REVIEW ARTICLE

Evaluation and Management of Anterior Cruciate Ligament Injuries: A Focused Review

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Anterior cruciate ligament (ACL) injuries are among the most common sports medicine complaints in the United States. There are approximately 150,000 ACL injuries annually with the majority of them occurring via non-contact mechanisms. Assessment of the knee should be performed immediately after an ACL injury and includes a comprehensive history and physical exam. The Lachman test is most accurate in diagnosing an ACL injury. Magnetic resonance imaging confirms the diagnosis of an ACL injury and also evaluates the surrounding soft tissue for concomitant injury. Treatment depends on the extent of injury as well as the activity level of what the patient desires. Both conservative treatment and post-operative care include extensive rehabilitation to increase range of motion and stability to the knee joint. Complications of ACL injuries most commonly involve chronic pain and eventual osteoarthritis. Prevention of an ACL injury requires a dedicated regimen of strength and neuromuscular training.

Sample ACL Prevention Program available for download at ofpjournal.com

INTRODUCTION

The majority of ACL injuries occur in people aged 15-45. This is reflective of a more active lifestyle and higher participation in athletic activity during that age range.[1] The total number of injuries is greater in males (due to a higher number of participants) but females have a 2-8 times higher risk of injury. [2] Theories on why injuries are more prevalent among women include a greater Q angle at the knee joint leading to a genu valgus alignment, a wider pelvis, increased joint laxity, and hormonal changes that occur throughout the menstrual cycle.[2] The classification of ACL injuries is divided into three grades.[3] A grade 1 injury involves microscopic damage with a predominately intact ligament. A Grade 2 injury has partial tearing and separation of the fibers with surrounding edema. It can be further subdivided into low-grade partial and high-grade partial tears, depending on severity. A grade 3 injury is a complete tear in which the entire ligament is torn and the knee joint is unstable.

ANATOMY

The knee joint permits flexion and extension as well as rotational movement of the lower extremity.[4] The primary structures that stabilize the knee joint include the anterior cruciate ligament, posterior cruciate ligament, medial collateral ligament, lateral collateral ligament, and the medial and lateral menisci.[4] Cartilage, bursae, and synovial fluid act to maintain and support the integrity of these structures.[4] Despite this intricate support system, the knee joint and especially the ACL are subject to a variety of twisting and weight bearing stressors that make it especially prone to injury.[4] The ACL originates at the posterior aspect of the femur and attaches to the anterior tibia.[4] It prevents anterior displacement of the tibia relative to the femur.[4]

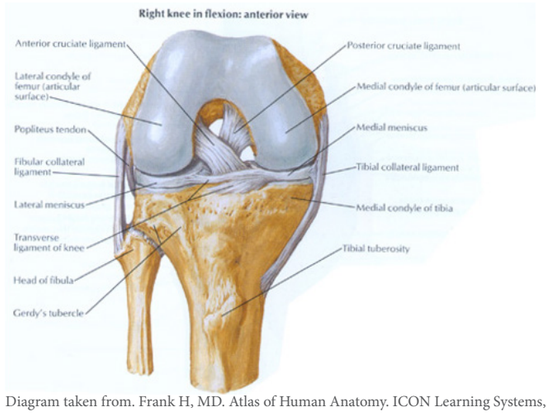


Diagram taken from. Frank H, MD. Atlas of Human Anatomy. ICON Learning Systems, New Jersey 1997. Plate 475

MECHANISM OF INJURY

Approximately 75% of ACL tears are non-contact and most commonly occur either with a sudden deceleration prior to a change in direction or landing in an extended position.[5] Conventionally it was thought that an ACL injury occurred only due to anterior translation of the tibia on the femur, but recent studies have shown that a tri-planar motion of anterior translation of the tibia, abduction of the knee, and internal rotation of the knee all contribute to ACL stressors that cumulate in a tear or strain.[6] Excessive quadriceps contraction and reduced hamstring co-contraction near full knee extension increases ACL tensile forces past its anatomical barrier, ultimately leading to an injury.[7] Direct contact ACL tears usually involve a lateral blow to a planted leg.[8] It is often referred to as the "unhappy triad" because they include concomitant medial collateral ligament (MCL) and meniscal injury as originally described by O'Donoghue's classic article in 1950.[9]

