instability.	Most athletes benefit from an initial non-operative program that is aggressive, multidimensional, and responsive to early treatment outcomes. Concurrent osteochondral injuries are common and a major contributor to adverse outcomes. Diagnostically, plays an important role in determining the location and extent of MPFL injury.	5b
Holman (2004)	To discuss the differences between acute disease and chronic disease and how they are treated differently.	An expert opinion about the shift of healthcare from acute illness/injury to management of chronic illness/injury.	The current system is inadequate for dealing with chronic issues in many arenas. A new health care model is necessary, including: healthcare workers as partners, helping patients cope with illness, increased standardization of care, and an electronic record system.	5b
Holwerda (2012)	To investigate the cardiovascular responses and tissue temperature decreases of common therapeutic applications of cryotherapy, including ice bag/elastic wrap and the continuous circulating water and intermittent pneumatic compression provided by the Game Ready system.	Experimental crossover repeated measure design. Ten healthy subjects (23 ± 3 years) volunteered for 4 cryotherapy sessions (30-minute treatments with 30-minute passive recovery). Treatments included ice with elastic wrap and Game Ready (GR) with no, medium, and high compression. Oral, skin surface, and intramuscular quadriceps temperatures were measured along with mean arterial pressure, heart rate, rate pressure product, forearm blood flow, and vascular conductance.	The application of cold and intermittent pneumatic compression using GR did not produce acute cardiovascular strain that exceeded the strain produced by standard ice bags/elastic wrap treatment. Greater temperature decreases are achieved with medium- and high-pressure settings when using the GR system.	3b

Hopkins (2006)	To quantify muscle recruitment changes and knee joint function after joint effusion and subsequent joint cryotherapy.	A randomized control trial with forty-five volunteers (26 males, 19 females; age 19-23). Experimental joint effusion was used to elicit inhibition of the quadriceps muscle. Cryotherapy was used as a treatment intervention.	Joint cryotherapy negated movement deficiencies represented by knee peak torque and power decreases. This could be due to facilitated vastus lateralis activation relative to other groups.	2a
Janwantanakul (2006)	To compare cold pack/skin interface temperature during a 20-minute ice application with various levels of compression.	Repeated measures. Forty healthy females aged between 20 and 23 years. An ice pack was applied to the right thigh with compression using an elastic bandage. Five different levels of compression were used: 0 .14, 24, 34 and 44 mmHg to see skin temperature change.	Ice application with adjunctive compression leads to a greater magnitude and rate of cooling compared with ice application without compression. The higher the level of compression, the shorter the time to the minimum recorded temperature.	4b
Lippacher (2014)	To demonstrate postoperative outcomes and the return-to-sports rate a minimum of 2 years after isolated MPFL reconstruction in a young patient cohort.	Case series with seventy-two MPFL reconstructions were performed for recurrent patellar dislocation. Pre and postoperative assessment included a thorough history of symptoms and a clinical examination. Knee function was assessed using the Kujala score, International Knee Documentation Committee score, Tegner activity score, visual analog scale (VAS), and Activity Rating Scale (ARS).	All patients who had participated in sports returned, with 53% returning at equal or higher levels and the others not. Most (79.4%) were satisfied with the results. The median Kujala, IKDC, and VAS pain all improved. Conversely, activity levels, according to the Tegner score, dropped. There was also a persistent instability rate of 10% as well as a slight loss of knee flexion in 24 of 72 knees.	4b
Lorig (2003)	To discuss the short history of self-management.	A review article that presents three self-management tasks: medical management, role management, and emotional management.	Self-management skills are presented including problem solving, decision-making, resource utilization, the formation of a patient-provider partnership, action planning, and self-tailoring. Evidence of the effectiveness of self-management interventions is also provided.	5b
Lysholm (2007)	To critically evaluate the commonly used knee ligament scoring scales regarding requirements on a score, such as validity, reliability, responsiveness.	Literature review with search of PubMed using knee score, reliability, validity, knee evaluation, knee and activity grading. The five most common scales included: Lysholm-Tegner, IKDC, Cincinnati, KOOS, and Marshall/HSS.	Lysholm-Tegner evaluates change in activity level. IKDC showed good reliability, validity and responsiveness. Cincinnati is also well documented. KOOS had validity, reliability, responsiveness, internal consistency and no floor or ceiling effect. Marshall/HSS does not have validity and reliability documented. No indisputable gold standard was found. But, Lysholm-Tegner appears most widely used and KOOS is most widely applicable due to its quality of life evaluation.	5a
Moseley (2005)	To compare the efficacy of short and long duration passive stretching for management of plantar flexion contractures after casting for ankle fracture.	Randomized control trial for adults with plantarflexion contracture (N=150) after cast immobilization for ankle fracture. All subjects were weight bearing or partial weight bearing. Exercise only, exercise plus short-duration passive stretch, and exercise plus long-duration stretch.	There were no statistically significant or clinically important between-group differences in Lower Extremity Functional Scale and passive dorsiflexion range of motion with the knee bent and straight. The addition of passive stretching confers no benefit over exercise alone for the treatment of plantarflexion contracture after cast immobilization for ankle fracture.	2a
Mulford (2007)	To review the literature on the patellofemoral joint, examination items, and the appropriate	Literature review discussing the stabilizing features of the patellofemoral joint.	The stability of a joint depends on the underlying morphology and the balance of static and dynamic soft-tissue forces that interact in a complex way.	5b

	treatment.			
