INTRODUCTION TO SPORTS INJURY. SOFT TISSUE INJURY, REPAIR, AND MANAGEMENT

We want to know 1) Soft Tissue Lesions 2) Clinical Conditions Resulting from Trauma or Pathology 3) Severity of Tissue Injury(grades) 4) Stages of Tissue Healing and interventions 5) Causes of Chronic Inflammation and its Contributing Factors 6) Management guidelines of Chronic Inflammation/Cumulative Trauma Syndromes

It is important during the examination process to determine whether the tissues involved are in the acute, subacute, or chronic stage of recovery so that the type and intensity of Treatment do not interfere with recovery but can most effectively facilitate healing for maximum return of function and and prevention of further problems.

Soft Tissue Lesions

Examples of Soft Tissue Lesions:

Musculoskeletal Disorders

- **Synovitis**: Inflammation of a synovial membrane; an excess of normal synovial fluid in a joint or tendon sheath caused by trauma or disease.
- **Hemarthrosis**: Bleeding into a joint, usually due to severe trauma.
- **Ganglion**: Ballooning of the wall of a joint capsule or tendon sheath. Ganglia may arise after trauma, and they sometimes occur with rheumatoid arthritis.
- **Bursitis**: Inflammation of a bursa.
- **Contusion**: Bruising from a direct blow, resulting in capillary rupture, bleeding, edema, and an inflammatory response.
- **Overuse syndromes**, cumulative trauma disorders, repetitive strain injury: Repeated, submaximal overload and/or frictional wear to a muscle or tendon resulting in inflammation and pain.

- **Strain**: Overstretching, overexertion, overuse of soft tissue: tends to be less severe than a sprain, occurs from slight trauma or unaccustomed repeated trauma of a minor degree. This term is frequently used to refer to some degree of disruption of the musculotendinous unit.
- **Sprain**: Severe stress, stretch, or tear of soft tissues, such as joint capsule, ligament, tendon, or muscle. This term is frequently used to refer specifically to injury of a ligament and is graded as first- (mild), second- (moderate), or third- (severe) degree sprain.
- **Dislocation**: Displacement of a part, usually the boney partners in a joint, resulting in loss of the anatomical relationship and leading to soft tissue damage, inflammation, pain, and muscle spasm.
- **Subluxation**: An incomplete or partial dislocation of the boney partners in a joint that often involves secondary trauma to surrounding soft tissue.
- **Muscle/tendon rupture or tear**: If a rupture or tear is partial, pain is experienced in the region of the breach when the muscle is stretched or when it contracts against resistance.

Clinical Conditions Resulting from Trauma or Pathology:

- **Adhesion:** Abnormal adherence of collagen fibers to surrounding structures during immobilization, after trauma, or as a complication of surgery, which restricts normal elasticity and gliding of the structures involved.
- **Reflex muscle guarding**: Prolonged contraction of a muscle in response to a painful stimulus. The primary pain causing lesion may be in nearby or underlying tissue, or it may be a referred pain source. When not referred, the contracting muscle functionally splints the injured tissue against movement. Guarding ceases when the painful stimulus is relieved.
- **Muscle weakness**: A decrease in the strength of muscle contraction. Muscle weakness may be the result of a systemic, chemical, or local lesion of a nerve of the central or peripheral nervous system or the myoneural junction. It may also be the result of a direct insult to the muscle or simply due to inactivity.
- **Myofascial compartment syndromes**: Increased interstitial pressure in a closed, nonexpanding, myofascial compartment that compromises the function of the blood vessels, muscles, and nerves. It results in ischemia and

irreversible muscle loss if there is no intervention. Causes include, but are not limited to, fractures, repetitive trauma, crush injuries, skeletal traction, and restrictive clothing, wraps, or casts.

- **Intrinsic muscle spasm**: Prolonged contraction of a muscle in response to the local circulatory and metabolic changes that occur when a muscle is in a continued state of contraction. Pain is a result of the altered circulatory and metabolic environment, so the muscle contraction becomes self-perpetuating regardless of whether the primary lesion that caused the initial guarding is still irritable (Fig. 1). Spasm may also be a response of muscle to viral infection, cold, prolonged periods of immobilization, emotional tension, or direct trauma to muscle.

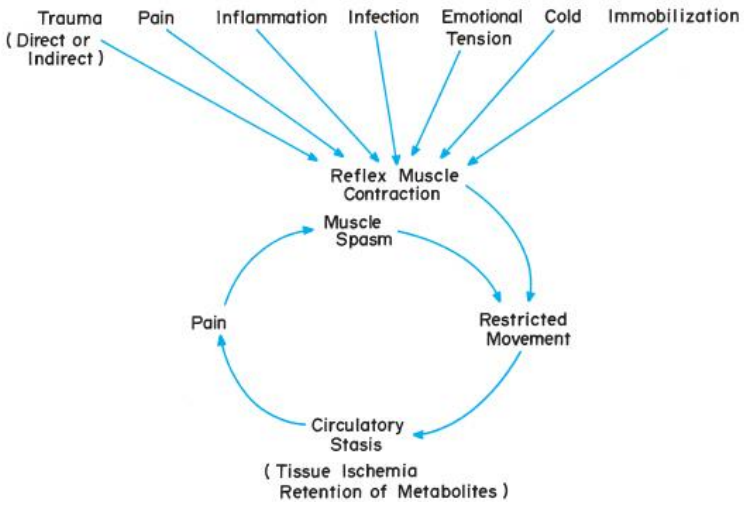

FIGURE .1 Self-perpetuating cycle of muscle spasm

- **Dysfunction**: Loss of normal function of a tissue or region. The dysfunction may be caused by adaptive shortening of the soft tissues, adhesions, muscle weakness, or any condition resulting in loss of normal mobility.
- **Joint dysfunction**: Mechanical loss of normal joint play in synovial joints; commonly causes loss of function and pain. Precipitating factors may be trauma, immobilization, disuse, aging, or a serious pathological condition.
- **Contracture**: Adaptive shortening of skin, fascia, muscle, or a joint capsule that prevents normal mobility or flexibility of that structure.
- **Adhesion:** Abnormal adherence of collagen fibers to surrounding structures during immobilization, after trauma, or as a complication of surgery, which restricts normal elasticity and gliding of the structures involved.

Severity of Tissue Injury

- ***Grade 1 (first-degree).*** Mild pain at the time of injury or within the first 24 hours. Mild swelling, local tenderness, and pain occur when the tissue is stressed.
- ***Grade 2 (second-degree).*** Moderate pain that requires stopping the activity. Stress and palpation of the tissue greatly increase the pain. When the injury is to ligaments, some of the fibers are torn, resulting in some increased joint mobility.
- ***Grade 3 (third-degree).*** Near-complete or complete tear or avulsion of the tissue (tendon or ligament) with severe pain. Stress to the tissue is usually painless; palpation may reveal the defect. A torn ligament results in instability of the joint.

Stages of Tissue Healing and interventions

1. Stages of Inflammation and Repair After any insult to connective tissue, whether it is from mechanical injury (including surgery) or chemical irritant, the vascular and cellular response is similar (Table 1.1). Tissue irritability, or sensitivity, is the result of these responses and is typically divided into **three overlapping stages of inflammation, repair, and maturation/remodeling.**

(Table 1.1) Stages of Tissue Healing: Characteristics, Clinical Signs, and Interventions

Acute Stage: Inflammatory Reaction	Subacute Stage: Proliferation, Repair and Healing	Chronic Stage: Maturation and Remodeling
Tissue responses and characteristics		
Vascular changes Exudation of cells and chemicals Clot formation Phagocytosis, neutralization of irritants Early fibroblastic activity	Removal of noxious stimuli Growth of capillary beds into area Collagen formation Granulation tissue Very fragile, easily injured tissue	Maturation of connective tissue Contracture of scar tissue Remodeling of scar Collagen aligns to stress
Clinical signs		
Inflammation Pain before tissue resistance	Decreasing inflammation Pain synchronous with tissue resistance	Absence of inflammation Pain after tissue resistance
Physical therapy goals and interventions for phases of rehabilitation		
Protection Phase: early	Controlled-Motion Phase: intermediate	Return to Function Phase: advanced
Control effects of inflammation: selective rest, ice, compression, elevation *Prevent deleterious effects of rest*: nondestructive movement: passive range of motion, massage, and muscle setting with caution	*Develop mobile scar:* selective stretching, mobilization/manipulation of restrictions *Promote healing:* nondestructive active, resistive, open- and closed-chain stabilization, muscular endurance, and cardiopulmonary endurance exercises, carefully progressed in intensity and range	*Increase tensile quality of scar:* progressive strengthening and endurance exercises *Develop functional independence:* functional exercises, and specificity drills

Management Guidelines: Healing: Characteristics, Clinical Signs, and Interventions

Management during the Acute Stage

Guidelines-Acute Stage/Protection PGUIDELINES-Acute Stage/ Protection Phase Structural and Functional Imp:

Structural and Functional Impairments:

Inflammation, pain, edema, muscle spasm
Impaired movement
Joint effusion (if the joint is injured or if there is arthritis)
Decreased use of associated areas

Plan of Care	Intervention (up to 1 week postinjury)
1. Educate the patient.	1. Inform patient of anticipated recovery time and how to protect the part while maintaining appropriate functional activities.
2. Control pain, edema, spasm.	2. Cold, compression, elevation, massage (48 hours). Immobilize the part (rest, splint, tape, cast). Avoid positions of stress to the part. Gentle (grade I or II) joint oscillations with joint in pain-free position.
3. Maintain soft tissue and joint integrity and mobility.	3. Appropriate dosage of passive movements within limit of pain, specific to structure involved. Appropriate dosage of intermittent muscle setting or electrical stimulation.
4. Reduce joint swelling if symptoms are present.	4. May require medical intervention if swelling is rapid (blood). Provide protection (splint, cast).
5. Maintain integrity and function of associated areas.	5. Active-assistive, free, resistive, and/or modified aerobic exercises, depending on proximity to associated areas and effect on the primary lesion. Adaptive or assistive devices as needed to protect the part during functional activities.

