Knee Injuries in American Football: An Epidemiological Review

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Abstract

Football has the highest injury rate amongst popular American sports. Of those injuries that end seasons or careers, the knee is the most common culprit. This is of particular concern because knee injuries are most common in football. This article reviews 4 of the most common knee injuries in American football, with emphasis on epidemiology, risk factors, and treatment outcomes. The injuries reviewed are tears of the anterior cruciate ligament, medial collateral ligament, medial patellofemoral ligament, and posterior cruciate ligament.

Football is one of the most popular sports in the United States. Every year more than 1 million high school males and over 60,000 collegiate males participate in organized football. The number of males who play football is greater than the combined number of males and females who participate in track and field or basketball.[1] Football has the highest injury rate amongst popular American sports.[2] From 2001 to 2005, there was an estimated 1.1 million emergency room visits as a direct result of football.[3] Injuries are more likely to occur during games,[1,2,4,5] more likely to require surgery,[4] and more likely to end the player's season or career when compared to other sports.[6] Of those injuries that end seasons or careers, the knee is the most common culprit.[6] This is of particular concern because knee injuries are most common in football.[1,2,5,7] This article reviews the epidemiology of 4 of the most common knee injuries in American football: tears of the anterior cruciate ligament (ACL), medial collateral ligament (MCL), medial patellofemoral ligament (MPFL), and posterior cruciate ligament (PCL).

Anterior Cruciate Ligament

The ACL is the primary structure preventing anterior tibial translation. It is composed of 2 anatomic bundles: the anteromedial and posterolateral bundles. The ACL originates from the posteromedial portion of the lateral femoral condyle and inserts between and slightly anterior to the tibial intercondylar eminence. The bundles are named for their relative insertions onto the tibia.

Injury to the ACL occurs both through noncontact and contact mechanisms. Typical noncontact mechanism is a forceful valgus collapse with the knee close to full extension with combined external or internal rotation of the tibia.[8] This is often the result of a sudden deceleration prior to a change in direction.[9] Contact injuries to the ACL are the result of a direct blow to the knee causing valgus collapse.[9] The majority of ACL injuries amongst all sports are a result of a noncontact mechanism. However, Dragoo and colleagues[10] found the majority of football ACL injuries (55%-60%) were from contact. As a result, football players are 4 times more likely to sustain ACL injuries than in other sports.[11]

ACL injuries are associated with significant time loss from sport. At the high school level, they are the most likely injury to end a season or career.[6] Because these are higher-energy injuries, they are frequently associated with damage to additional structures. ACL injuries that occur in football are associated with increased rates of meniscus, chondral, and multi-ligamentous injuries.[12,13]

The incidence of ACL injuries increases with level of competition. In high school athletes it is 11.1 per 100,000 athlete exposures (AE).[1,11] In collegiate football, the rate increases to 14.2 to 18 per 100,000 AE.[2,14] Though no incidence data per AE was found in our review of the literature, there

were 219 ACL injuries in the National Football League (NFL) from 2010 to 2013.[15] In addition, 14.2% of retired NFL athletes in one survey reported a history of ACL injury.[16]

The most common high-risk positions are running backs and linebackers. Brophy and colleagues[17] found that 9.7% of running backs and 8.9% of linebackers participating in the NFL Combine had a history of ACL injury. This may be because both the running back and linebacker are involved in frequent high-energy collisions and often quickly change direction. Other studies have also identified running backs and linebackers as high risk, in addition to tight ends, wide receivers, and interior linemen.[13,15,18]

Treatment of choice for elite level athletes with ACL injury is reconstruction.[19] Of those who undergo ACL reconstruction, the rate of return to play ranges from 63% to 80%.[20-22] The average time to return to play is 9 to 13 months. The odds of making a successful return hinges on how successful the athlete was prior to injury. Factors such as prior game experience, position on depth chart, being on scholarship, and draft position for NFL athletes have all been shown to have a positive predictive value on a patient's chance of returning from ACL reconstruction.[20,21]

Players who return have variable levels of success afterwards. In a study of NFL quarterbacks who sustained ACL injuries, 12 out of 13 were able to return to game action with no appreciable dropoff in performance based on in-game production.[23] Carey and colleagues[24] looked specifically at NFL wide receivers and running backs and found an 80% return to play rate but with an approximate decrease in production of one-third upon return. Furthermore, in the Multicenter Orthopaedic Outcomes Network (MOON) cohort study, only 43% of participants felt they returned to their preoperative level.[22]