Palmieri-Smith (2008)	To review the current literature and critically discuss current rehabilitation approaches to restore quadriceps muscle function after ACL reconstruction.	Literature review discussing rehabilitation approaches to restore quadriceps muscle function.	The magnitude of quadriceps weakness appears to lessen with time, but may predispose a patient to poor functional outcomes due to the critical nature of this muscle group to dynamic joint stability. Weak quadriceps may lead to early onset of osteoarthritis. The best strategy to maximize quadriceps strength may be to include interventions that will target inhibition in addition to those that are focused on minimizing atrophy.	5a
Panni (2011)	To explore anomalies of dynamic and static factors, including excessive patellar height, tibial tubercle lateralization or trochlear dysplasia, and how they may influence the development of the patella.	Retrospective cohort study of one hundred and five patients (140 knees) with objective patellar instability to study a possible association between the above-mentioned predisposing factors and patellar shape. All patients were evaluated with static and dynamic CT scans, and plain lateral and antero-posterior radiographs, and skyline patellar views.	Increased lateral stresses may produce a Wiberg type C patella, with a hypoplastic medial facet and a more developed lateral facet. An imbalance between dynamic medial and lateral stabilizers may act as an additional factor. A rehabilitation program aiming to reduce this unbalance may decrease the incidence of type C patella in young patients.	4b
Parikh (2011)	To report on and describe patterns of patellar fractures after patellar stabilization procedures.	Retrospective cohort and subsequent literature review. Between 2005 and 2009, surgical stabilization was performed to treat patellar instability in 195 patients. The probable causes of the patellar fractures were analyzed for each patient. A literature review of patellar fractures after patellar stabilization procedures was performed with the use of PubMed.	Two patterns of patellar fractures were identified: type 1 fractures are transverse fractures through the patellar tunnel or drill hole and type 2 are superior pole fractures, or sleeve avulsion fractures, associated with proximal realignment, lateral release or excessive dissection near the superior aspect of the patella. A third pattern was identified through literature review. Type 3 fractures are medial rim avulsion fractures through drill holes in the patella, associated with recurrent lateral patellar dislocation after patellar stabilization procedures.	4a
Paxton (2003)	To determine the most reliable and valid instruments for assessing patient outcome after acute patellar dislocation.	Prospective cohort study with 153 patients with acute patellar dislocation (110 with first-time dislocations and 43 with a history of patellofemoral subluxation or dislocation). They used the modified International Knee Documentation Committee form, Kujala, Fulkerson, Lysholm, Tegner, Short Form 36, and Musculoskeletal Function Assessment instruments on two separate occasions (test-retest reliability). Validity was assessed by comparing scores of the two groups and by comparing scores of patients with and without recurrent subluxations/dislocations during follow-up.	The knee-specific instruments yielded the highest test-retest reliability. The knee-specific and general health instruments identified higher disability levels in the patients with a history of patellofemoral problems than in those with first-time dislocations. The general health instruments identified higher disability levels in patients with patellar dislocation than published norms. The Fulkerson and Lysholm scales were the only instruments to differentiate between patients with and without recurrent subluxations/dislocations.	2a
Philippot (2012)	To determine the most appropriate graft tension applied during MPFL-R to approximate the original physiological	Biomechanical cadaver study, 9 knees mean of 71.4 years, four acquisition phases : 1) analysis of patellar kinematics in healthy knee, 2) after identification and section of the junction between the MPFL	MPFL accounts for 50-60% of the medial stabilization of the lateral patellar shift and is the primary stabilizer for lateral rotation and patellar tilt during the initial 30 degrees of flexion. Additional results indicate that the MPML and MPTL help control patellar rotation (28-48%) and	4b

	conditions.	and VMO, 3) after identification and section of the patellar MPFL attachment, 4) after identification and section of MPML and MPTL.	tilt (23-71%) primarily after 45 degrees of knee flexion. In addition this study provided no evidence to support the VMO as a stabilizer of the patella.	