PRECAUTIONS: The proper dosage of rest and movement must be used during the inflammatory stage. Signs of too much movement are increased pain or increased inflammation.

CONTRAINDICATIONS: Stretching and resistance exercises should not be performed at the site of the inflamed or swollen tissue.

Management During the Subacute Stage, (Controlled Motion Phase)

Structural and Functional Impairments:

Pain when end of available ROM is reached
Edema (decreasing but may still be present)
Joint effusion (decreasing but may still be present if joints are involved)
Soft tissue, muscle, and/or joint contractures (developing in immobilized region)
Muscle weakness from reduced usage or pain
Decreased functional use of the part and associated areas

Plan of Care	Intervention (up to 3 weeks postinjury)
1. Educate the patient.	1. Inform patient of anticipated healing time and importance of following guidelines. Teach home exercises and encourage functional activities consistent with plan; monitor and modify as patient progresses.
2. Promote healing of injured tissues.	2. Monitor response of tissue to exercise progression; decrease intensity if pain or inflammation increases. Protect healing tissue with assistive devices, splints, tape, or wrap; progressively increase amount of time the joint is free to move each day and decrease use of assistive device as strength in supporting muscles increases.
3. Restore soft tissue, muscle, and/or joint mobility.	3. Progress from passive to active-assistive to active ROM within limits of pain. Gradually increase mobility of scar, specific to structure involved. Progressively increase mobility of related structures if limiting ROM; use techniques specific to tight structure.
4. Develop neuromuscular control, muscle endurance, and strength in involved and related muscles.	4. Initially, progress multiple-angle isometric exercises within patient's tolerance; begin cautiously with mild resistance. Initiate AROM, protected weight bearing, and stabilization exercises. As ROM, joint play, and healing improve, progress isotonic exercises with increased repetitions. Emphasize control of exercise pattern and proper mechanics. Progress resistance later in this stage.
5. Maintain integrity and function of associated areas.	5. Apply progressive strengthening and stabilizing exercises, monitoring effect on the primary lesion. Resume low-intensity functional activities involving the healing tissue that do not exacerbate the symptoms.

PRECAUTIONS: The signs of inflammation or joint swelling normally decrease early in this stage. Some discomfort will occur as the activity level is progressed, but it should not last longer than a couple of hours. Signs of too much motion or activity are resting pain, fatigue, increased weakness, and spasm lasting beyond 24 hours.

Signs of Excessive Stress with Exercise or Activities

- Exercise or activity soreness that does not decrease after 4 hours and is not resolved after 24 hours
- Exercise or activity pain that comes on earlier or is increased over the previous session
- Progressively increased feelings of stiffness and decreased ROM over several exercise sessions
- Swelling, redness, and warmth in the healing tissue
- Progressive weakness over several exercise sessions
- Decreased functional usage of the involved part

Exercise progressions may cause some temporary soreness that can last 4 hours, but if the above signs and symptoms occur, the activity, exercise, or stretching maneuvers are too stressful and should be modified or reduced in intensity.

Management During the Chronic Stage

Structural and Functional Impairments:

Soft tissue and/or joint contractures and adhesions that limit normal ROM or joint play
Decreased muscle performance—weakness, poor endurance, poor neuromuscular control
Decreased functional usage of the involved part
Inability to function normally in an expected activity

Plan of Care	Interventions (>3 weeks post-injury)
1. Educate the patient.	1. Instruct patient in safe progressions of exercises and stretching. Monitor understanding and compliance. Teach ways to avoid reinjuring the part. Teach safe body mechanics. Provide ergonomic counseling.
2. Increase soft tissue, muscle and/or joint mobility.	2. Stretching techniques specific to tight tissue: ■ Joint and selected ligaments (joint mobilization/manipulation) ■ Ligaments, tendons, and soft tissue adhesions (cross-fiber massage) ■ Muscles (neuromuscular inhibition, passive stretch, massage, and flexibility exercises)
3. Improve neuromuscular *control*, strength, muscle endurance.	3. Progress exercises: ■ Submaximal to maximal resistance ■ Specificity of exercise using resisted concentric and eccentric, weight bearing and nonweight-bearing ■ Single plane to multiplanar motions ■ Simple to complex motions, emphasizing movements that simulate functional activities ■ Controlled proximal stability, superimpose distal motion ■ Safe biomechanics ■ Low repetitions to high repetitions at slow speeds; progress complexity and time; progress speed and time.
4. Improve cardiopulmonary endurance.	4. Progress aerobic exercises using safe activities.
5. Progress functional activities.	5. Continue using supportive and/or assistive devices until the ROM is functional with joint play, and strength in supporting muscles is adequate. Progress functional training with simulated activities from protected and controlled to unprotected and variable. Continue progressive strengthening exercises and advanced training activities until the muscles are strong enough and able to respond to the required functional demands.

PRECAUTIONS: There should be no signs of inflammation. Some discomfort will occur as the activity level is progressed, but it should not last longer than a couple of hours. Signs that activities are progressing too quickly or with too great a dosage are joint swelling, pain that lasts longer than 4 hours or that requires medication for relief, a decrease in strength, or fatiguing more easily.

Inform patient of anticipated recovery time and how to protect the part Adaptive or assistive devices as needed to protect the part during Tissue responses and characteristics Vascular changes

Causes of Chronic Inflammation

Prolonged or recurring pain and resulting limitations in activity and function occur as a result of stress being imposed on tissues that are unable to respond to the repetitive or excessive nature of the stress.

Overuse, cumulative trauma, repetitive strain. These are terms descriptive of the repetitive nature of the precipitating event. Repetitive microtrauma or repeated strain overload over time results in structural weakening, or fatigue breakdown, of

connective tissue, with collagen fiber cross-link breakdown and inflammation. Initially, the inflammatory response from the microtrauma is subthreshold but eventually builds to the point of perceived pain and resulting dysfunction.

Repetitive microtrauma to tendons may lead to tendon degeneration. It has been reported that inflammation occurs in the early stages of tendinopathy, but when tendons become degenerative, inflammation largely disappears, leading some to state that this is not an inflammatory condition. Histological findings in tendinopathy have shown a poor healing response with collagen degeneration, fiber thinning and disorientation, hypercellularity, and scattered vascular ingrowth.

Trauma. Trauma that is followed by superimposed repetitive trauma results in a condition that never completely heals. This may be the result of too early return to high-demand functional activities before the original injury has properly healed. The continued reinjury leads to the symptoms of chronic inflammation and dysfunction.

Reinjury of an "old scar." Scar tissue is not as compliant as surrounding, undamaged tissue. If the scar adheres to the surrounding tissues or is not properly aligned to the stresses imposed on the tissue, there is an alteration in the force transmission and energy absorption. This region becomes more susceptible to injury with stresses that normal, healthy tissue could sustain.

Contractures or poor mobility. Faulty postural habits or prolonged immobility may lead to connective tissue contractures that become stressed with repeated or vigorous activity.

Contributing Factors

By the nature of the condition, there is usually some factor that perpetuates the problem. Not only should the tissue at fault and its stage of pathology be identified, but the *mechanical cause* of the repetitive trauma needs to be defined. Evaluate for faulty mechanics or faulty habits that may be sustaining the irritation. Possibilities include:

- ***Imbalance between the length and strength of the muscles*** around the joint, leading to faulty mechanics of joint motion or abnormal forces through the muscles.

- ***Rapid or excessive repeated eccentric demand*** placed on muscles not prepared to withstand the load, leading to tissue failure, particularly in the musculotendinous region.
- ***Muscle weakness*** or an inability to respond to excessive strength demands that results in muscle fatigue with decreased contractility and shock-absorbing capabilities and increased stress to supporting tissues.
- ***Bone malalignment or weak structural support*** that causes faulty joint mechanics of force transmission through the joints (poor joint stability as in a flat foot).
- ***Change in the usual intensity or demands*** of an activity such as an increase or change in an exercise or a training routine or change in job demands.
- ***Returning to an activity too soon after an injury*** when the muscle-tendon unit is weakened and not ready for the stress of the activity.
- ***Sustained awkward postures or motions,*** placing parts of the body at a mechanical disadvantage, leading to postural fatigue or injury.
- ***Environmental factors*** such as a work station not ergonomically designed for the individual, excessive cold, continued vibration, or inappropriate weight-bearing surface (for standing, walking, or running), which may contribute to any of the previous factors.
- ***Age-related factors*** such that a person attempts activities that could be done when younger but his or her tissues are no longer in condition to withstand the sustained stress.
- ***Training errors,*** such as using improper methods, intensity, amount or equipment, or the condition of the participant, which lead to abnormal stresses.
- **A combination of several contributing factors** is frequently seen that cause the symptoms.