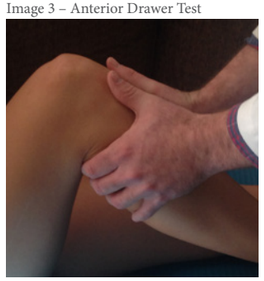
HISTORY AND PHYSICAL EXAM

A thorough history and physical exam should be performed immediately after a suspected tear. The patient might often describe hearing a "pop" associated with twisting, cutting, or landing from a jump. Decreased range of motion and a feeling of instability can follow the injury. The patient may complain of mechanical symptoms such as the knee "giving way" or functional deficits which result in "rounding cuts" instead of pivoting. Pain is variable; it can range anywhere from a "mild tweak" days later to excruciating pain seconds after an injury has been sustained.[10] Physical exam should begin with assessing the patient's posture, degree of swelling, gait, strength, and range of motion. Comparing the non-injured knee to the injured knee gives a relative understanding of the deficits incurred. Roberts and Stallard noted a hemarthrosis may indicate ligamentous injury in the acutely injured knee.[17] This is due to tearing of the middle geniculate artery, which runs longitudinally within the synovial sheath that envelopes the ACL.[18] If tense swelling appears within a few hours of injury, this likely represents a hemarthrosis. An acute on field exam is often much easier before edema, hemarthrosis, and guarding is established. Complete immobilization is generally contraindicated due to prolonged stiffness and muscle atrophy, but is acceptable in the setting of a traumatic injury where the extent and damage is unknown.[48] Atrophy, weakness, and inability to efficiently contract the quadriceps is very common following an acute ACL injury.[11] EMG studies have shown quadricep dyskinesia in subjects with ACL tears when performing both static (isometric contraction) and dynamic (cyclic flexion and extension) tests.[12]

One article searched MEDLINE (1970-2000) and reviewed the literature to determine the scientific validity of the Lachman test, pivot shift test, and the anterior drawer test used in the diagnosis of an ACL injury.[13] The Lachman test (Image 2) had a sensitivity ranging from 0.80 to 0.99 and a specificity of 0.95.[13] To perform the Lachman test, flex the knee to 30 degrees and apply anterior force on the tibia. It was concluded that it was the most sensitive and specific test for the diagnosis of an ACL tear, especially in acute injuries.[13] The pivot shift test had a sensitivity ranging from 0.84 to 0.98 with a specificity of 0.98 under general anesthesia, but values as low as 0.35 have been described in an alert patient.[13] To perform the pivot shift test, flex the knee to 30 degrees while internally rotating and apply a valgus force to knee. The anterior drawer test (Image 3) had a specificity of 0.97 and a sensitivity ranging from 0.22 to 0.41 in an alert patient and 0.79 to 0.91 in a patient under general anesthesia.[13] To perform the anterior drawer test, flex the hip to 45 degrees and knee to 90 degrees while applying anterior force on the tibia. Screening for further injury should also include testing for concomitant injuries to the posterior cruciate ligament (PCL), collateral ligaments, menisci, and the posterolateral corner (PLC) of the knee.

Image 2 – Lachman Test

Image 3 – Anterior Drawer Test



The posterolateral corner (PLC) of the knee is composed of the gastrocnemius, popliteus, LCL, popliteofibular ligament, and the arcuate –fabellofibular ligament complex.[14] The PLC complex resists varus and external rotational forces as well as posterior translation of the tibia on the femur.[14] Isolated injury to the PLC is rare and usually occurs with cruciate ligament injury.[14] Varus testing and the dial test (patient prone, externally rotating tibia with knees flexed at 30 and 90 degrees) can screen for postero-lateral instability. Also, Hughston and Norwood described the external rotational recurvatum test in 1980 which demonstrated hyperextension of the knee with external rotation of the tibia while holding the patient's great toes and lifting the heels off the table.[15] PLC damage is confirmed with radiographic and magnetic resonance imaging. Missed PLC injuries increase the failure rate of ACL reconstructive surgery and can exacerbate disability stemming from cartilage damage and chronic instability.[16]

IMAGING

The decision on whether to use radiographic imaging can be determined using the Ottawa Knee Rules.[19] A patient older than the age of 55, isolated tenderness at the fibular head or patella, the inability to flex to 90 degrees, and not being able to bear weight immediately after injury and in the emergency