Powers (2010)	This article discusses biomechanical influences of abnormal hip mechanics on knee injury.	A literature review of pertinent tibiofemoral and patellofemoral joint biomechanics and the clinical implications.	Impaired control of the hip, pelvis, and trunk likely plays a role with respect to injury mechanisms. Females are more prone to such influences.	5a
Ramzi (2004)	The author reports various ways to diagnose deep venous thrombosis (DVT) and pulmonary embolism (PE).	Review and expert opinion regarding risk factors and diagnosis of DVT and PE.	Classic signs of DVT, including Homans sign (pain on passive dorsiflexion of the foot), edema, tenderness, and warmth, are difficult to ignore, but they are of low predictive value and can occur in other conditions such as musculoskeletal injury, cellulitis, and venous insufficiency. However, combinations of clinical features in the form of clinical prediction rules can be useful for stratifying patients into risk categories.	5a
Rao (2001)	To evaluate the reproducibility of clinical and goniometric measurement of hip movements to define the pattern of alteration of normal hip movements in relation to age in children.	The measurement methods were visual estimation, visual goniometer, and a fluid goniometer. The fluid goniometer was used to evaluate hip motion in 325 normal schoolchildren ages 5-14. This same method of ROM assessment was used on 93 children who had symptoms related to one or both hip joints, or an abnormal gait.	Intraobserver reproducibility was best with fluid level goniometer. Normal ranges of hip movements decreased with age and most decrease occurs with flexion, abduction, and internal rotation. Clinical diagnosis of hip disorders can be made by looking at a grid pattern which could help guide the clinician as to what type of diagnostic test should be performed.	4b
Reinold (2006)	To provide an overview the principles of rehabilitation following articular cartilage repair procedures.	Reviewer and expert opinion regarding rehabilitation and restoration of function in patients following articular cartilage repair procedures.	Post-operative rehabilitation programs will need to be individualized to the patient based on the nature of the lesion, the unique characteristics of each patient, and the type of surgical procedure	5a
Rhea (2002)	To systematically examine studies comparing single- and triple-set training programs for strength.	Meta-analysis examining 15 studies regarding single versus 3-set training.	The results of this study suggest that triple-sets produced training results superior to single-sets.	2b
Rice (2009)	To examine the efficacy of cryotherapy in reducing quadriceps arthrogenic muscle inhibition caused by intra-articular swelling.	Randomized control study with sixteen subjects without knee pathology. Participants were randomly assigned to a cryotherapy or control group. All subjects received a dextrose saline injection into the knee to a intra articular pressure of 50 mm Hg. Thereafter, the cryotherapy group had ice applied to the knee for 20 minutes while the control group did not receive an intervention. Quadriceps peak torque, muscle fiber conduction velocity (MFCV), and the root mean square (RMS)	Quad peak torque and MFCV decreased significantly following joint infusion. Cryotherapy led to significantly increased quad torque and MFCV. Icing of knee joint reduces severity of quadriceps AMI (arthrogenic muscle inhibition) induced by swelling-cryotherapy may temporarily reduce AMI providing a therapeutic window during which more complete activation of the quadriceps musculature is permitted.	2a

		of EMG signals from vastus medialis were analyzed.		