Management Guidelines: Chronic Inflammation/Cumulative Trauma Syndromes

Structural and Functional Impairments:

Pain in the involved tissue of varying degrees:
- Only after doing repetitive activities
- When doing repetitive activities as well as after
- When attempting to do activities; completion of demands prevented
- Continued and unremitting

Soft tissue, muscle, and/or joint contractures or adhesions that limit normal ROM or joint play

Connective tissue weakness in painful region

Muscle weakness and poor muscular endurance in postural or stabilizing muscles as well as primary muscle at fault

Imbalance in length and strength between antagonistic muscles; biomechanical dysfunction

Decreased functional use of the region

Faulty position or movement pattern perpetuating the problem

Plan of Care	Interventions During Chronic Inflammation
1. Educate the patient.	1. Counsel as to cause of chronic irritation and need to avoid stressing the part while inflamed. Adapt the environment to decrease tissue stress. Implement a home exercise program to reinforce therapeutic interventions.
2. Promote healing; decrease pain and inflammation.	2. Cold, compression, massage Rest to the part (stop mechanical stress, splint, tape, cast)
3. Maintain integrity and mobility of involved tissue.	3. Nonstressful passive movement, massage, and muscle setting within limits of pain
4. Develop support in related regions.	4. Posture training Stabilization exercises
Plan of Care	**Interventions—Controlled Motion and Return to Function Phases**
1. Educate the patient.	1. Ergonomic counseling in ways to prevent recurrence Home instruction in safe progression of stretching and strengthening exercises. Instruction on signs of too much stress (see Box 10.3)
2. Develop strong, mobile scar.	2. Friction massage Soft tissue mobilization
3. Develop a balance in length and strength of the muscles.	3. Correct cause of faulty muscle and joint mechanics with appropriately graded stretching and strengthening exercises.
4. Progress functional independence.	4. Train muscles to function according to demand; provide alternatives or support if they cannot. Train coordination and timing. Develop endurance.
5. Analyze job/activity.	5. Adapt home, work, and sport environment/tools.

PRECAUTION: If there is progressive loss of ROM as the result of stretching, do not continue to stretch. Reevaluate the condition and determine if there is still a chronic inflammation with contracting scar or if there is protective muscle guarding. Emphasize stabilizing the part and training in safe adaptive patterns of motion.

Patellar Tendinitis (Jumper's Knee)

Overuse conditions that affect the extensor mechanism are commonly referred to as "jumper's knee." The most common form is patellar tendinitis or tendinopathy, which typically manifests as pain near the insertion of the tendon at the lower part of the patella. Less frequently, the symptoms may be localized to the insertion points at the tibial tubercle or the quadriceps tendon at the upper part of the patella. In adolescents, it often presents as apophysitis, occurring at the tibial tubercle .(Osgood-Schlatter) or the distal patellar pole (Sinding-Larsen-Johansson)

History of Patellar Tendinitis (Jumper's Knee)

The typical history of patellar tendinitis involves the gradual onset of anterior knee pain at the affected site, which develops during or shortly after repetitive running or jumping activities. Jumper's knee is a tendinopathy that primarily affects the insertion point of the patellar tendon at the lower part of the patella. It is not an inflammatory condition but rather characterized by hypercellularity, neovascularization, absence of inflammatory cells, and alteration in collagen appearance, indicating a "failed healing response." It is commonly observed in basketball, volleyball, and track and field athletes. One theory suggests that it results from cumulative damage after repetitive microtrauma to the tendon. Athletes with jumper's knee have been found to generate greater force during jumping activities compared to asymptomatic athletes, indicating an overload phenomenon as a possible cause. The type of playing surface, particularly hard surfaces like concrete floors, may also contribute to an increased incidence of tendon symptom

Additional Information

An epidemiological study showed that the average duration of substantial pain - .and reduced knee function in jumper's knee is nearly 3 years

The prevalence of jumper's knee is estimated to be around 40-50% among high- - .level volleyball players and 35-40% among elite basketball players

- Reduced ankle dorsiflexion is associated with patellar tendon tendinopathy, increasing the load and rate of stress on the tendon. Addressing this finding is important during rehabilitation.

- Age-related changes in the tendon, such as a reduction in proteoglycans and an increase in cross-links, contribute to stiffness and decreased load tolerance rather than degeneration.

- Eccentric single-leg squat exercises involving active lengthening of the muscle-tendon unit have shown effectiveness in treating patellar tendinopathy. Using a decline board during these exercises enhances the results.

- Recommended regimen includes twice-daily eccentric single-leg squats on a 25-degree decline board, consisting of three sets of 15 repetitions for a duration of 12 weeks. Patients are instructed to slowly flex the knee to 90 degrees, focusing on eccentric loading of the quadriceps muscle while using the noninjured leg to return to the starting position. The downward (eccentric) movement is performed with the affected leg, while the upward (concentric) movement is performed with the unaffected leg. The use of a decline board in this exercise regimen is believed to reduce calf muscle tension, allowing for better isolation of the knee extensor mechanism and leading to improved outcomes compared to the standard squat group.

- Young et al. (2005) recommend implementing this 12-week protocol during the off-season if possible, as there may be some associated patellar tendon pain with the eccentric-based program.

- In a level 1 study, Bahr et al. (2006) found no advantage to surgical treatment of jumper's knee compared to eccentric strength training. Therefore, they recommend trying the 12-week eccentric training program before considering any open surgical tenotomy.

- A review of 23 studies on the surgical treatment of patellar tendinopathy showed favorable outcomes, ranging from 46% to 100%.

Knee Ligament Injuries: Nonoperative Management

Mechanisms of Injury

Ligament injuries commonly occur in individuals aged 20 to 40 years, primarily as a result of sports-related incidents such as skiing, soccer, and football. However, they can affect individuals of all ages. The anterior cruciate ligament (ACL) is the most frequently injured ligament, and it's common to sustain damage to multiple ligaments in a single injury. Knee sprains and strains are categorized as knee .instability and movement coordination impairments

Anterior Cruciate Ligament (ACL)

ACL injuries can result from both contact and noncontact mechanisms. The most common contact mechanism involves a lateral blow to the knee, causing a valgus force. This type of injury can affect not only the ACL but also the medial collateral ligament (MCL) and the medial meniscus. It is often referred to as the "unholy triad" or "terrible triad" injury due to the high occurrence of these three structures being injured together. Noncontact mechanisms typically involve rotational movements, where the tibia externally rotates on the planted foot. Research suggests that this mechanism accounts for up to 78% of all ACL injuries. Forceful .hyperextension of the knee is the second most common noncontact mechanism

In the absence of an ACL, prolonged walking or weight-bearing can stress the secondary restraints, namely the lateral collateral ligament and posterolateral joint capsule, causing laxity. This may lead to the development of a "quadriceps avoidance gait," where individuals consciously reduce quadriceps contraction to .compensate for the ACL deficiency

Posterior Cruciate Ligament (PCL)

Injury to the posterior cruciate ligament (PCL) typically occurs when a forceful impact is applied to the anterior tibia while the knee is flexed. Examples include a blow to the knee against a dashboard or falling onto a flexed knee. A study evaluating acute and chronic PCL-deficient knees reported that the three most common mechanisms of injury were a "dashboard" or anterior injury mechanism, accounting for 38.5% of cases, followed by a fall on the flexed knee with the foot in plantarflexion (24.6%), and a sudden, violent hyperflexion of the knee joint .(%11.9)

Medial Collateral Ligament (MCL)

Injuries to the MCL usually occur when a valgus force is applied to the inner side of the knee, causing damage to the ligament. Unlike ACL and PCL injuries that are often complete tears, MCL injuries can be partial or incomplete. They are classified into three grades (I, II, III) based on the severity of the injury

Lateral Collateral Ligament (LCL)

LCL injuries are less common and typically result from a traumatic varus force applied to the knee, causing damage to the ligament. It is not uncommon for multiple ligaments, joint capsules, and menisci to be affected in a single injury, .leading to posterolateral instability

Ligament Injuries in Female Athletes

There has been an increase in the number of female athletes, along with a corresponding rise in the number of injuries, particularly knee injuries. Notably, females are three times more likely to tear their ACL than males when sustaining noncontact injuries. The American Academy of Orthopaedic Surgeons has published papers addressing the risk factors and prevention strategies for noncontact ACL injuries in female athletes. Several retreats and consensus statements have also been organized to investigate gender bias in ACL injuries,

with identified risk factors falling into four categories: biomechanical, .neuromuscular, structural, and hormonal

Common Impairments and Limitations

After a ligament injury, joint swelling may not occur immediately but may develop over time. Pain is typically felt when the injured ligament is stressed, and complete tears result in joint instability. When the knee is effused, movement is restricted, the joint assumes a position of minimal stress (usually flexed 25°), and the quadriceps muscles may be inhibited. Acute injuries make weight-bearing and ambulation difficult without assistance. Complete tears result in instability, causing the knee to give way during weight-bearing activities, preventing the individual .from returning to activities that require dynamic knee stability

Nonoperative Management of Ligament Injuries

Acute sprains, partial tears, and even complete ruptures of a single knee ligament can be managed conservatively through rest, joint protection, and exercise. Rehabilitation exercises focus on regaining normal range of motion, balance, gait pattern, and strength, endurance, and neuromuscular control of the muscles that support and stabilize the joint during functional activities. The extent of instability following a ligament tear determines the level of activity the patient can safely resume. Less active individuals can usually function with some loss of knee stability and expect to return to their preinjury activities with nonoperative treatment. However, athletes who wish to return to high-demand activities following an ACL injury may require an intensive rehabilitation program, including balance and perturbation training to enhance neuromuscular control and dynamic knee stability. In cases of significant ligament damage or concurrent injuries with poor dynamic knee stability after nonoperative treatment, surgical reconstruction is often recommended to regain high-level function and return to work or sports activities.

