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Meniscal Tears in Concomitant ACL Injuries: A Review of Meniscal Repair as a Treatment Option

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Abstract: The anterior cruciate ligament (ACL) is a common injury in sports such as football, soccer, and wrestling, and often results in concurrent injury to the meniscus, a thin cartilaginous tissue in the knee. As such, there has been increasing emphasis on meniscal repair as the significance of its roles in load transmission, shock absorption, stability, and lubrication of the articular surface is recognized. The most common methods of preserving meniscus function include leaving stable or partial tears in situ for self-healing, partial meniscectomy, or meniscal repair. While a 2004 study suggested that stable meniscal tears could be left in situ to self-heal following ACL reconstruction (ACLR) operations, studies conducted after 2,000 point to a rising prevalence for performing meniscal repair concurrently with ACLR. These studies suggest that minimally traumatized tears, longitudinal tears, lesions occurring in the vascularized portions of the meniscus, and meniscus root tears or ramp lesions are all cases where meniscal repair is typically preferred. Advancements made in arthroscopic surgery and increasing understanding of meniscal function are making meniscal repair an appealing treatment option. However, whether meniscal repair is the most optimal treatment option for every patient is still unclear, and the studies claiming meniscal repair to be preferable all have their limitations. A 2006-2018 trend analysis study suggested that meniscal repair is becoming a more popular option, but its observation period was only 180 days, which may have failed to capture injuries that would occur early after return to sport. Therefore, further research and clinical data are needed to help determine the best course of action for ACL injuries with concomitant meniscus tears.

Keywords: Sports Medicine, Orthopedics, Anterior Cruciate Ligament, ACL, Meniscus, Meniscus Repair, ACL Reconstruction, ACLR, Arthroscopic Surgery

Introduction:

Anterior cruciate ligament (ACL) ruptures are common in the United States amongst athletes, particularly for those that play at the club and intercollegiate levels. Sports that involve physical contact such as football, soccer, and wrestling, as well as those that involve sudden deceleration or change in directions such as volleyball or skiing, are especially at high risk for ACL ruptures.

However, as common as ACL injuries are, over half of the individuals presenting with an ACL rupture demonstrate concurrent injury in thin fibrous cartilaginous tissue in the knee joint called the meniscus. Likewise, as many as 65% of ACL injuries are presented with concomitant meniscus tears: the estimated statistic is that between 100,000 and 200,000 ACL ruptures occur yearly in the US, and there are as many as 130,000 corresponding meniscus tears. As such, in the US, approximately 500,000 procedures on medial and lateral menisci are performed annually, "making abnormalities of the meniscus the most commonly treated knee disorder (Westermann,
2184)."

Correspondingly, there has been increased attention and emphasis on meniscal repair particularly over the last three decades, as the significance of meniscus' roles in load transmission, shock absorption, stability, and lubrication of the articular surface, is increasingly recognized. Moreover, the meniscus has been proven to be essential in preventing osteoarthritis, a degenerative joint condition that involves the wearing down of cartilage at either end of both femur and tibia. Indeed, the meniscus is a crucial anatomical structure of our knees, and therefore, it is in the best interest of the patients that sustain injuries in their meniscus to preserve it and restore its functions. Common meniscal preservation tactics include: leaving stable or partial tears in situ for self-healing, performing partial meniscectomy, or meniscal repair.

This paper aims to not only survey the degree of prevalence of meniscal tears that occur concomitantly to ACL injuries, but most importantly, investigate, out of the aforementioned preservation methods, what the most optimal treatment option for addressing meniscal tears is.

I. Meniscal Injury Associated with ACL Tears among Athletes

1. Epidemiology of Meniscal Injury Associated with Anterior Cruciate Ligament Tears in Young Athletes[2]

Due to the prevalence of meniscus tears that occur concurrently with ACL ruptures among athletes, there are a number of studies that discuss this particular condition. This study was done on 10 consecutive graduating classes of 10,419 cadets at the US Military Academy from 1994 to 2003, to determine the epidemiology of meniscal tears that occur following ACL injuries in the young, athletic population. The

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subjects were all patients who sustained ACL injuries at the academy during the study period, and their demographic information, time to surgery, sex, sport played, mechanism of injury, and activity level were all recorded. Although all patients underwent MRI scans, the diagnosis of the meniscal tear itself was made arthroscopically. And every patient that sustained concomitant meniscal tears from ACL injuries underwent meniscal repair, as "every effort was made to perform repairs whenever possible…[due to] the success of meniscal repair when performed in conjunction with ACLR (Anterior Cruciate Ligament Reconstruction) in young patients (209)."