Roemmich (2006)	To test the validity of the Pictorial Children's Effort Rating Table (PCERT) and OMNI walk/run scales.	Observational study with children (26 boys age and 25 girls age 11 years) performed a five-stage incremental exertion treadmill test. The undifferentiated perceived exertion from the PCERT and OMNI scales was assessed for construct validity using Pearson correlations with V˙ O2 and heart rate as criteria and concurrent validity by correlating PCERT and OMNI scores.	Correlations between increases in the perceived exertion and physiologic measures of exercise intensityranged from 0.86 to 0.94. No differences were found in magnitude of the correlation coefficients between the two perceived exertion scales or between boys and girls.	4a
Ryan (2009)	To identify gaps in the science of self-management and present a descriptive mid-range self-management theory.	Literature review and expert opinion regarding a new descriptive midrange theory for Individual and Family Self-management Theory is presented. Assumptions are identified, concepts are defined, and proposed relationships are outlined.	Individual and family-centered interventions impact self-management by addressing either the context or the process. Interventions aimed at the context can reduce risk or foster conditions that support self-management. Interventions aimed at the process can enhance knowledge and beliefs, increase an individual's use of self-regulation behaviors and foster social facilitation.	5a
Senavongse (2005)	To measure the forces required to cause the patella to sublux medially and laterally, allowing the effects of various abnormalities associated with patellar instability to be quantified.	Descriptive/Observational cadaver study of 8 knees mean age 69 years. Patellar stability was tested from 0° to 90° knee flexion with the quadriceps tensed to 175 N. Four conditions were examined: intact, vastus medialis obliquus (VMO) relaxed, flat lateral condyle, and ruptured medial retinaculae.	Abnormal trochlear geometry reduced lateral stability by 70% at 30° knee flexion, while relaxed VMO caused 30% reduction. Ruptured medial retinaculae had largest effect at 0°flexion with 49% reduction in stability. The results suggest that the role of VMO may be less important than abnormal trochlear articular geometry, and that the medial retinaculae become more important for patellar stability as the knee extends.	4b
Shah (2012)	To report on the various techniques for MPFL reconstruction described in the literature and to assess the rate of complications associated with the procedure.	Meta-analysis; A systematic review of the literature was performed in early October 2010 using keywords "medial patellofemoral ligament," "MPFL," "reconstruction," "complication(s)," and "failure(s)." Graft choice, surgical technique, outcome measures, and complications were recorded and organized in a database.	Surgical techniques when categorized into sutures vs tunnel techniques yielded a trend of overall more complications for the tunnel techniques (29.8% vs 21.6%). However, the suture techniques demonstrated a higher rate of recurrent dislocation/subluxation (4.8%) and apprehension/hypermobility (24.0%) than the tunnel technique 3.3% and 8.6%, respectively). Patellar fracture occurred only in those that underwent tunnel technique.	1a
Shea (2006)	To review the literature and provide thoughts on various aspects of treatment of skeletally immature athletes with patellar dislocation.	Review and expert opinion for anatomical risk factors, mechanism of injury, natural history, and management of patellar dislocations in skeletally immature athletes.	Evaluation of the skeletally immature patient should consist of a detailed history and physical examination with radiologic testing and treatment protocols chosen judiciously. Surgical approaches should take into consideration physeal anatomy about the knee. Regardless of treatment protocol, all patients should undergo early physical therapy with gradual return to sport.	5b
Singh (2001)	To determine the efficacy of continuous cryotherapy on subjective responses after both open and arthroscopic procedures on the	Prospective, randomized, but not blinded study of seventy patients scheduled for either arthroscopic (38 patients) or open shoulder surgical procedures (32 patients) were recruited for this investigation. Thirty-two patients received no	These results indicate that cryotherapy is an effective method for postoperative pain control because it decreases the severity and frequency of pain and allows a return to normal sleep patterns while increasing overall postoperative comfort and satisfaction.	2a

	shoulder.	postoperative cryotherapy and served as the control group.		