If the collateral or coronary ligaments are affected, they can benefit from cross-fiber massage, which helps align the healing fibers and maintain their mobility. Due to the specific structural characteristics of the MCL (a wide, flat ligament with deep and superficial parts, collagen fibers aligned in parallel, and fan-shaped attachments at both ends), injuries to the MCL are typically treated using a conservative approach without surgery. The conservative management of MCL injuries is outlined, and the progression of treatment depends on the observed signs and symptoms. A similar rehabilitation program used for ACL injuries is followed, .with necessary precautions taken to avoid placing excessive stress on the ligament

Nonoperative Rehabilitation Phases for ligamentous Injuries

Phases and Timing of Rehabilitation

Phase 1: Weeks 1–3 (Maximum Protection) -

Phase 2: Weeks 3–6 (Moderate Protection) -

Phase 3: Weeks 5–8 (Minimum Protection) -

Phase 4: Weeks 8–12 (Return to Activity) -

Patient Presentation

Joint effusion -

Pinpoint tenderness -

Decreased range of motion (ROM) -

Key Examination Procedures

Pain scale assessment -

Evaluating joint effusion -

Assessing ligament stability -

Measuring range of motion (ROM) -

Evaluating muscle control -

Assessing functional status -

Examining patellar mobility -

Interventions and Goals for Each Phase

Phase 1: Weeks 1–3 (Maximum Protection)

:Goals

Protect healing tissues -

Prevent reflex inhibition of muscles -

Decrease joint effusion -

Reduce pain -

Establish a home exercise program -

:Interventions

PRICE (protective bracing, rest, ice, compression, elevation) -

Ambulation training with crutches, weight bearing as tolerated -

Passive range of motion (PROM) and active-assisted range of motion (A-AROM) -

Patellar mobilization (grades I and II) -

Muscle setting exercises for quadriceps, hamstrings, and adductors -

Straight leg raises (SLRs) -

Aerobic conditioning -

Phase 2: Weeks 3–6 (Moderate Protection)

:Goals

Achieve full, pain-free range of motion -

Restore muscular strength -

Normalize gait without assistive devices -

Improve activities of daily living (ADL) function -

Adherence to home exercise program -

:Interventions

Continued multiple-angle isometric exercises -

Initiation of progressive resistance exercises (PRE) -

Closed-chain strengthening exercises -

Lower extremity flexibility exercises -

Endurance training (e.g., biking, swimming, ski machine) -

Perturbation/balance training -

Stabilization exercises -

Initiation of a walk/jog program towards the end of this phase -

Initiation of skill-specific drills towards the end of this phase -

Phase 3: Weeks 5–8 (Minimum Protection)

:Goals

Increase strength, power, and endurance -

Improve neuromuscular control -

Enhance dynamic stability -

:Interventions

Continued lower extremity flexibility exercises -

Advancement of PRE strengthening exercises -

Advancement of closed-chain exercises -

Advancement of perturbation training -

Advancement of endurance training -

Isokinetic training (if available) -

Progression of running program (full-speed jog, sprints, figure-eight running, - cutting)

Phase 4: Weeks 8–12 (Return to Activity)

:Goals

Further increase strength, power, and endurance -

Regain the ability to function at the highest desired level -

Transition to a maintenance program -

Determine the need for protective bracing prior to return to sport or work -

:Interventions

Continued focus on flexibility and strengthening exercises with appropriate - advancements

Advancement of agility drills -

Advancement of running drills -

Advancement of perturbation drills -

Implementation of drills specific to the sport or occupation -

Evaluation of the need for protective bracing before returning to sport or work -

Management of Ligament Injuries: Surgical and Postoperative Approaches

Introduction

The ligaments in the knee play a crucial role in stabilizing the joint and facilitating its accessory motions. Injuries to these ligaments can result in functional impairments and require appropriate management. Among the knee ligaments, the anterior cruciate ligament (ACL) is the most commonly injured and treated surgically. The decision to opt for surgery depends on various factors such as the type of ligament injured, the extent of instability experienced by the patient, associated pathologies, and the desired level of functionality. Failure to address ligament injuries adequately can lead to chronic instability and subsequent joint .deterioration

:**Types of Ligament Surgery**

Ligament surgeries are classified as intra-articular, extra-articular, or combined procedures, and can be performed using different approaches such as open,

arthroscopically assisted, or all-arthroscopic methods. Intra-articular reconstruction, which has evolved over the years, is the primary surgical approach for managing ACL and posterior cruciate ligament (PCL) injuries. This procedure involves using tissue grafts to restore knee stability. Initially, open approaches were used, but they required lengthy immobilization periods and had suboptimal outcomes. Modern techniques employ arthroscopic or all-arthroscopic .approaches, leading to reduced tissue damage and faster postoperative recovery

Extra-articular reconstruction procedures, such as using the iliotibial (IT) band, were previously used but are now less common as they do not restore normal knee kinematics as effectively as intra-articular procedures. Augmenting intra-articular reconstruction with extra-articular procedures has shown limited .benefits

:**Grafts and Fixation**

Intra-articular ligament reconstruction relies on tissue grafts, typically autografts (patient's own tissue), although allografts (donor tissue) or synthetic grafts may be used when autografts are not suitable. Autografts, particularly the bone-patellar tendon-bone graft and the semitendinosus-gracilis tendon graft, are commonly employed for ACL reconstruction. Extensive research has focused on graft healing, placement, and fixation, as well as the strength and stiffness of different graft materials. Bone-patellar tendon-bone and quadrupled hamstring tendon grafts have demonstrated superior strength and stiffness compared to the .native ACL ligament

Conclusion

Surgical management of ligament injuries is considered when conservative rehabilitation fails to achieve functional goals or when there are signs of early joint degeneration. Intra-articular reconstruction techniques have become the primary approach for ACL and PCL injuries, offering better outcomes and faster

recovery compared to older methods. The choice of graft material and fixation technique plays a crucial role in the success of ligament reconstruction surgery

note: Understanding the changes that occur in a graft after implantation is crucial for the rehabilitation process and surgical outcomes. Initially, the graft undergoes avascular necrosis, leading to a loss of strength. This is followed by revascularization, remodeling, and maturation, which typically takes at least a year. During the first 6 to 8 weeks after surgery, the graft is most vulnerable to excessive loads as its strength depends solely on the fixation device. Advances in graft selection, preparation, placement, and fixation, along with arthroscopic techniques, have eliminated the need for long periods of postoperative immobilization and protected weight bearing. However, it is still important to carefully select and gradually increase the stresses imposed on the healing graft .during early rehabilitation

General considerations for rehabilitation include restoring joint stability and motion, achieving pain-free and stable weight bearing, developing sufficient postoperative strength and endurance for functional demands, and enabling a return to preinjury activities. Preoperative intervention, including edema control, exercises to minimize muscle atrophy and maintain range of motion, protected ambulation, and patient education, can contribute to successful postoperative outcomes. The duration and progression of postoperative rehabilitation programs vary in the literature, and open communication with the surgeon is essential to .address individual patient needs and concerns

Regardless of the specific ligament injury or surgical procedure, the focus of rehabilitation is on restoring functional abilities while protecting the healing graft and preventing complications and reinjury. Early controlled motion and weight bearing have been shown to reduce the incidence of postoperative complications and allow for a quicker return to activity without compromising the integrity of the reconstructed ligament. In recent years, rehabilitation protocols have shifted

from strict time-based guidelines to criteria-based progression, where the advancement of exercises and activities is based on specific goals and functional tests. Clinical practice guidelines have also been developed to provide evidence-based recommendations for knee stability rehabilitation following ligament injury .and surgery

Unlike the medial collateral ligament (MCL), which can often heal with nonoperative management, the healing capacity of a torn anterior cruciate ligament (ACL) is poor, especially in young, active individuals. Surgical reconstruction is frequently recommended to restore knee stability. Indications for ACL reconstruction include disabling knee instability due to ACL deficiency, frequent episodes of the knee giving way despite nonoperative management, positive pivot-shift test indicating rotatory instability, concurrent MCL injury to prevent impaired healing, and a high risk of reinjury due to participation in .demanding activities