A total of 341 cadets had ACL injuries, for a total of 353 injuries. With the exception of just one injury case that was treated nonoperatively, 136 knees underwent acute ACLR (defined as surgical treatment <30 days after injury), and 216 received delayed ACLR. In the acute group, 52% of the knees were found to have sustained meniscal tears, and in the delayed group, 41% were meniscal tears. The study reported that they did not find a statistically significant difference between the two groups in either the treatment or the incidence rate.

One of the most significant findings of this particular study was its analysis of meniscal injury incident rate per sports type and gender. The study found that meniscal injuries occurring concomitantly to ACL injuries are most commonly observed in athletes participating in sports at the club and intercollegiate level; fewer meniscal injuries were sustained for athletes playing an intramural level. In addition, wrestling and volleyball had the highest incidence rate of concomitant meniscal tears at 77% and 125%, respectively. Football and soccer came in next but did not differ to a significant extent from other sports. Moreover, the study established a trend based on its findings that men have a higher probability of sustaining meniscal injuries than women. However, the study provided a disclaimer that this finding may be limited in its generalizability, due to their subjects being predominantly male.

2. Meniscal Injuries Associated With Acute Anterior Cruciate Ligament Tears in Alpine Skiers[3]
Meniscal tear occurring concomitantly to ACL rupture is an injury that bears significant relevance to athletes. Even aside from all types of sports mentioned above, there is even a dedicated study published that focuses specifically on meniscal tears among alpine skiers. This paper investigates ACL injuries that occurred in 315 alpine skiers between the years 1989 to 1991. The study found that 32% of the injured skiers had isolated ACL injuries, whereas the remaining 68% suffered concomitant injuries either in their medial or lateral meniscus. This goes to show the prevalence of meniscal tears occurring concomitantly to ACL injuries. Moreover, the study reveals that meniscal injuries most commonly occur during sports that require motions of sudden decelerations or changes in direction.

II. Trend toward Combined ACLR and Meniscal Repair

1. Healing Potential of Meniscal Tears without Repair in Knees with Anterior Cruciate Ligament Reconstruction[4]
Due to the now-widely recognized importance of the meniscus and its preservation methods, many studies have proposed diverse, and oftentimes conflicting, insights on what the best treatment option for meniscal injury would be. Early on, when the interest in treating meniscal injuries was beginning to take off, there were debates on whether or not repair on meniscus should be done at all alongside performing ACLR. This study, published in 2004, was a prospective cohort study conducted on ACLR operations performed at the Tokyo Medical and Dental University Hospital from 1992 to 1997. The study aimed at evaluating the healing potential of meniscal tears left without repair. Therefore, torn menisci were left without repair as much as possible at the time of ACLR. Tears that measured less than 15mm in length sufficed as tears that could be left in situ without repair. A total of 192 patients were included as subjects, and the average age of the patients at the time of reconstruction was 25.4 years. All ACLR procedures were performed arthroscopically using either a semitendinosus tendon graft or a bone-patellar tendon-bone graft. Evaluations on meniscal status were made independently at the time of ACLR, and the tears were recorded in terms of location, depth, and type. The study discovered that nearly three-fourths of the torn menisci at the time of reconstruction were healed without undergoing repair. The healing rates, however, differed by injured locations within the menisci: lateral meniscus tended to heal more readily without repair, whereas medial and radial menisci displayed lower healing potentials.

The conclusion reached by this particular study was that stable (defined as tear length <15mm) meniscal tears at the time of ACL reconstruction possibly could benefit from being left in situ, given the comparably high healing rate of approximately 75% that was discovered in the study, as well as the potential risks of damaging articular cartilage and nerve in a meniscal repair procedure. The study, however, acknowledged that deep and thick tears or tears that occurred in the radial or medial region may require meniscal repair operation.

2. A Matched-cohort Population Study of Reoperation after Meniscal Repair with and without Concomitant Anterior Cruciate Ligament Reconstruction[5]
The authors of this study began with an initial assumption that the success rate of meniscal repair

alone in a stable knee would be equal to that of meniscal repair performed in conjunction with ACLR. The study utilized data obtained from health records reported in Ontario, Canada between 2003 and 2008 in patients aged 15 to 60 years. There were 1332 patients who had received meniscal repair combined with ACLR, and 1239(93%) of those patients were matched for sex, age, and calendar year of surgery, for comparison with patients who had received meniscal repair alone. The success rates of the procedures were measured by reoperation rate and the time it took for each patient until reoperation was needed.

The findings of the study showed that the rate of meniscal reoperation was significantly lower in the cohort that underwent the combined meniscal repair and ACLR (9.7%) than in the cohort that underwent meniscal repair alone. Moreover, the time to reoperation was significantly shorter in the case of the cohort that received meniscal repair alone. All in all, the study concluded that after accounting variables such as age, sex, and provider case volume, "meniscal repair has a significantly lower rate of reoperation when performed with ACLR than without (350)."