Sluijs (1993)	To investigate whether patient compliance was related to characteristics of the patient or the patient's illness, to the patient's attitude, or to the physical therapist's behavior.	Correlational study with a random sample of 300 physical therapists in private practice in the Netherlands. 222 therapists responded to a questionnaire survey. Eighty-four respondents also made audio recordings.	The results show that the three main factors related to noncompliance were (1) the barriers patients perceive and encounter, (2) the lack of positive feedback, and (3) the degree of helplessness. The first factor showed the strongest relation with noncompliance. There was no difference between men and women with regard to patient compliance, but less educated patients were slightly more compliant than more highly educated patients.	4b
Smith (2010)	To review the literature to determine the clinical outcomes following rehabilitation for patients following a lateral patellar dislocation.	Systematic review: All publications presenting the outcomes of patients following a conservatively managed lateral patellar dislocation. All eligible articles were appraised critically using the Critical Appraisal Skills Programme appraisal tool. Data on interventions, cohort characteristics, outcome measures and results were extracted.	Although a proportion of patients experienced recurrent instability and dislocation episodes after rehabilitation, a large proportion of patients reported acceptable outcomes following physiotherapy. No randomized controlled clinical trials were identified assessing different physiotherapy interventions. The evidence base included a number of under-powered studies which poorly described the specific physiotherapy interventions prescribed.	1b
Smith (2008)	To determine the onset and intensity of VMO and vastus lateralis (VL) in patients with patellar instability.	Systematic review that resulted in 5 publications that met inclusion and exclusion criteria. All eligible articles were appraised critically using the Critical Appraisal Skills Programme appraisal tool.	Four studies reported no difference in relative EMG intensity of VMO and VL in patients with patellar instability compared with asymptomatic control subjects. One study reported some evidence of a difference in VM) to VL EMG intensity in one cohort of patients with patellar subluxation. No robust evidence for any difference in the relative intensity of EMG activity between the VMO and VL in patients with patellar instability.	1b
Smith (2011)	The purpose of this study was to determine how senior musculoskeletal physiotherapists working in acute National Health Service (NHS) hospitals manage patients following first-time patellar dislocation in the United Kingdom.	Descriptive study for 306 institutions. Each institution was sent a 14 question self-administered questionnaire pertaining to the assessment, treatment, evaluation, and outcomes for patients following a primary patellar dislocation.	The questionnaire indicated that first-time patellar dislocation is not a commonly seen pathology for senior physiotherapists in acute NHS hospitals in the UK. Main assessments used included: observation of lateral or medial glide, patellar tracking, VMO atrophy or hypertrophy, knee effusion, and gait. Most frequently used treatments included reassurance regarding the injury and rehab process, rest and or behavior or sporting modification and exercise prescription. Common exercises prescribed were isometrics, functional exercises, quad exercises, VMO exercises, stretching.	4b
Smits-Engelsman (2011)	To evaluate the validity of the Beighton score as a generalized measure of hypermobility and to measure the prevalence of hypermobility and pain in a random population of school age children.	Prospective study of 551 children attending various Dutch elementary schools participated; 47% were males (258) and 53% (293) females, age range was 6 to 12 years. Participants' joints and movements were assessed according to the Beighton score by qualified physiotherapists and by use of goniometry measuring 16 passive ranges of motion of joints on both sides of the body	More than 35% of children scored more than 5/9 on the Beighton score. Children who scored high on the Beighton score also showed increased range of motion in the other joints measured. Moreover 12.3% of children had symptoms of joint pain, and 9.1% complained of pain after exercise or sports. Importantly, this percentage was independent of the Beighton score. There were no significant differences in Beighton score for sex in this population	3b