There are no absolute contraindications for ACL reconstruction, but relative contraindications include individuals with limited exposure to high-demand activities, the ability to modify lifestyle to avoid high-risk activities, coping with infrequent instability episodes, advanced knee arthritis, and poor likelihood of .complying with postoperative restrictions and rehabilitation

The surgical procedure for ACL reconstruction has evolved from open reconstruction to arthroscopically assisted or endoscopic techniques, which reduce tissue morbidity and recovery time. The most common procedure involves using an autograft, either a bone-patellar tendon-bone graft or a hamstring tendon graft. Precise graft placement is crucial for joint stability and mobility, as improper placement can lead to postoperative limitations in range of motion. The choice between the two types of autografts depends on various factors, and both

have advantages, disadvantages, and potential complications associated with .them

Overall, a comprehensive understanding of the rehabilitation process, surgical techniques, and patient-specific factors is essential for successful ACL reconstruction and postoperative rehabilitation. Clinical practice guidelines can provide evidence-based recommendations to support decision-making during knee stability rehabilitation

Advantages and Disadvantages/Complications of Semitendinosus-Gracilis :Autograft

:**Advantages**

- The autograft has a high tensile strength and stiffness, which exceeds that of .the anterior cruciate ligament (ACL) when the graft is quadrupled
- .It does not disrupt the epiphyseal plate in skeletally immature patients
- .There is evidence of regeneration of the hamstring tendon at the donor site
- Loss of knee flexor muscle strength is resolved within two years after the .surgery

:**Disadvantages/Potential Complications**

- Tendon-to-bone fixation devices, especially tibial fixation, are not as reliable as .bone-to-bone fixation
- The healing time at the tendon-bone interface is longer, taking approximately .12 weeks
- .There is a risk of hamstring muscle strain during early rehabilitation

- Short- and long-term weakness in the knee flexor muscles may occur, although it is not associated with functional limitations.

- There may be a possibility of increased anterior knee translation, but it is not associated with functional limitations:

NOTE: Restricted range of motion (ROM) in knee extension can also be attributed to graft impingement caused by inadequate femoral notch size or the accumulation of scar tissue in the notch. To ensure sufficient clearance of the graft during knee extension, a femoral notchplasty is performed, which involves enlarging the intercondylar notch.

The success of ACL reconstruction heavily relies on graft fixation. In the case of a bone-patellar tendon-bone graft, the bone plugs are secured at each end within the prepared tunnels using screw fixation (either metal or bioabsorbable interference screws), achieving bone-to-bone fixation. For hamstring tendon grafts, various soft tissue fixation devices such as endobuttons, washers, and staples have been utilized. Interference and transfixation screws have also been advocated. Despite these advancements, achieving strong tendon-bone fixation, especially tibial fixation, remains challenging.

One advantage of modern fixation devices is their ability to withstand controlled tensile forces exerted on the graft during the early stages of rehabilitation without compromising its stability. This allows for early weight bearing and range of motion (ROM) of the knee, which are typical components of contemporary accelerated rehabilitation programs.

Following graft fixation and before closing the incision, the knee is moved through its ROM to assess the integrity of the graft and the tension experienced during

knee movement. Similar to graft placement, proper tensioning of the graft at the time of fixation directly impacts postoperative joint mobility and stability. Insufficient tension can result in excessive knee laxity and potential instability, while excessive tension can limit knee ROM. After closing the incision, a small compression dressing is immediately applied, and the leg may be immobilized .with a knee immobilizer for protection

:**Complications**

There are several operative and postoperative complications that may affect outcomes following ACL reconstruction Even minor technical errors during reconstruction can have adverse effects on function. As discussed earlier, improper graft or bone tunnel placement, issues with graft harvesting such as inadequate graft length, and incorrect graft tension can all negatively impact joint stability and mobility. Insufficient graft length occurs more frequently during hamstring graft harvesting compared to patellar tendon grafts. Insufficient graft fixation can lead to graft slippage and early failure. In the case of a bone-patellar tendon-bone graft, a bone plug may fracture during harvesting or implantation, .necessitating the use of an alternative autograft or an allograft

Postoperatively, potential complications include knee pain, loss of motion, persistent strength deficits, and inadequate joint stability. Anterior knee pain at the donor site of a patellar tendon graft or at the patellofemoral joint can affect functional activities. Knee pain during kneeling may be caused by a neuroma of .the infrapatellar branch of the saphenous nerve

Loss of full knee extension and persistent quadriceps weakness are significant complications following ACL reconstruction, particularly if full extension was not achieved before the surgery. In rare cases, there may be permanent damage to the extensor mechanism due to patellar tendon graft harvesting, resulting in

quadriceps weakness or even patellar tendon rupture. Limited ROM of the knee may preexist before surgery or develop afterward. Scar tissue accumulation in the intercondylar notch may necessitate arthroscopic notchplasty. Additionally, restricted knee ROM can also result from limited patellar mobility. Preoperative strength and ROM of the patient may also impact postoperative knee motion and :strength

:**Postoperative Management**

In the past, the rehabilitation process following ACL reconstruction involved prolonged periods of immobilizing the knee in a flexed position and a significant duration (often 6 to 8 weeks) of restricted weight bearing. It would take about a year to return to full activity. However, with advancements in surgical techniques and a better understanding of graft healing and the effects of stress on the healing process, early postoperative motion and weight bearing, known as "accelerated rehabilitation," have become the standard of care for active and typically young patients undergoing primary ACL reconstruction with an autogenous graft. This approach is based on the belief that a precisely positioned and appropriately tensioned graft is not only strong enough to withstand the stresses of early motion and weight bearing but also responds positively to these stresses during the healing process

Interventions for Accelerated Postoperative Rehabilitation following ACL Reconstruction

:Phase and Levels of Protection

:Time Frame

Phase: Day 1–Week 4 -

Phase: Weeks 4–10 -

Phase: Weeks 11–24 -

:Patient Presentation

:Key examination procedures

:Goals

:Phase: Day 1–Week 4 -

No joint instability -

No pain or swelling -

Full knee range of motion (ROM) -

Muscle function: 75% of the noninvolved extremity -

Symmetrical gait -

Unrestricted activities of daily living (ADL) -

Possible use of functional brace or sleeve -

:Phase: Weeks 4–10 -

Joint stability assessed using a joint arthrometer -

Muscle strength testing -

Functional testing -

Full clinical examination -

Increase muscle strength, endurance, and power -

Improve neuromuscular control, dynamic stability, and balance -

Regain cardiopulmonary endurance -

Transition to maintenance program -

Regain ability to function at the highest desired level -

Reduce risk of reinjury -

:Phase: Weeks 11–24 -

Pain controlled -

Joint effusion controlled -

Full or near full knee ROM -

Fair plus to good muscle strength (3+/5 to 4/5) -

Muscular control of joint -

Independent ambulation -

Pain scale assessment -

Girth measurement for effusion -

Joint stability assessed using a joint arthrometer -

ROM assessment -

Patellar mobility assessment -

Muscle strength testing -

Functional testing -

Full, pain-free ROM -

muscular strength 5/4 -

Dynamic control of knee -

Improved kinesthetic awareness -

Normalize gait pattern and ADL function -

Adherence to home exercise program -

:Interventions

The interventions for accelerated postoperative rehabilitation following ACL reconstruction vary across the different phases and levels of protection. These interventions aim to promote healing, restore function, and prevent .complications

:**Phase: Day 1–Week 4**

- Pain and hemarthrosis management

- Protection of healing tissues

- Diminished voluntary quadriceps activation

- Ambulation with crutches

- Use of protective bracing if prescribed

- Pain scale assessment

- Joint effusion measurement

- Ligament stability assessment (days 7–14)

- Range of motion (ROM) exercises

- Patellar mobility exercises

- Muscle control exercises

- Functional status assessment

- Establishment of a home exercise program

:**Phase: Weeks 4–10**

- Increase muscle strength, endurance, and power through progressive resistive exercises
- Improve neuromuscular control, dynamic stability, and balance through proprioceptive and balance training
- Regain cardiopulmonary endurance through cardiovascular conditioning exercises
- Transition to a maintenance program
- Regain the ability to function at the highest desired level
- Reduce the risk of reinjury
- Pain scale assessment
- Joint effusion measurement
- Ligament stability assessment
- ROM assessment
- Patellar mobility assessment
- Muscle strength testing
- Functional testing

:**Phase: Weeks 11–24**

- Pain control
- Joint effusion control
- Full or near full knee ROM
- Fair plus to good muscle strength
- Muscular control of the joint

Independent ambulation -

Pain scale assessment -

Girth measurement for effusion -

Joint stability assessment -

ROM assessment -

Patellar mobility assessment -

Muscle strength testing -

Functional testing -

Full, pain-free ROM -

muscular strength 5/4 -

Dynamic control of the knee -

Improved kinesthetic awareness -

Normalize gait pattern and ADL function -

Adherence to the home exercise program -

:Phase and Levels of Protection

:Time Frame

Phase: Day 1–Week 4 -

Phase: Weeks 4–10 -

Phase: Weeks 11–24 -

:**Weeks 0–2**

- Follow the PRICE principle: protective bracing, rest, ice, compression, and elevation
- Receive gait training using crutches and progress from partial weight bearing to weight bearing as tolerated
- Perform passive range of motion (PROM) and active-assisted range of motion (A-AROM) exercises with a range-limiting brace if prescribed
- Perform patellar mobilization techniques (grades I/II)
- Engage in muscle setting and isometric exercises for quadriceps, hamstrings, and adductors at multiple angles (may augment with electrical stimulation)
- Perform assisted straight leg raises (SLRs) in a supine position
- Perform ankle pumps

:**Weeks 2–4**

- Continue with the interventions mentioned above
- Progress to full weight bearing and begin closed-chain squats and heel/toe raises
- Perform SLRs in four planes of movement
- Engage in low-load PRE exercises for the hamstrings
- Perform open-chain knee extension exercises (range 90°–40°)
- Focus on trunk/pelvis stabilization exercises
- Participate in aerobic conditioning using a stationary cycle

It's important to note that the specific interventions and their progression may vary depending on individual patient factors and the healthcare professional's .judgment

It's important to note that the specific interventions and their progression may vary depending on individual patient factors and the healthcare professional's judgment

...