Medial Collateral Ligament

The MCL consists of superficial and deep components. The superficial MCL is the primary restraint to valgus laxity at the knee. The superficial MCL has 1 femoral and 2 tibial attachments. The deep MCL is a thickening of the medial joint capsule and runs deep and parallel to the superficial MCL. The amount of medial joint gapping with a valgus force on examination is used to grade severity of MCL injuries. Grade I is a <5-mm opening; Grade II, 5- to 10-mm opening; and grade III, >10-mm opening.

The MCL is the most common knee injury in

high school, collegiate, and professional football.[1,18,25-28] Injuries are typically due to contact when a valgus force is applied to the knee.[29] The annual incidence of MCL injuries amongst high school football players is 24.2 per 100,000 AE.[1] The positions that appear to be at greatest risk for MCL injuries are offensive and defensive linemen.[18,30-32] In a review of 5047 collegiate athletes participating in the NFL Combine from 1987 to 2000, 23% of offensive linemen had a history of MCL injury, compared to the overall rate of 16%.[33] In a similar study, Bradley and colleagues[18] performed medical histories on athletes invited to the 2005 NFL Combine and also found offensive linemen had the highest rate of MCL injury at 33%, compared to the overall rate of 22%. They reasonably hypothesized that "chop blocks" and other players "rolling up" on the outside of linemen's knees were responsible for these injuries. Albright and colleagues[32] found that prophylactic knee braces decreased the incidence of MCL injuries in collegiate offensive lineman. However, additional studies have not been able to reproduce these results and the use of prophylactic knee braces remains controversial.[26]

Treatment of MCL injuries depends upon the grade of injury, associated injuries, and anatomical location of injury. Management of MCL injuries is for the most part nonsurgical. In 1974, Ellsasser and colleagues[34] were the first to publish data on nonoperative management of Grade I and Grade II injuries with immediate motion and rehabilitation instead of cast immobilization. They found 93% of patients returned to football in 3 to 8 weeks.[34] Derscheid and Garrick[27] observed nonoperative treatment of Grade I and II sprains in collegiate football players, with a time loss of 10.6 days and 19.5 days for Grade I and II injuries, respectively. Holden and colleagues[35] evaluated nonoperative management of Grade I and II MCL injuries in collegiate football players and found an average return to play of 21 days.

Grade III injury treatment is more controversial. Indelicato and colleagues[36] demonstrated successful nonoperative management of Grade III MCL injuries in collegiate football players, with an average return to play of 64.4 days. Jones and colleagues[37] had similar success with high school football players, with an average return to play of

34 days. However, isolated Grade III injuries are rare and therefore treatment is likely to be dictated by concomitant injuries. Fetto and Marshall[38] found that 78% of Grade III injuries were associated with an additional ligamentous injury. Of those additional injuries, 95% were ACL tears.

Finally, one must consider the location of the MCL injury. Injuries of the distal MCL at its tibial insertion may result in poor healing, as the ligament is displaced away from its insertion. Therefore, some authors recommend surgical management for these injuries.[39,40]

Medial Patellofemoral Ligament

The patellofemoral joint is a complex structure in which the patella is stabilized within the trochlear groove of the femur by both bony and soft tissue structures. The MPFL is one of the most important soft tissue stabilizers. The MPFL is the primary restraint to lateral patellar translation within the first 20° of knee flexion, contributing to 60% of the total restraining force.[41] The MPFL originates on the medial femoral condyle and inserts on the superomedial aspect of the patella.

Patellar instability is the subluxation or dislocation of the patella out of the trochlear groove. Patellar subluxation and dislocation account for approximately 3% of all knee injuries.[42] Patella dislocations are more common in younger populations[43-45] with the majority (52%-63%) occurring during sports.[43,44,46] Mitchell and colleagues[47] reported an incidence of 4.1 patellar subluxations/dislocations per 100,000 AE in high school football players.