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room are indications to screen for skeletal fractures. The Ottawa Knee Rules has played an important role in ruling out skeletal fractures and avoiding unnecessary plain films. One study showed that the Ottawa Knee Rules had 98.5% sensitivity in ruling out a fracture with traumatic injury to the knee.[20] Plain films may show evidence of a segond fracture, which is an avulsion fracture of the lateral aspect of the tibial plateau.[21] Approximately 75% of segond fractures are associated with ACL tears, and this is especially useful when physical exam is made limited by a painful and traumatized knee.[21] Scientific literature concludes that a segond fracture is a strong indirect sign of an ACL tear.[21]

Magnetic Resonance Imaging (MRI) is the gold standard in confirming an ACL tear with a sensitivity and specificity of 90.9% and 84.6%, respectively.[22] An MRI is indicated and should be ordered if the diagnosis is uncertain or if concomitant meniscal or ligamentous injury is suspected. Damage to the menisci and the collateral ligaments occurs in 60-75% of ACL tears.[23] As physical exam may be limited due to pain and decreased range of motion, MRI becomes a valuable tool. It has played an instrumental role in decreasing the number of diagnostic arthroscopies in the United States.[24]

MANAGEMENT

Acute management, post-injury or postoperatively, must focus on decreasing pain and edema. This is accomplished via pain control with nonsteroidal anti-inflammatory drugs (NSAIDs), relative rest, ice, compression, and elevation (also known as the PRICE method). Restoring range of motion using a variety of soft tissue and manipulative techniques should then be implemented 2-3 days after injury or surgery. Osteopathic Manipulative Treatment (OMT) can be especially helpful during this phase of ACL rehabilitation. Once the PRICE method is implemented and the acute stage of injury is complete, OMT can address any hypertonic muscles, restrictions of myofascial structures, and triggerpoints that may be contributing to the presence of pro-inflammatory substances and edematous fluid. Application of indirect soft tissue techniques such as myofascial release and counterstrain therapy for lower extremity trigger points will reduce the hypersympathetic state of the damaged tissue. By correcting asymmetry, restrictions, and tenderness classically seen in any somatic dysfunction, tissue equilibrium can be re-established leading to decreased nociceptor activation and increased venous and lymphatic return.[25] Restriction in the patella and fibular head can also hinder range of motion and thus delay the healing process, and special attention needs to be directed at these locations. Great emphasis needs to be placed on this phase of rehabilitation because studies have shown that loss of motion is one of the most important factors in the development of osteoarthritis.[26] Once control of pain and swelling has occurred, along with restoration of range of motion, progression to resistance training and dynamic conditioning may be attained within the first month.[27] Increased resistance training, balance and proprioceptive conditioning, agility, and sport-specific activity will be added as the patient continues to meet milestones and advancement criteria.[27] Studies have proven that neuromuscular training along with balance and proprioceptive conditioning will have a better outcome than strength training alone.[28] To minimize injury in both non-operative and post-operative management, incorporate closed-chain exercises starting at 4 weeks post-operatively and progress to open-chained exercises at approximately 12 weeks.[28]

SURGICAL TREATMENT

The decision on whether to conservatively manage or to undergo surgery depends upon the patient's age, the extent of the injury, and the functional goals of the individual.[29] Young and middle-aged adults, a high-grade Type 2 to Grade 3 tear, and a patient with at least a goal of moderate activity are the most ideal candidates for surgery.[29] Other factors that favor surgery include a history of instability or "giving out" episodes and associated meniscal or collateral ligament damage.[29] Surgical management in children and younger adolescents is more complex due to the potential of growth plate damage. However, delaying ACL reconstruction in a skeletally immature individual increases the risk of permanent intra-articular damage, and pediatric ACL reconstruction is recommended.[31] One study showed that even in isolated ACL injuries, the risk of meniscal damage and eventual tearing of the medial meniscus increases without surgical correction.[30] An adult type ACL reconstruction is indicated in females over 15 years old and males over 16.[31] The elderly are usually not good candidates due to decreased functional goals. Ultimately, the decision to undergo surgical intervention is a multi-factorial dilemma that must be decided on an individual basis.