:**Weeks 5–6**

- Perform multiple-angle isometric exercises

- Engage in closed-chain strengthening and PRE

- Follow a LE stretching program

- Participate in endurance training using a stationary bike, pool, or elliptical trainer

- Engage in proprioceptive training in single-leg stance using a balance board or BOSU

- Perform stabilization exercises with elastic bands and band walking

:**Weeks 7–10**

- Advance strengthening exercises including proprioceptive neuromuscular facilitation (PNF), endurance, and flexibility exercises

- Engage in proprioceptive training with high-speed stepping drills, unstable surface challenge drills, and balance beam exercises

- Initiate a walk/jog program towards the end of this phase

:**Weeks 11–24**

- Continue lower extremity (LE) stretching

- Advance progressive resistive exercises (PRE) or initiate isokinetic training if desired

- Advance closed-chain exercises

- Initiate plyometric drills such as bounding and jumping

- Initiate plyometric drills like bouncing, jumping rope, and box jumps (double-leg/single-leg)

- Advance proprioceptive and balance training

- Progress agility drills such as figure-eight and skill-specific patterns

- Simulated work or sport-specific training

- Transition to full-speed jogging, sprints, running, and cutting:

Considerations for Weight Bearing:

Advancements in graft fixation techniques have made early weight bearing possible after primary ACL reconstruction using a bone-patellar tendon-bone or hamstring tendon autograft. However, recommendations regarding protected weight bearing immediately after surgery vary. Some guidelines suggest restricted weight bearing for the first 2 weeks, while others recommend weight bearing as tolerated with the use of two crutches right after surgery. The decision depends on individual factors. If there are additional knee injuries or repairs (such as articular cartilage defects in the femoral or tibial condyle), protected weight bearing may need to be continued for a longer duration.

By around 4 weeks post-surgery, if weight bearing is pain-free and the patient has achieved full active knee extension and sufficient quadriceps strength to control

the knee, full weight bearing and ambulation without crutches, with or without an unlocked protective brace, is typically permitted. The decision is not necessarily based on the type of graft or graft fixation used, or whether a protective brace is .worn, but rather determined empirically based on individual progress

Limited randomized studies in the literature suggest that immediate and delayed weight bearing during the first few weeks after surgery yield similar outcomes

:**Precautions for Exercise After ACL Reconstruction**

:**Resistance Training—General Precautions**

- Progress exercises more gradually for hamstring tendon graft reconstructions compared to bone-patellar tendon-bone graft reconstructions.

- Exercise caution when progressing knee flexor strengthening exercises for patients with a hamstring tendon graft, and knee extensor strengthening exercises for those with a patellar tendon graft.

:**Closed-Chain Training**

- When performing squats in an upright position, ensure that the knees do not move forward beyond the toes as the hips descend. This helps to minimize shear forces on the tibia and prevent excessive stress on the autograft.

- Avoid closed-chain quadriceps strengthening exercises between 60° to 90° of knee flexion.*

:**Open-Chain Training**

- Initially, when performing progressive resistive exercises (PRE) to strengthen the hip muscles, position the resistance above the knee until adequate knee control is established.

- Avoid resisted open-chain knee extension exercises (short-arc quadriceps training) between 45° or 30° to full extension for at least 6 weeks, and possibly up to 12 weeks.*

- Avoid applying resistance to the distal tibia during quadriceps strengthening exercises.*

Contraction of the quadriceps in these positions and ranges of motion results in the greatest anterior tibial translation, which can potentially impose excessive stress on the graft during the early stages of healing

Criteria for Return to High-Demand Activities After ACL Reconstruction:

- Absence of knee pain or joint swelling during the final phase of rehabilitation.

- Full and active range of motion (ROM) in the knee.

- Quadriceps strength greater than 85% to 90% compared to the unaffected side, or peak torque relative to body mass of 40% to 60% for men and 30% to 50% for women (tested at speeds of 300°/sec and 180°/sec, respectively).

- Hamstring strength equal to 100% of the unaffected side.

- Hamstring-to-quadriceps strength ratio greater than 70%.

- No history of postoperative knee instability or episodes of the knee giving way.

- Negative pivot shift test, indicating stability during rotational movements of the knee.

- Knee stability measured with an arthrometer, showing less than a 3 mm difference between the reconstructed and uninjured sides.

.(%100) Proprioceptive testing demonstrating normal function -

- Successful performance in functional tests, such as a series of hop, jump, and/or squat tests, with a score greater than 85% or 90% compared to the unaffected .side or meeting normative values

- Attainment of an acceptable patient-reported score on a comprehensive knee function measurement tool, such as the International Knee Documentation Committee Subjective Knee Form

:**Posterior Cruciate Ligament (PCL) Reconstruction**

In contrast to anterior cruciate ligament (ACL) injuries, PCL injuries are relatively uncommon. When a PCL injury does occur, it often involves damage to other structures in the knee. Generally, it is agreed upon that surgical intervention is necessary when there is a PCL injury along with damage to another ligament or .knee structure

For isolated PCL injuries, most patients respond well to nonoperative treatment and can return to their preinjury level of activity without surgery. However, severe PCL injuries have been associated with an increased risk of developing osteoarthritis in the medial compartment of the knee over time. Motion analysis of PCL-deficient knees has shown altered kinematics in the medial compartment, specifically anterior subluxation of the medial femoral condyle (posterior subluxation of the medial tibial plateau). These findings suggest that surgical intervention may be beneficial in preventing degenerative changes in PCL-.deficient knees

Indications for PCL Reconstruction Surgery include

- Complete tear or avulsion of the PCL with posterolateral, posteromedial, or rotary instability of the knee, along with damage to another ligament, menisci, or articular cartilage.

- Isolated, symptomatic grade 3 PCL tear with significant posterior displacement (8 to 10 mm or more) compared to the noninjured knee, resulting in instability during functional activities.

- Persistent pain and instability after unsuccessful nonoperative treatment following an isolated PCL injury.

- Chronic PCL insufficiency associated with posterolateral instability, pain, limitations in functional activities, and deterioration of the knee's articular surfaces.

There are various surgical procedures available for managing a torn or ruptured PCL, including arthroscopic, arthroscopically assisted, or open procedures. Reconstruction is the most commonly chosen option, involving the implantation of a graft to replace the damaged ligament. Graft options include autografts such as bone-patellar tendon-bone, hamstring (semitendinosus-gracilis), quadriceps tendon, or allografts like Achilles tendon or anterior tibialis tendon. Synthetic grafts may also be used in some cases.

The surgical procedure typically starts with diagnostic arthroscopy, followed by graft harvest if an autograft is used. Graft placement methods include transtibial tunnel and tibial inlay techniques. The knee's flexion and extension are checked to ensure proper graft placement and tension, allowing full range of motion. After the procedure, the knee is immobilized in full extension using a hinged, range-limiting protective brace. Weight-bearing and ambulation are done with the brace locked in extension for an extended period.