Snyder-Mackler (1995)	To assess the effectiveness of common regimens of electrical stimulation as an adjunct to ongoing intensive rehabilitation in the early postoperative phase after reconstruction of the anterior cruciate ligament.	Immediately after reconstruction of the ACL, 110 patients were randomly assigned to treatment with high-intensity neuromuscular electrical stimulation (31 patients), high-level volitional exercise (34 patients), low-intensity neuromuscular stimulation (25 patients), or combined high and low-intensity neuromuscular electrical stimulation (20 patients). All treatment was performed isometrically with the knee is 65 degrees of flexion.	Quadriceps strength averaged 90% or more of the strength on the uninvolved side in the 2 groups that were treated with high-intensity electrical stimulation (either alone or combined with low-intensity electrical stimulation), 57% in the group that was treated with high-level volitional exercise, and 51% in the group that was treated with low-intensity electrical stimulation. The kinematics of the knee joint were directly and significantly correlated with the strength of the quadriceps.	2a
Stefancin (2007)	To describe when clinicians should treat patellar dislocations with nonoperative instead of operative methods.	Systematic review for all English language studies from January 1, 1966 to May 31, 2006 on first-time patellar dislocations.	The redislocation rates were higher in the nonoperative treatment groups compared with the operative group; however, the mean followup comparing the closed treatment group with the surgical treatment group was almost double, 8.4 years versus 4.4 years, respectively. Based on the reviewed studies, the authors recommend initial nonoperative management of a first-time traumatic dislocation except in the cases where osteochondral fractures, substantial disruption of the medial patellar stabilizers, or with patients who do not improve with nonoperative care.	1b
Steiner (2006)	**To describe outcomes for patients with chronic patellar instability and trochlear dysplasia treated with a surgical stabilization procedure.**	Case series of 34 **patients** with chronic **patellar instability** and **trochlear dysplasia** treated with **medial patellofemoral ligament reconstruction** using an adductor tendon autograft, bone-quadriceps tendon autograft, or bone-**patellar** tendon allograft. All **patients** were evaluated preoperatively and postoperatively with Kujala, Lysholm, and Tegner scores at a minimum of 24 months.	Thirty-four **patients** were followed for a mean of 66.5 months (range, 24-130 months) after surgery. Kujala scores improved from 53.3 to 90.7, Lysholm scores improved from 52.4 to 92.1, and Tegner activity scores improved from 3.1 to 5.1. All improvements were highly statistically significant. No statistical difference was found between the postoperative Lysholm, Kujala, and Tegner scores and the degree of **dysplasia**, graft type, or degree of symptoms. There were 85.3% and 91 .1% good and excellent results based on Kujala and Lyshoim scores, respectively. No recurrent dislocations have occurred.	4b
VanderGiessen (2001)	To validate the Beighton Score and describe the prevalence of connective tissue signs in Dutch children.	Cohort study investigating hypermobility investigation according to Beighton in 773 healthy children aged 4-12 years. An inventory of the signs that fitted with connective tissue disorders was compiled.	The percentage of general hypermobility at a cutoff point of > or = 4 was 26.5% (range 11.4-49%) in children aged 4-9 yrs. At the age of 10-12 yrs, this percentage was 5.3% (range 0-7.1%). There was good agreement (kappa = 0.65) between the measurement on the left and the right sides at all ages. Of the investigated connective tissue signs, thin transparent skin was noted in 0.1%, blue sclerae in 0.1%, and an elevated palate in 2.3% of the children. It was observed that 8.2% of the children were able to touch their nose with their tongue (Gorlin's sign) and 23.7% were able to touch their chin. The other signs were not observed in any of the children.	4b
Visuri (2002)	To describe the types of injury, injury events, clinical signs of injury, operative	Correlational study of 119 males (65 primary, 51 recurrent dislocation).	Correlation between Kujala and VAS was significant (r=.80, p <0.001). Most common cause of injury was military training at battle exercise. The typical injury mechanism was	4b

	techniques, outcomes, and postoperative fitness classifications of military conscripts with primary and recurrent patellar dislocation.		knee valgus rotation on a fixed foot and tibia in 82% conscripts. Nine percent were injured by direct blow, and 9% were injured in a fall. During the follow-up period 19% experienced re-dislocations, and of that group, 39% had another surgery while the others were managed non-operatively.	