REHABILITATION

Postoperative rehabilitation is a must with ACL injuries. A 2010 systematic review of evidence-based rehabilitation protocols was conducted to design an evidence-based accelerated rehabilitation return to play protocol over 6 months following ACL reconstructive surgery.[32] The most important factors involved in returning to sports activity included full range of motion and stability, no pain or swelling with sport-specific activity, and at least 85% hamstring and quadricep strength compared to the contralateral side.[32] Return to work varies upon the ambulatory requirements of each specific profession. This review also highlighted the importance of presurgical rehabilitation in addressing pain control and inflammation, improving range of motion and neuromuscular control, providing clear instruction to the patient regarding the content of a rehabilitation program, and creating a realistic view of the rehabilitation process. These measures have shown to stimulate earlier recovery and decreased expected postsurgical pain.Return to activity varies depending on the functional goals of the individual, and currently there is no consensus regarding criteria on when it is safe to return to activity.[33] The rates of re-injury to the reconstructed knee or of sustaining an ACL rupture on the contralateral knee range from 3 percent to 49 percent, and this is often attributed to premature clearance to return to normal activity.[34] Studies have shown that ligamentization of a free tendon graft into a functional ACL takes as long as 10-12 months.[35] Hartigan et al even showed deficient knee motion kinematics in downhill running and single leg hopping as well as biomechanical asymmetries over a year post-operatively.[36]

PREVENTION

Prevention of ACL injuries is critical not only due to the extensive cost and rehabilitation commitment, but also to avoid long term complications. Sequelae of ACL injuries most commonly involve chronic pain and osteoarthritis.[37] Neuromuscular training focused on increasing strength and stability of the knee joint, balance exercises, and plyometric-like conditioning is the most effective method in preventing ACL injury. Evidence demonstrates that many risk factors are modifiable with intervention programs and that athletic performance measures can even be enhanced. One study compared 600 semi-professional and amateur athletes split into two groups based on whether or not they received proprioceptive training using various balance boards. The proprioceptive training group trained daily for 20 minutes during the preseason and at least three times per week during the season. At the end of the season, the incidence of ACL injuries in the group who did not undergo balance training was 1.15 compared with 0.15 for the group that underwent the extra training.[38] Another comparative study of female soccer players showed that when undergoing balance board training throughout a season, the incidence of ACL injuries was lower than the group that did not use the balance board.[39] These results display the importance of proprioceptive and balance training in reducing the incidence of ACL injuries during athletic activity Warming up before any physical activity decreases risk of injury. One study followed 4564 soccer players aged 12-17 that were split into an interventional group and a control group. The interventional group participated in a neuromuscular warm-up program for 15 minutes throughout the entire season. Results showed half as many ACL injuries during the season for the interventional group than the control group.[40] In a separate study, 844 soccer players received sports specific education, stretching, strengthening, and plyometric training as a warm up program and were compared with 1913 other soccer players who participated in a traditional warm-up. They were monitored for two seasons and the results showed an 88% decrease in ACL injury the first year and a 74% reduction the second year in the group who received the specialized program compared to the group with a traditional warm up.[41]

It has long been proposed that core stability improves both preventative and rehabilitative efforts in ACL injuries. Decreased core stability allows for excessive and uncontrolled trunk movements, and this adversely affects knee positioning and loading and can lead to improper alignment.[42] Over time the body will develop inappropriate compensatory mechanisms leading to somatic dysfunction, ultimately leading to a strain or tear. 277 collegiate athletes were tested for trunk displacement after a sudden force release and then prospectively followed for three years. 25 of these athletes sustained knee injuries during this time period, and trunk displacement was greater in athletes with knee, ligament, and ACL injuries as opposed to uninjured athletes.[43]

Core hip strength is also essential in ACL injury prevention. The gluteus medius is responsible for abduction of the hip and helps stabilize the pelvis and lower extremity.[4] A deficiency in strength of the gluteus medius results in a valgus collapse and excessive rotational forces at the knee, resulting in an increased risk of ligamentous injury.[44] One study showed that myoelectric stimulation of the gluteus medius delivered immediately after foot strike significantly reduced knee valgus torque.[44] This result displays the importance of core hip strength in maintaining knee integrity. There has been recent literature that suggests biomechanical and proprioceptive deficits persist or may even be exacerbated after ACL reconstruction.[45] Some of these abnormalities linger up to 4 years after reconstruction. Focus has shifted to secondary prevention considering these deficits increase the rate of both reinjury and contralateral ACL injury. As most predictors of reinjury are modifiable with the exception of age and sex, there has been a push for late phase postoperative rehabilitation and symmetry training to ensure resolution of neuromuscular deficits.[45] Bracing is commonly used in both conservative treatment and post-operative management of an ACL injury. However, current studies have shown no proven benefit in making an ACL-deficient knee functional or in protecting a previously reconstructed ACL using bracing technology.[46] There has also been no supporting evidence that bracing improves pain, range of motion, or graft stability.[47] Further research is needed to investigate any therapeutic benefits that bracing offers.