The study then goes on to list a few potential explanations for why the difference in reoperation rate is observed. One possibility that the study mentions is that menisci may be healing better due to the biological healing influence brought into the knee by drilling bony tunnels, which is typically done whilst performing ACLR. Another potential explanation that the study cites is that, while physicians assume patients receiving solely the meniscal repair would have stable knees, some knees may have been naturally ACL deficient, to begin with. This unaccounted variable may have contributed to the instability of these patients' knees compared to those of patients that received combined ACLR and meniscal repair.

In conclusion, this particular study provided a unique insight that ACLR is both "statistically and clinically significantly protective against reoperations after meniscal repair," with an "absolute risk reduction of 7% (351)."

3. Factors Associated With Meniscus Repair in Patients Undergoing Anterior Cruciate Ligament Reconstruction[6]

As studies that claimed the effectiveness of performing meniscal repairs with ACLR began to emerge, research on the determining factors of performing meniscal repairs concurrently with ACLR was also conducted. This cross-sectional study was carried out, using data from the Kaiser-Permanente Anterior Cruciate Ligament Reconstruction Registry (KP ACLRR), to identify factors leading to a higher likelihood of performing meniscus repairs. The study included a total of 9195 patients, all of whom were undergoing primary ACLR procedures.

The main factors evaluated in the study were patient characteristics, which include race, sex, age, BMI), injury pattern, surgeon case volumes, and hospital case volumes. And the findings from an evaluation of all factors were that younger patient age, lower patient BMI, surgeon's sports medicine fellowship training, higher surgeon case volume, and higher hospital case volume were all factors that contribute to a higher likelihood of a patient undergoing a meniscus repair. As a result, out of the total of 9195 patients who were undergoing ACLR, 5712 (62.1%) underwent concomitant meniscus repair, which is within the range of 55%~65% as reported in other studies.

4. Treatment Trends in Meniscal Pathology in the Setting of Concomitant ACL Injuries in Pediatric and Young Adult Patients. An Insurance Database Study[7]

Based on the findings above, there was also an investigation on to how commonly meniscal repair procedure was being utilized in the field of orthopedic surgery. This insurance database study was conducted on privately insured individuals of ages 5 to 30 who received arthroscopic ACLR between 2006 and 2018. For the study's purpose of assessing the correlation between age group and rates of receiving meniscal repair, it classified patients 5 to 17 years of age as the pediatric/adolescent group and patients 18 to 30 years as the young adults group. The study aimed to "define trends in meniscal repair versus meniscectomy in the setting of ACLR among pediatric and adolescent patients, and compare these trends with young adults. (2)" In doing so, it also examined differences in short-term complications that resulted in reoperation between the two procedures so as to track the prognosis of patients undergoing either treatment.

The study found a strong positive correlation between the proportion of meniscal repair conducted alongside ACLR and the year in which the procedures were performed for the pediatric/adolescent group. Likewise, the proportion of concomitant meniscal repairs steadily increased over the study period, with a corresponding decrease in the proportion of concomitant meniscectomies. The study also found that there were no significant differences in rates of reoperation for those undergoing ACLR with meniscal repair versus ACLR with meniscectomy. Though the magnitude of the correlation between the proportion of meniscal repair conducted alongside ACLR and the year in which the procedures were performed was smaller for the young adult group, the study concluded that there is a trend toward meniscal repair—rather than meniscectomy—across all age groups. Furthermore, it attributed such a phenomenon to "multiple advancements in the field of orthopedics: appreciation of the adverse effect of meniscectomy,

improvement in all-inside meniscal repair technique (a type of suture technique), and an increase in procedures performed by fellowship-trained specialists. (5)"

While the study acknowledged the potential shortcoming of conducting meniscal repair at the time of ACLR, in that it could lead to increased chances of sustaining arthrofibrosis, it maintained that meniscal repair is still typically preferred over meniscectomy, given the "increased prevalence of progressive osteoarthritis after meniscectomy," hence leading to the trend demonstrated in its findings (1).

III. Outcomes of Meniscal Repairs done concurrently to ACLR

1. Meniscal Repair With Concurrent Anterior Cruciate Ligament Reconstruction Operative Success and Patient Outcomes at 6-Year Follow-up[1]