Dislocation is most commonly the result of knee flexion with the tibia in a valgus position.[44,48] The majority of patellar dislocations occur via a noncontact mechanism.[44,48] However, the majority of these injuries in football are from contact (63%).[47]

Acute patellar dislocations are associated with more soft tissue damage than those with recurrent dislocations.[46] In acute patella dislocations, the MPFL is almost always ruptured.[44] In contrast, Fithian and colleagues[46] found only 38% of recurrent dislocators had MPFL injury. As a result, it is thought that those with recurrent instability dislocate without trauma and do not have the same characteristics as those who dislocate from high-energy trauma in sport. Risk factors for at-

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raumatic dislocation are numerous and have been well described in the literature.[49] However, traumatic dislocators usually do not have risk factors.[50]

Traumatic patella dislocations are higher energy and are associated with chondral injury in up to 95% of cases [51] and osteochondral injury 58% to 76% of the time.[52,53] In contrast, people with "articular hypermobility" are less likely to sustain articular damage.[54] This concept is important when considering risk for recurrent patella dislocation. The literature reports a 17% to 50% rate of recurrent instability after acute patella dislocation.[46,55,56] However, most studies do not distinguish between traumatic and atraumatic injuries. Because the majority of patellar dislocations in football occur through contact mechanisms, the rate of recurrent instability in these athletes may in fact be less than what is reported in the literature.

First-time patella dislocations are generally treated nonoperatively. Mitchell and colleagues[47] reported that 72.6% of high school athletes with patella subluxation treated conservatively were able to return to sports within 3 weeks, compared to only 34.1% of those with patellar dislocations. In the same study, patellar dislocations were season-ending 37% of the time.[47] Atkin and colleagues[50] followed 74 patients treated conservatively for first-time patellar dislocation and noted 58% at 6 months still had difficulty in squatting, jumping, or cutting.

Those who have failed conservative management and have an additional dislocation are 7 times more likely to redislocate.[46] Therefore, they are usually treated operatively with MPFL reconstruction. Return to sport ranges from 3 to 6 months,[57] with 53% to 77.3% reporting return to their previous functionality.[57-59] Overall, 84.1% of patients are able to return to sport with 1.2% risk of recurrent dislocation.[60]

Posterior Cruciate Ligament

The PCL is the primary posterior stabilizer of the knee.[61,62] It consists of the anterolateral and posteromedial bundles, named by their insertion on the posterior tibial plateau. The larger, stronger anterolateral bundle is the primary restraint to posterior tibial translation.[63]

Due to the relative infrequency of PCL injuries, there is a paucity of epidemiological data on sports-related PCL injuries. These injuries in the literature are commonly found due to traffic accidents (45%-57%) or from sports (33%-40%).[64,65] According to Swensen and colleagues,[1] PCL inju-

ries account for 2.4% of all high school sport knee injuries. In a cohort of 62 knees with PCL injuries, Patel and colleagues[66] found football was the most common cause of injury (19.3%).

The most common mechanism of injury in athletes is knee hyperflexion or a direct blow to the tibia in a flexed knee.[67] In football, contact mechanisms are the most common. In a 16-year review of the National Collegiate Athletic Association (NCAA) injury surveillance system, the incidence of contact PCL injuries during games were 7.3 times higher than noncontact.[68] The most common activity was being tackled, which accounted for 22.9% of all PCL injuries.[68]

Due to the high energy of these injuries, isolated PCL injuries are rare. In one trauma center's experience, 96.5% of PCL injuries had an additional ligament injury.[64] In that study, injuries to the PCL were associated with posterolateral corner, ACL, and MCL injuries 62%, 46%, and 31% of the time, respectively.[64,69]

Because isolated PCL injuries are rare, clinicians must rely on a thorough history and physical examination when evaluating athletes with knee injuries. Classification of PCL injuries is based on the amount of posterior tibial translation in relation to the femur with the knee bent to 90°. Grade I is 1 to 5 mm; Grade II, 6 to 10 mm; and Grade III, >10 mm. If there is suspicion of a PCL injury, there should be a very low threshold for magnetic resonance imaging, given the high association with additional injuries.