Complications of PCL reconstruction may include damage to the popliteal neurovascular bundle during tibial bone tunnel drilling, bleeding leading to compartment syndrome, anterior knee pain or pain during kneeling if a patellar tendon autograft is used, limited knee flexion, and the possibility of graft failure .necessitating revision reconstruction

Postoperative management involves wearing the protective brace locked in extension during weight-bearing and ambulation. The brace is gradually discontinued after a few weeks, and physical therapy and rehabilitation are initiated to restore knee function and strength

In contrast to ACL reconstruction, the progression of weight bearing after PCL surgery is more gradual. The timing for initiating and advancing weight bearing varies widely in the literature. Recommendations range from partial weight bearing (around 30%) immediately after surgery using crutches and a locked extension brace, to non-weight bearing for a week to five weeks postoperatively. The increase in weight bearing occurs over several weeks while keeping the brace locked in extension. As the patient's quadriceps control improves and pain and joint effusion are well controlled, the brace is unlocked to allow protected range .of motion during ambulation with crutches and weight-bearing exercises

Crutches are discontinued, and full weight bearing with the brace unlocked is permitted when the patient meets specific criteria. These criteria are typically met around 8 to 10 weeks postoperatively. The use of the brace is then gradually .discontinued

The exercise progression after PCL reconstruction is similar to that after ACL reconstruction, with some key differences. The exercises are progressed more gradually, and exercises that exert posterior shear forces on the tibia are

postponed during the initial and intermediate phases of rehabilitation when the .graft is most vulnerable

Strengthening the quadriceps is emphasized for knee control after PCL reconstruction because it acts as a dynamic restraint to posterior tibial translation. When resistance exercises for hamstring strengthening are introduced during advanced rehabilitation, they are adjusted based on the .stability of the knee

During the first phase of rehabilitation (maximum protection phase), which lasts for 4 to 6 weeks, the focus is on protecting the graft while regaining mobility and developing quadriceps control. The goals include controlling acute symptoms, preventing vascular complications, reestablishing quadriceps control, maintaining patellar mobility, achieving approximately 90° of knee flexion within 2 to 4 weeks, improving neuromuscular control and balance, enhancing strength and flexibility of the hip and ankle muscles if needed, and improving cardiopulmonary fitness. Pain and swelling are managed using standard methods, and ankle-pumping .exercises are initiated immediately after surgery

There are specific criteria for ambulation without crutches after PCL reconstruction, including minimal to no pain or joint effusion, full active knee extension, passive and active knee flexion, adequate quadriceps strength, and .normal gait mechanics

Exercise precautions are outlined throughout the rehabilitation process to avoid excessive posterior shear forces and disruption of the healing graft. Specific precautions are provided for early and intermediate rehabilitation as well as advanced rehabilitation. These precautions include avoiding certain exercises, limiting knee flexion repetitions, maintaining proper body mechanics during

exercises, and postponing certain activities and resistance training until specific timeframes. Wearing a functional knee brace during high-demand activities is also ...recommended

:**Phase 1 Rehabilitation**

- Perform exercises such as patellar-gliding techniques, quadriceps-setting exercises, and four-position SLRs (Straight Leg Raises) while wearing a protective brace locked in full extension. Additionally, use neuromuscular electrical stimulation to augment the exercises. Use an upper extremity ergometer for .aerobic conditioning. Establish a home exercise program

- When knee motion is allowed, follow exercise precautions for early rehabilitation as previously mentioned. Begin with multiple-angle isometrics of the quadriceps, starting from full extension to 25° to 30° of flexion. Progress to assisted knee extension and then active knee extension while seated. To regain knee flexion, start with gravity-assisted flexion in a seated position, holding the patient's leg in full knee extension and allowing gravity to flex the knee as the .patient controls leg lowering

- If weight-bearing is permitted, perform trunk and lower extremity stabilization exercises and heel raises in a supported standing position while wearing the locked brace. When the brace can be unlocked, begin closed-chain quadriceps strengthening exercises in bilateral stance, such as terminal knee extension and minisquats, while holding onto a stable surface for support. Focus on hip and lumbopelvic stabilization to prevent abnormal movements at the knee. Stretch the hip and ankle muscles, particularly the hamstrings, IT band, and .plantarflexors

:**Criteria to progress to the next phase**

- Minimal joint swelling

- Full, active knee extension without extensor lag

- At least 100° of knee flexion

- Grade 3/5 quadriceps strength on manual muscle test

- Understanding of home program and exercise/activity precautions

:**Phase 2 Rehabilitation**

- Goals and interventions during the intermediate phase are similar to those in the early phase. The timeline is more extended, especially for hamstring strengthening.

- By 9 to 12 weeks postoperatively, aim to achieve full knee range of motion (0° to 135°) to discontinue the use of the protective brace if quadriceps control is sufficient.

- Continue precautions to prevent excessive posterior shear forces on the tibia during exercises and functional activities.

- Emphasize quadriceps strengthening for full, active knee extension and overall strength in the quadriceps, hip, and ankle muscles for weight-bearing activities.

- Initiate resistance training for hamstring strength based on posterior knee stability. Start with closed-chain exercises such as bilateral bridging and progress to unilateral bridging. Consider incorporating eccentric squat programs and open-chain hamstring strengthening exercises (hamstring curls) when posterior knee stability allows.

- Incorporate advanced neuromuscular training, plyometrics, balance activities, agility drills, progressive aerobic conditioning, and activity-specific training for a safe transition to full functional activities. A full return to vigorous activities may take 9 months to a year.

Meniscus Tears: Nonoperative Management

- Mechanisms of injury for medial meniscus tears include foot fixed on the ground with internal rotation of the femur, while lateral meniscus tears can result from lateral rotation of the femur on a fixed tibia. Squatting or trauma can also .cause tears

- Common impairments and limitations include acute locking of the knee or chronic symptoms with intermittent catching/locking, pain along the joint line during hyperextension or maximum flexion, joint swelling, and quadriceps atrophy. The McMurray test or Apley's compression/distraction test may be .positive

- Management involves active leg movement to unlock the knee or passive manipulative reduction of the meniscus. After acute symptoms subside, perform exercises in open- and closed-chain positions to improve strength and endurance .in isolated muscle groups and prepare for functional activities

:**Meniscus Tears: Surgical and Postoperative Management**

- Surgical options include partial meniscectomy and meniscal repair. Repair is preferred for peripheral tears involving the highly vascular portion of a meniscus, while partial meniscectomy is performed for complex tears or tears involving the avascular zone. Total meniscectomy may be necessary in cases of extensive .damage

- Rehabilitation progression and time to return to full activity depend on the tear extent, surgical procedure, and involvement of other knee structures. Rehabilitation is more conservative for repair or transplantation of a meniscus or total meniscectomy compared to partial meniscectomy. Other soft tissue damage, such as ACL tears, also affects the rehabilitation process

Indications for Surgery

:Surgery to repair a torn meniscus is recommended in the following cases

- A tear located in the outer third of the medial or lateral meniscus, where there is good blood supply.

- A tear extending into the central portion of the meniscus in physically active individuals, either young (younger than 40-50 years old) or older (older than 50 years old).

Contraindications

:Surgery to repair the meniscus is not recommended in the following situations

- A tear limited to the inner avascular third of the meniscus.

- A tear with significant tissue fragmentation.

- A tear that cannot be completely repositioned during surgery.

Procedure Overview

Before the surgical procedure, a thorough arthroscopic examination is performed to assess the suitability of the meniscus tear for repair and to identify any additional injuries, such as damage to the ACL. The repair can be done using an arthroscopically assisted open approach or a fully arthroscopic approach, depending on the location and nature of the tear.

There are different surgical techniques available for meniscus repair, including inside-out, outside-in, and all-inside techniques. The inside-out and outside-in techniques involve a combination of arthroscopic and open approaches, while the all-inside technique is fully arthroscopic. Various suturing techniques using nonabsorbable or bioabsorbable sutures can be employed during the repair, and other fixation devices like darts or staples may also be used. The most common

and widely accepted technique is the arthroscopically assisted inside-out suture .repair

During the procedure, small incisions are made around the knee for portals, and saline is introduced into the joint to expand the capsule. After examining the joint, any unstable tissue fragments are removed through arthroscopic debridement. The torn meniscus is then repaired by closely approximating the edges of the tear and placing sutures every 3 to 4 mm to ensure complete closure without any gaps. The sutures are tied with the knee fully extended or slightly flexed to allow full extension of the knee postoperatively without stressing the repaired meniscus. After the repair, a compression dressing is applied to control .joint swelling, and the knee is immobilized

Complications

Complications specific to meniscus surgery include damage to the neurovascular bundle at the posterior aspect of the knee during the suturing process. For medial meniscus repair, there is a risk of injuring the saphenous nerve, while for lateral meniscus repair, there is a risk of damaging the peroneal nerve. Scar tissue formation can also entrap these nerves postoperatively. Other complications include flexion contracture or extensor lag, which can affect knee alignment and stability during activities involving knee flexion beyond 45°. The risk of repair failure is highest during the first few months after surgery, particularly during .activities that load the joint and require significant knee flexion

Postoperative Management

The components and progression of postoperative rehabilitation after meniscus repair depend on several factors, including the location and size of the tear, tear pattern, type of surgical fixation device used, knee joint alignment, and the

presence of any concomitant injuries. Rehabilitation is typically divided into .different phases

During the maximum protection phase, exercises and gait training with crutches are initiated from the first day after surgery. Pain and swelling control measures are implemented, and weight-bearing precautions are emphasized. The range-limiting brace is worn to protect the repaired meniscus, gradually allowing .increased knee flexion over time

In the early and intermediate rehabilitation phases, knee flexion is increased gradually, especially for central zone repairs. Weight-bearing exercises are performed cautiously, with limited knee flexion beyond certain angles depending on the type of repair. Exercise precautions include avoiding twisting motions, postponing certain exercises like leg press and hamstring curls, and gradually .progressing the intensity and range of motion

In the advanced rehabilitation phase, exercises involving deep squatting, deep lunges, twisting, and pivoting are avoided for several months. Jogging or running programs can begin after 5 to 6 months, and return to recreational and sports activities should be done gradually, avoiding high joint compressions and shear .forces

It's important to note that the specific timelines and guidelines for rehabilitation may vary, and adjustments may be made based on individual patient factors and surgeon recommendations

:**Goals**

Within the first 4 weeks after surgery, the goals of exercise are to achieve - functional range of motion (ROM), prevent restrictions in the patella, regain control of the knee muscles, restore postural stability, improve strength and

flexibility in the hip and ankle, and maintain cardiopulmonary fitness. By the end of 4 weeks, the patient should be able to fully extend the knee and achieve a .maximum flexion of 120°