VonBaeyer (2009)	To present 3 datasets in which the Numerical Rating Scale (NRS) was used together with another self-report scale.	Study A compared post-operative pain ratings on the NRS with scores on the Faces Pain Scale-Revised (FPS-R) in 69 children age 7–17 years who had undergone a variety of surgical procedures. Study B compared post-operative pain ratings on the NRS with scores on the Visual Analogue Scale (VAS) in 29 children age 9–17 years who had undergone pectus excavatum repair. Study C compared ratings of remembered immunization pain in 236 children who comprised an NRS group and a sex- and age-matched VAS group.	Correlations of the NRS with the FPS-R and VAS were r = 0.87 and 0.89 in Studies A and B, respectively. In Study C, the distributions of scores on the NRS and VAS were very similar except that scores closest to the no pain anchor were more likely to be selected on the VAS than the NRS. The NRS can be considered functionally equivalent to the VAS and FPS-R except for very mild pain (<1/10). Use of the NRS is tentatively supported for clinical practice with children of 8 years and older, and its recommended that further research is done on the lower age limit and on standardized age-appropriate anchors and instructions for this scale	4b
Ward (2007)	To compare patellofemoral joint alignment and contact area in subjects who had patella alta with subjects who had normal patellar position, to determine the effect of high vertical patellar position on knee extensor function.	Twelve subjects with patella alta and thirteen control subjects participated in the study. Lateral patellar displacement (subluxation), lateral tilt, and patellofemoral joint contact area were quantified from axial magnetic resonance images of the patellofemoral joint acquired at 0°, 20°, 40°, and 60° of knee flexion with the quadriceps contracted.	With the knee at 0° of flexion, the subjects with patella alta demonstrated significant differences compared with the control group, with greater lateral displacement (mean [and standard error], 85.4% ± 3.6% and 71.3% ± 3.0%, respectively, of patellar width lateral to the deepest point in the trochlear groove; p = 0.007), greater lateral tilt (mean, 21.6° ± 1.9° and 15.5° ± 1.8°; p = 0.028), and less contact area (157.6 ± 13.7 mm2 and 198.8 ± 14.3 mm2; p = 0.040). Differences in displacement and tilt were not observed at greater knee flexion angles. However, contact area differences were observed at all angles evaluated. When data from both groups were combined, the vertical position of the patella was positively associated with lateral displacement and lateral tilt at 0° of flexion and was negatively associated with contact area at all knee flexion angles.	4a
Watkins (1991)	The purpose of this study was to examine the intra-tester and inter-tester reliability for goniometric measurements of knee flexion and extension passive range of motion (PROM).	Correlational study with 43 patients (29 males, 14 females) that were at least 18 years of age. PROM for knee flexion and knee extension were measured by two independent physical therapists.	The intraclass correlation coeficients (ICCs) for intratester reliability of measurements obtained with a goniometer were .99 for flexion and .98 for extension. Intertester reliability for measurements obtained with a goniometer was .90 for flexion and .86 for extension. The ICCs for parallel-form reliability for measurements obtained with a goniometer and by visual estimation ranged from .82 to .94. The intertester reliability for measurements obtained by visual estimation was .83 for flexion and .82 for extension.	4b
Wilk (1998)	To introduce a classification system for treatment	Expert opinion with formulation of the classification system formulated based on published	The proposed classification system divides patellofemoral disorders into eight groups, including: 1) patellar compression syndromes, 2)	5a

	strategies and interventions for nonsurgical management of patellofemoral pain.	research and the clinical observations of the authors of this paper.	patellar instability, 3) biomechanical dysfunction, 4) direct patellar trauma, 5) soft tissue lesions, 6) overuse syndromes, 7) osteochnodritis diseases, and 8) neurologic disorders.	
Williams (2007)	To assess the concurrent validity and ability of multiple measures of readiness to change to change to predict behavior and consequences.	Prospective cohort study with 228 patients with unhealthy alcohol use with randomized disclosure of alcohol screening results to physicians. Readiness to change using 1 multi-item measure of stage of change, and 5 single-item measures. Outcomes included alcohol consumption and alcohol-related consequences.	Greater readiness to change was associated with more consequences and was not predictive of consumption. However, assessing confidence in the ability to change one's alcohol use may have a role in predicting subsequent decreases in both consumption and consequences.	3a
Williamson (2005)	To explore the research available relating to three commonly used pain rating scales: 1) the Visual Analogue Scale, 2) the Verbal Rating Scale, and 3) the Numerical Rating Scale.	A MedLine review via PubMed was carried out with no restriction of age of papers retrieved. Papers were examined for methodological soundness before being included	All three pain-rating scales are valid, reliable and appropriate for use in clinical practice. The Visual Analogue Scale has been shown to have more practical difficulties than the Verbal Rating Scale or the Numerical Rating Scale. For general purposes the Numerical Rating Scale has good sensitivity and generates data that can be statistically analysed for audit purposes.	