Natural history of Grade I and II isolated PCL injuries is generally favorable compared to Grade III and multi-ligamentous injuries.[70] As a result, isolated Grade I and II PCL injuries are generally treated nonoperatively. Treatment consists of physical therapy with emphasis on quadriceps strengthening. Return to play can be considered as early as 2 to 4 weeks from injury.[71] Recent long-term data have shown successful conservative management of Grade I and II injuries with quadriceps strength to 97% of contralateral leg and full range of motion.[72] However, there was 11% moderate to severe osteoarthritis in these patients at a mean follow-up of 14.3 years.[72] Fowler and Messieh[67] managed athletes with 7 isolated complete PCL tears and 5 partial tears nonoperatively, all of whom were able to return to sport without limitation. Parolie and Bergfeld[73] managed 25 athletes with isolated PCL tears conservatively. In this study, 80% of athletes reported satisfaction and 68% returned to previous level of play.[73] Neither of the aforementioned stud-

ies specify the grades of the injuries. Finally, Patel and colleagues[66] managed 6 NFL athletes with Grade I and II injuries nonoperatively, and all were able to return to sport.

Treatment of isolated Grade III PCL injuries is more controversial, and no consensus exists in the literature. In an epidemiological study, Dick and colleagues[68] found that only 39% of NCAA football athletes underwent surgery for their torn PCLs, compared to 79% of ACL injuries. However, their study makes no mention to the severity of these injuries. Numerous options exist for PCL reconstruction, with no consensus on the preferred method.

Conclusion

Knee injuries are the most common injury in football. Knowledge of the natural history of these injuries, as well as treatment options and expected outcomes, will help treating physicians educate their patients on the optimal treatment and manage return to play expectations.

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References

1. Swenson DM, Collins CL, Best TM, Flanigan DC, Fields SK, Comstock RD. Epidemiology of knee injuries among U.S. high school athletes, 2005/2006-2010/2011. *Med Sci Sports Exerc.* 2013;45(3):462-469.
2. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train.* 2007;42(2):311-319.
3. Mello MJ, Myers R, Christian JB, Palmisciano L, Linakis JG. Injuries in youth football: national emergency department visits during 2001-2005 for young and adolescent players. *Acad Emerg Med.* 2009;16(3):243-248.
4. Rechel JA, Collins CL, Comstock RD. Epidemiology of injuries requiring surgery among high school athletes in the United States, 2005 to 2010. *J Trauma.* 2011;71(4):982-989.
5. Ingram JG, Fields SK, Yard EE, Comstock RD. Epidemiology of knee injuries among boys and girls in US high school athletics. *Am J Sports Med.* 2008;36(6):1116-1122.
6. Tirabassi J, Brou L, Khodaee M, Lefort R, Fields SK, Comstock RD. Epidemiology of high school sports-related injuries resulting in medical disqualification: 2005-2006 through 2013-2014 academic years. *Am J Sports Med.* 2016 May 10. [Epub ahead of print]

7. Fernandez WG, Yard EE, Comstock RD. Epidemiology of lower extremity injuries among U.S. high school athletes. *Acad Emerg Med.* 2007;14(7):641-645.

8. Olsen OE, Myklebust G, Engebretsen L, Bahr R. Injury mechanisms for anterior cruciate ligament injuries in team handball: a systematic video analysis. *Am J Sports Med.* 2004;32(4):1002-1012.

9. Boden BP, Dean GS, Feagin JA Jr, Garrett WE Jr. Mechanisms of anterior cruciate ligament injury. *Orthopedics.* 2000;23(6):573-578.

10. Dragoo JL, Braun HJ, Harris AH. The effect of playing surface on the incidence of ACL injuries in National Collegiate Athletic Association American Football. *Knee.* 2013;20(3):191-195.

11. Joseph AM, Collins CL, Henke NM, Yard EE, Fields SK, Comstock RD. A multisport epidemiologic comparison of anterior cruciate ligament injuries in high school athletics. *J Athl Train.* 2013;48(6):810-817.

12. Granan LP, Inacio MC, Maletis GB, Funahashi TT, Engebretsen L. Sport-specific injury pattern recorded during anterior cruciate ligament reconstruction. *Am J Sports Med.* 2013;41(12):2814-2818.

13. Bradley JP, Klimkiewicz JJ, Rytel MJ, Powell JW. Anterior cruciate ligament injuries in the National Football League: epidemiology and current treatment trends among team physicians. *Arthroscopy.* 2002;18(5):502-509.