CONCLUSION

ACL injuries are very common in the family practice setting. As the population becomes more active, these injuries will continue to be encountered by primary care physicians. A thorough understanding of the anatomy, presentation, evaluation, and management of these injuries will ensure a functional and healthy quality of life. Further research is needed to address the most effective methods in preventing and managing these injuries.

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REVIEW ARTICLE

Ultimate Fighting Championship Injuries; A Two-Year Retrospective Fight Injury Study

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KEYWORDS:

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Injuries
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Purpose: This epidemiologic study gives insight on management of fighters both in and out of the ring.

Methods: Data from 304 professional fighters in 152 fights were included.

Study Selection: The Fighters' Complaints, Physician Diagnosis, Imaging Results, and mechanism of win/loss were tabulated. Each fighter had a maximum of 4 injuries.

Data Extraction: All data was summated & either a Fishers Exact Test or Chi-Squared analysis was performed on individual injuries and fight outcome.

Results: 200 (66%) of the fighters were uninjured compared to 102(33%). The majority of injuries were soft tissue in nature. 43 x-rays, 7% found new fractures and 34 CTs confirmed 13 facial bone fractures and no subdural, epidural or intraparenchymal bleeds were observed. Three outcomes had a substantial increase in injury incidence; TO (armbar) 58.3% (7/12), TKO 52.9% (27/51), decisions 46.8% (37/79). Statistically significant injury rates were seen in TKO/KO compared to other outcomes; 1/3 of the total injuries occurred (9.27% of 33%, p= 0.004), 78% of total facial bone fracture (p=<0.001) & 83% of the total eye injuries (p<0.001). 34 (11.7%) competitors had CT Scans; 18 (52.9%) were negative, 13 (38.4%) identified facial bone fractures.

INTRODUCTION

Mixed Martial Arts (MMA) has recently seen an explosion in popularity worldwide. MMA is a full contact combat sport involving a variety of strikes, kicks and technical maneuvers including chokes and torsions in competitions. MMA encompasses boxing, wrestling and a variety of marital arts in competition. Open gloves, exposing the fingers and palms are used in competition in comparison to a closed glove used in boxing. Typical glove weight in MMA competition ranges from 4-6 ounces, whereas gloves worn in professional boxing typically weigh 10-12 ounces. It is conventional knowledge, albeit without statistical support, that the lighter the glove, the higher the velocity and impact of the strike. An array of minor and potentially serious injuries can occur in the ring during an MMA bout.

The Ultimate Fighting Championship (UFC), initially founded in 1993, has the lion share of both professional fighter pool and national/international fanfare. The UFC solidified their international power and fighter base with the acquisition of the World Extreme Cagefighting (WEC) in 2006, Pride in 2007, as well as Strikeforce in 2011 respectively[1]. Beginning in 2009, viewership of pay per view events surpassed the one million mark per televised event. Although the UFC typically does not release official numbers and statistics, it is public knowledge that they have experienced exponential growth in the last few years. Estimated earning of the UFC in 2008 exceeded $250 million, with a total estimated worth of $1 Billion[1].

As depicted above, the UFC's growth has drawn massive amounts of attention to the sport of MMA. Small and large MMA gyms have begun to open throughout the United States training interested participants the art of MMA. Due to the success of the UFC, both amateur and professional MMA events have become popular around the nation. MMA has created a new sporting venue that many medical personnel are unfamiliar with. Medical personnel's knowledge of the injuries incurred in the ring vary widely. Clearly, not only the UFC, but the sport that it has made mainstream, MMA, will have a huge impact in Sports Medicine today and in the future.

To date, only one MMA injury study has been published in the United States[3]. However, the following research is unique in the fact that only data obtained from UFC events was tabulated. UFC arguably is the highest level of MMA competition and is considered by most to have the most experienced fighters. At the time of authorship, no previous research has been published with specificity towards injury incurred in the UFC events.

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