:**Interventions**

- Knee ROM: Depending on the surgeon's discretion, continuous passive motion (CPM) may be prescribed. The day after surgery, active-assisted range of motion (A-AROM) and active range of motion (AROM) exercises should be started within a safe range. Knee flexion may be limited by a hinged brace. Exercises such as gravity-assisted knee flexion in a seated position and assisted heel slides in a lying .position should be included and gradually progress to active heel slides

- .Patellar mobility: Teach the patient grade I and II patellar gliding exercises

- Activation of knee musculature: Focus on quadriceps control in full extension through exercises like quadriceps-setting exercises, assisted straight leg raises (SLRs) in a lying position, and assisted progression to active knee extension/flexion in a seated position. Neuromuscular electrical stimulation or .biofeedback can be used to enhance quadriceps activation

- Hamstring and multiple-angle isometric exercises: Perform hamstring-setting .exercises and isometric exercises at different angles

- Neuromuscular control, proprioception, and balance: Initiate balance training in a standing position, taking into account weight-bearing restrictions and keeping the brace locked in extension. Emphasize stabilization exercises for the trunk and .lower extremities

- Closed-chain exercises: When permitted to unlock the brace under controlled weight-bearing conditions, start bilateral closed-chain exercises such as mini .squats and standing wall slides, initially limiting flexion to no more than 45°

- Hip and ankle musculature flexibility and strength: Stretch the hamstrings and plantarflexors if tight. Begin gluteal and adductor setting exercises on the first day

after surgery. Progress to four-position straight leg raises with the brace locked or unlocked depending on the patient's ability to perform an SLR in a lying position without any lag. Perform bilateral heel raises once 50% weight-bearing on the .operated leg is allowed

- Cardiopulmonary function: Use an upper body ergometer for aerobic .conditioning exercises

Criteria to progress to the next phase (Moderate Protection/Controlled Motion :Phase)

- Minimal joint effusion and pain

- Superior gliding of the patella with quadriceps setting

- Full, active knee extension without any lag

- Approximately 120° of knee flexion

:**Exercise: Moderate Protection/Controlled Motion Phase**

This phase lasts from 4 to 6 weeks to about 12 weeks after surgery. The knee brace can be discontinued around 6 to 8 weeks if there is adequate knee control and no extensor lag. Using a cane or single crutch during ambulation is .recommended for protection

:Goals

- Restore full knee range of motion, improve lower extremity flexibility, strength, and muscular endurance, reestablish neuromuscular control and balance, and .enhance overall aerobic fitness

:**Interventions**

- Range of motion (ROM): Progress with low-load, long-duration stretching .exercises if full knee range of motion is not achieved

- Muscle performance: Initiate stationary cycling against light resistance. Use elastic resistance for low-intensity exercises in both open-chain and closed-chain .exercises

- Hip and ankle strengthening exercises: Progress exercises that target hip .abductors and extensors

- Neuromuscular control, proprioception, and balance: Emphasize proper lower extremity alignment during activities. Include closed-chain exercises and add perturbation training on an unstable surface such as a minitrampoline or BOSU. Once full weight bearing is allowed, start unilateral balance activities, partial lunges, step-ups, and step-downs. Practice walking on high-density foam rubber .or an unstable surface

- Flexibility of the hip and ankle: Stretch the iliotibial (IT) band and rectus femoris .after achieving full knee flexion with hip flexion

- Cardiopulmonary fitness: Begin stationary cycling or a pool-walking program at the beginning of this phase. Introduce treadmill training, land walking, or the use .of a cross-country ski machine or elliptical trainer around 9 to 12 weeks

- Functional activities: Gradually reintroduce light functional activities during this .phase

:**Criteria to progress to the next phase**

- No pain or joint effusion

- Full, active knee range of motion

- Lower extremity strength (maximum isometric contraction) at 60% to 80% compared to the unaffected side

Exercise: Minimum Protection/Return to Function Phase

At the beginning of the final phase of rehabilitation, which typically starts around 12 to 16 weeks and may continue until 6 to 9 months after surgery, some degree of protection is still necessary. The return to a high level of physical activity depends on achieving adequate strength, full range of motion without pain, and .satisfactory clinical examination

Goals: The primary goal of this phase is to prepare the patient to resume full functional activities using normal movement patterns. Patient education is continued to reinforce the importance of selecting activities that do not .overstress the repaired meniscus

Interventions: During advanced resistance training, focus on movement patterns that simulate functional activities. Gradually introduce drills such as plyometric training and agility drills to improve power, coordination, and rapid response times. Emphasize proper trunk and lower extremity alignment. Increase the duration or intensity of the aerobic conditioning program. Transition from a walking program to a jogging/running program, if desired, at around 4 to 6 months. Detailed progression guidelines for aerobic conditioning activities after .meniscus repair are available in published resources

Outcomes: Repair of a torn medial or lateral meniscus using various surgical techniques generally yields successful results. Suture repair of a tear in the peripheral zone has predictable outcomes. Repairs in the central zone are less predictable but have shown evidence of good healing and long-term symptom relief. The presence of an anterior cruciate ligament (ACL) injury influences outcomes, with better results observed in patients who undergo ACL reconstruction. Recurrent tear rates are higher in ACL-deficient knees compared to ACL-stable knees. Age is not a limiting factor for meniscus repair, as successful

outcomes have been reported in patients aged 40 or older with central zone tears. There is no single superior postoperative rehabilitation protocol. The effectiveness of meniscus transplantation with an allograft in the long term is still .being evaluated

:**Partial Meniscectomy**

Indications for Surgery: Partial meniscectomy is indicated for a tear of the medial :or lateral meniscus in the following situations

- .Symptomatic tear associated with pain and locking in older, inactive individuals

- Tears extending into the central, less vascular third of the meniscus that are .determined to be non-repairable during arthroscopic examination

- .Tears localized to the inner, avascular third of the meniscus

Procedure: Arthroscopic meniscectomy is typically performed as an outpatient procedure under local anesthesia. Small incisions are made at the knee for portals, and saline solution is injected to distend the knee. The torn portion of the meniscus is identified, grasped, and removed using endoscopic tools. Intra-articular debris or loose bodies are also removed. After irrigation and drainage, .the incisions are closed, and a compression dressing is applied to the knee

Postoperative Management: The rehabilitation goal after partial meniscectomy is to restore knee range of motion and develop lower extremity strength to reduce stress on the knee and protect its articular surfaces. The progression of exercises .and functional activities depends on the patient's symptoms and signs

Immobilization and Weight Bearing: There is no need for prolonged immobilization or motion-controlling orthosis after arthroscopic partial meniscectomy. Cryotherapy, compression, and elevation are used to control edema and pain in the early postoperative days. Weight bearing is progressed as tolerated

:**Exercise: Maximum and Moderate Protection Phases**

Exercise instruction ideally begins on the day of or after surgery. However, if supervised therapy is not immediately available, it is recommended to teach the patient initial exercises preoperatively to prevent atrophy and contracture. These .exercises can be initiated at home immediately after surgery

After arthroscopic partial meniscectomy, there is no extended period of maximum protection postoperatively due to minimal soft tissue trauma during surgery. However, moderate protection is necessary for approximately 3 to 4 weeks. All exercises and weight-bearing activities should be pain-free and gradually progressed during the initial postoperative weeks

Goals: During the initial phase of rehabilitation, the primary objectives are to manage inflammation and pain, regain independent walking ability, and restore .knee control and range of motion (ROM)

Interventions: Immediately following surgery, the rehabilitation program should include muscle-setting exercises, straight leg raises (SLRs), active knee range of motion exercises, and weight-bearing activities as tolerated. Full weight bearing is typically achieved within 4 to 7 days, and by day 10, the goal is to attain at least 90° of knee flexion and full extension. Closed-chain exercises and stationary cycling can be initiated a few days after surgery, or as determined by pain levels and weight-bearing status, with the aim of regaining dynamic strength and .endurance in the knee

Precaution: Patients who have undergone partial meniscectomy should be cautioned against pushing themselves too quickly. Overly rapid progression of exercises can lead to recurrent joint swelling and potential damage to the .articular cartilage

Exercise: Minimum Protection/Return to Function Phase

By 3 to 4 weeks after surgery, the knee requires minimal protection, but it is important to achieve full, pain-free active knee range of motion and a normal gait pattern before advancing to high-demand exercises. The rehabilitation program can be rapidly progressed to include resistance training, endurance activities, both bilateral and unilateral closed-chain exercises, and proprioceptive/balance training to enhance neuromuscular control. Advanced activities such as plyometrics, maximum effort isokinetic training, and simulated high-demand functional movements can be introduced as early as 4 to 6 weeks or 6 to 8 weeks .postoperatively, with a focus on restoring normal movement mechanics

Precaution: If high-impact weight-bearing activities like jogging or jumping are included in the program, they should be added and progressed cautiously to prevent potential future damage to the knee joint. It is important to correct any improper lower extremity alignment during weight-bearing, such as valgus .collapse or pelvic drop, before advancing to plyometric and high-impact activities