14. Dragoo JL, Braun HJ, Durham JL, Chen MR, Harris AH. Incidence and risk factors for injuries to the anterior cruciate ligament in National Collegiate Athletic Association football: data from the 2004-2005 through 2008-2009 National Collegiate Athletic Association Injury Surveillance System. *Am J Sports Med.* 2012;40(5):990-995.

15. Dodson CC, Secrist ES, Bhat SB, Woods DP, Deluca PF. Anterior cruciate ligamenti in National Football League athletes from 2010 to 2013: a descriptive epidemiology study. *Orthop J Sports Med.* 2016;4(3):2325967116631949.

16. Golightly YM, Marshall SW, Callahan LF, Guskiewicz K. Early-onset arthritis in retired National Football League players. *J Phys Act Health.* 2009;6(5):638-643.

17. Brophy RH, Lyman S, Chehab EL, Barnes RP, Rodeo SA, Warren RF. Predictive value of prior injury on career in professional American football is affected by player position. *Am J Sports Med.* 2009;37(4):768-775.

18. Bradley J, Honkamp NJ, Jost P, West R, Norwig J, Kaplan LD. Incidence and variance of knee injuries in elite college football players. *Am J Orthop.* 2008;37(6):310-314.

19. Erickson BJ, Harris JD, Fillingham YA, et al. Anterior cruciate ligament reconstruction practice patterns by NFL and NCAA football team physicians. *Arthroscopy.* 2014;30(6):731-738.

20. Daruawalla JH, Greis PE, Hancock R; ASP Collaborative Group, Xerogeanes JW. Rates and determinants of return to play after anterior cruciate ligament reconstruction in NCAA Division 1 college football athletes: a study of the ACC, SEC, and PAC-12 conferences. *Orthop J Sports Med.* 2014;2(8):2325967114543901.

21. Shah VM, Andrews JR, Fleisig GS, McMichael CS, Lemak LJ. Return to play after anterior cruciate ligament reconstruction in National Football League athletes. *Am J Sports Med.* 2010;38(11):2233-2239.

22. McCullough KA, Phelps KD, Spindler KP, et al. Return to high school- and college-level football after anterior cruciate ligament reconstruction: a Multicenter Orthopaedic Outcomes Network (MOON) cohort study. *Am J Sports Med.* 2012;40(11):2523-2529.

23. Erickson BJ, Harris JD, Heninger JR, et al. Performance and return-to-sport after ACL reconstruction in NFL quarterbacks. *Orthopedics.* 2014;37(8):e728-e734.

24. Carey JL, Huffman GR, Parekh SG, Sennett BJ. Outcomes of anterior cruciate ligament injuries to running backs and wide receivers in the National Football League. *Am J Sports Med.* 2006;34(12):1911-1917.

25. Hershman EB, Anderson R, Bergfeld JA, et al. An analysis of specific lower extremity injury rates on grass and FieldTurf playing surfaces in National Football League Games: 2000-2009 seasons. *Am J Sports Med.* 2012;40(10):2200-2205.

26. Salata MJ, Gibbs AE, Sekiya JK. The effectiveness of prophylactic knee bracing in American football: a systematic review. *Sports Health.* 2010;2(5):375-379.

27. Derscheid GL, Garrick JG. Medial collateral ligament injuries in football. Nonoperative management of grade I and grade II sprains. *Am J Sports Med.* 1981;9(6):365-368.

28. Meyers MC, Barnhill BS. Incidence, causes, and severity of high school football injuries on FieldTurf versus natural grass: a 5-year prospective study. *Am J Sports Med.* 2004;32(7):1626-1638.

29. Lundblad M, Waldén M, Magnusson H, Karlsson J, Ekstrand J. The UEFA injury study: 11-year data concerning 346 MCL injuries and time to return to play. *Br J Sports Med.* 2013;47(12):759-762.

30. Hewson GF Jr, Mendini RA, Wang JB. Prophylactic knee bracing in college football. *Am J Sports Med.* 1986;14(4):262-266.

31. Rovere GD, Haupt HA, Yates CS. Prophylactic knee bracing in college football. *Am J Sports Med.* 1987;15(2):111-116.

32. Albright JP, Powell JW, Smith W, et al. Medial collateral ligament knee sprains in college football. Brace wear preferences and injury risk. *Am J Sports Med.* 1994;22(1):2-11.

33. Brophy RH, Barnes R, Rodeo SA, Warren RF. Prevalence of musculoskeletal disorders at the NFL Combine–trends from 1987 to 2000. *Med Sci Sports Exerc.* 2007;39(1):22-27.

34. Ellsasser JC, Reynolds FC, Omohundro JR. The non-operative treatment of collateral ligament injuries of the knee in professional football players. An analysis of seventy-four injuries treated non-operatively and twenty-four injuries treated surgically. *J Bone Joint Surg Am.* 1974;56(6):1185-1190.

35. Holden DL, Eggert AW, Butler JE. The nonoperative treatment of grade I and II medial collateral ligament injuries to the knee. *Am J Sports Med.* 1983;11(5):340-344.

36. Indelicato PA, Hermansdorfer J, Huegel M. Nonoperative management of complete tears of the medial collateral ligament of the knee in intercollegiate football players. *Clin Orthop Relat Res.* 1990;(256):174-177.

37. Jones RE, Henley MB, Francis P. Nonoperative management of isolated grade III collateral ligament injury in high school football players. *Clin Orthop Relat Res.* 1986;(213):137-140.

38. Fetto JF, Marshall JL. Medial collateral ligament injuries of the knee: a rationale for treatment. *Clin Orthop Relat Res.* 1978;(132):206-218.

39. Corten K, Hoser C, Fink C, Bellemans J. Case reports: a Stener-like lesion of the medial collateral ligament of the knee. *Clin Orthop Relat Res.* 2010;468(1):289-293.

40. Marchant MH Jr, Tibor LM, Sekiya JK, Hardaker WT Jr, Garrett WE Jr, Taylor DC. Management of medial-sided knee injuries, part 1: medial collateral ligament. *Am J Sports Med.* 2011;39(5):1102-1113.

41. Desio SM, Burks RT, Bachus KN. Soft tissue restraints to lateral patellar translation in the human knee. *Am J Sports Med.* 1998;26(1):59-65.

42. Casteleyn PP, Handelberg F. Arthroscopy in the diagnosis of occult dislocation of the patella. *Acta Orthop Belg.* 1989;55(3):381-383.

43. Waterman BR, Belmont PJ Jr, Owens BD. Patellar dislocation in the United States: role of sex, age, race, and athletic participation. *J Knee Surg.* 2012;25(1):51-57.

44. Sillanpää P, Mattila VM, Iivonen T, Visuri T, Pihlajamäki H. Incidence and risk factors of acute traumatic primary patellar dislocation. *Med Sci Sports Exerc.* 2008;40(4):606-611.

45. Hsiao M, Owens BD, Burks R, Sturdivant RX, Cameron KL. Incidence of acute traumatic patellar dislocation among active-duty United States military service members. *Am J Sports Med.* 2010;38(10):1997-2004.

46. Fithian DC, Paxton EW, Stone ML, et al. Epidemiology and natural history of acute patellar dislocation. *Am J Sports Med.* 2004;32(5):1114-1121.

47. Mitchell J, Magnussen RA, Collins CL, et al. Epidemiology of patellofemoral instability injuries among high school athletes in the United States. *Am J Sports Med.* 2015;43(7):1676-1682.

48. Nikku R, Nietosvaara Y, Aalto K, Kallio PE. The mechanism of primary patellar dislocation: trauma history of 126 patients. *Acta Orthop.* 2009;80(4):432-434.

49. Tsai CH, Hsu CJ, Hung CH, Hsu HC. Primary traumatic patellar dislocation. *J Orthop Surg Res.* 2012;7:21.

50. Atkin DM, Fithian DC, Marangi KS, Stone ML, Dobson BE, Mendelsohn C. Characteristics of patients with primary acute lateral patellar dislocation and their recovery within the first 6 months of injury. *Am J Sports Med.* 2000;28(4):472-479.

51. Nomura E, Inoue M, Kurimura M. Chondral and osteochondral injuries associated with acute patellar dislocation. *Arthroscopy.* 2003;19(7):717-721.

52. Kirsch MD, Fitzgerald SW, Friedman H, Rogers LF. Transient lateral patellar dislocation: diagnosis with MR imaging. *AJR Am J Roentgenol.* 1993;161(1):109-113.

53. Virolainen H, Visuri T, Kuusela T. Acute dislocation of the patella: MR findings. *Radiology.* 1993;189(1):243-246.

54. Stanitski CL. Articular hypermobility and chondral injury in patients with acute patellar dislocation. *Am J Sports Med.* 1995;23(2):146-150.

55. Mäenpää H, Huhtala H, Lehto MU. Recurrence after patellar dislocation. Redislocation in 37/75 patients followed for 6-24 years. *Acta Orthop Scand.* 1997;68(5):424-426.

56. Buchner M, Baudendistel B, Sabo D, Schmitt H. Acute traumatic primary patellar dislocation: long-term results comparing conservative and surgical treatment. *Clin J Sport Med.* 2005;15(2):62-66.

57. Fisher B, Nyland J, Brand E, Curtin B. Medial patellofemoral ligament reconstruction for recurrent patellar dislocation: a systematic review including rehabilitation and return-to-sports efficacy. *Arthroscopy.* 2010;26(10):1384-1394.

58. Lippacher S, Dreyhaupt J, Williams SR, Reichel H, Nelitz M. Reconstruction of the medial patellofemoral ligament: clinical outcomes and return to sports. *Am J Sports Med.* 2014;42(7):1661-1668.

59. Panni AS, Alam M, Cerciello S, Vasso M, Maffulli N. Medial patellofemoral ligament reconstruction with a divergent patellar transverse 2-tunnel technique. *Am J Sports Med.* 2011;39(12):2647-1655.

60. Schneider DK, Grawe B, Magnussen RA, et al. Outcomes after isolated medial patellofemoral ligament reconstruction for the treatment of recurrent lateral patellar dislocations: a systematic review and meta-analysis. *Am J Sports Med.* 2016 Feb 12. [Epub ahead of print]

61. Amis AA, Bull AM, Gupte CM, Hijazi I, Race A, Robinson JR. Biomechanics of the PCL and related structures: posterolateral, posteromedial and meniscofemoral ligaments. *Knee Surg Sports Traumatol Arthrosc.* 2003;11(5):271-281.

62. Fu FH, Harner CD, Johnson DL, Miller MD, Woo SL. Biomechanics of knee ligaments: basic concepts and clinical application. *Instr Course Lect.* 1994;43:137-148.

63. Markolf KL, Feeley BT, Tejwani SG, Martin DE, McAllister DR. Changes in knee laxity and ligament force after sectioning the posteromedial bundle of the posterior cruciate ligament. *Arthroscopy.* 2006; 22(10):1100-1106.

64. Ganelli GC, Edson CJ. Posterior cruciate ligament injuries in trauma patients: Part II. *Arthroscopy.* 1995;11(5):526-529.

65. Schulz MS, Russe K, Weiler A, Eichhorn HJ, Strobel MJ. Epidemiology of posterior cruciate ligament injuries. *Arch Orthop Trauma Surg.* 2003;123(4):186-191.

66. Patel DV, Allen AA, Warren RF, Wickiewicz TL, Simonian PT. The nonoperative treatment of acute, isolated (partial or complete) posterior cruciate ligament-deficient knees: an intermediate-term follow-up study. *HSS J.* 2007;3(2):137-146.

67. Fowler PJ, Messieh SS. Isolated posterior cruciate ligament injuries in athletes. *Am J Sports Med.* 1987;15(6):553-557.

68. Dick R, Ferrara MS, Agel J, et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):221-233.

69. LaPrade CM, Civitarese DM, Rasmussen MT, LaPrade RF. Emerging updates on the posterior cruciate ligament: a review of the current literature. *Am J Sports Med.* 2015;43(12):3077-3092.

70. Torg JS, Barton TM, Pavlov H, Stine R. Natural history of the posterior cruciate ligament-deficient knee. *Clin Orthop Relat Res.* 1989(246):208-216.

71. Miller MD. *Orthopaedic Knowledge Update: Sports Medicine 5.* Rosemont, IL; American Academy of Orthopaedic Surgeons; 2016.

72. Shelbourne KD, Clark M, Gray T. Minimum 10-year follow-up of patients after an acute, isolated posterior cruciate ligament injury treated nonoperatively. *Am J Sports Med.* 2013;41(7):1526-1533.

73. Parolie JM, Bergfeld JA. Long-term results of nonoperative treatment of isolated posterior cruciate ligament injuries in the athlete. *Am J Sports Med.* 1986;14(1):35-38.

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