Ultimately, follow-up studies that examine the long-term outcomes of combined ACLR and meniscal repair were published. This study was a prospective longitudinal study performed by The Multicenter Orthopedic Outcomes Network (MOON) at 7 centers (University of Iowa, Washington University in St Louis, Vanderbilt University, Cleveland Clinic, The Ohio State University, University of Colorado, and Hospital for Special Surgery). The subjects of the study were 1440 patients (median age 21) who had undergone unilateral primary ACLRs between 2002 and 2004. Of the 1440 patients, 955(66.3%) sustained meniscal tears. And out of those 995 with concurrent meniscal tears, 286 (29.9%) were treated with repair, 496 (51.9%) were treated with meniscectomy, 164 (17.2%) underwent no treatment (left in-situ to self-heal), 7 (0.7%) were treated with abrasion and trephination, and 2 (0.2%) were treated with meniscal transplant. Moreover, of the 286 patients who underwent concurrent meniscal repair, 235(82.2%) were available for follow-up at 6 years post-op. At 6 years mark, there were 51 patients that underwent subsequent arthroscopic knee procedures available for review. And of those 51 cases, there were 33 patients that needed their originally repaired meniscus re-treated (these were considered failed cases). This led to the failure rate of meniscus repair (done in conjunction to ACLR) to be 14% (33/235) at 6 years. As such, the study concluded that the operative success rate for meniscus repair done concurrently to ACLR was greater than 85%.

2. Meniscal Repair in anterior cruciate ligament reconstruction: a long-term outcome study[8]

Another study was done to investigate the sustainability of outcomes of combined ACLR and meniscal repair in longer-term than the MOON cohort study, this time using the International Knee Documentation Committee (IKDC) scoring system as the evaluation index. 44 patients, with an average age of 28 at the time of their combined ACLR and meniscal repair, were identified for analysis with a median follow-up of 10 years, with 12.6years being the longest observation period. However, 9 patients were excluded for previous records of meniscal or ACL surgery. Therefore, there were 35 patients and 37 total menisci that underwent meniscal repair. Of the 35, 24 patients were available for long-term follow-up. This group of 24 patients was then age and sex-matched with a comparative group, composed of patients who had received combined ACLR and meniscectomy treatment as well as those who had received ACLR but with the intact meniscus.

Upon inspection of the outcomes, this long-term study observed a trend of patients that had received meniscal repair having much more stable outcomes with better-restored functions (evaluated using the IKDC functional score system), compared to the meniscectomy group. As such, the authors of the study concluded that, where possible, conducting meniscal repairs, in the context of ACLR, offers patients "the best chance of optimal outcome (1733)."

Discussion

While the 2004-published study from Tokyo Medical University (study conducted from 1992 to 1998) concluded that stable meniscal tears—defined in the study as tears measuring less than 15mm in length—could possibly be left in situ to self-heal following ACLR operations, citing the outcomes of their study that "almost three-fourths of the torn menisci at the time of reconstruction were healed without undergoing repair," studies conducted within the last two decades (post-2000) all point to a rising prevalence for performing meniscal repair concurrently with ACLR (Yagishita, 1959). The main concern that had been raised by the 2004 study done in Tokyo Medical University was that conducting meniscal repair could potentially damage the articular cartilage and nerve in the process of carrying out the procedure.

Nevertheless, the insurance database study on treatment trends, a study done between the years 2006 and 2018 which suggests there to be an increased likelihood of patients undergoing meniscal repair as opposed to leaving torn meniscus in situ or receiving meniscectomy, also acknowledges there being a possible drawback to the treatment claiming, "meniscal repair at the time of ACL reconstruction may increase rates of arthrofibrosis. (Block, 2)" Otherwise, the insurance database study is in support of conclusions reached by the more recent studies, such as the 6-year follow-up on meniscal repair study and the IKDC long-term outcome evaluation study, in maintaining that, "minimally traumatized tears, longitudinal tears, lesions occurring in the vascularized portions of the meniscus, and meniscus

root tears or ramp lesions," are all cases where "meniscal repair is typically preferred. (Block, 2)" After all, even the 2004-published Japan study which shows optimism for the self-healing potential of meniscal tears left in situ, admits that "medial tears that have long lengths" or tears in "radial menisci should be treated operatively. (Yagishita, 1960)"

The increasing prevalence of meniscal repair being performed over leaving torn menisci in situ, or performing either partial or complete meniscectomy, may be attributed to the "increasing awareness" that may be "improving the orthopedic community's recognition of current pathology at the time of ACL reconstruction," as stated by the aforementioned 2006-2018 trend analysis study. Likewise, the advancements made in the field of arthroscopic surgery over the last 25 years, coupled with "increasing understanding of meniscal function when intact, damaged or removed," may be making meniscal repair procedures all the more appealing treatment options (Block, 4).

While meniscal repair is indeed becoming a more popular option, whether meniscal repair is the most optimal treatment option for every patient is still not clear-cut. Likewise, the studies that claim meniscal repair to be preferable, all have their limitations in reaching a definitive conclusion. For instance, the 2006-2018 trend analysis study was limited to surveying the reoperation rates of patients who underwent meniscal repair concomitantly to ACLR for an observation period of only 180 days. This may have failed to "capture injuries that would occur early after return to sport," which is generally within an 8-12 months period (Block, 5). In addition, the nature of such a database study limits the study from having a comprehensive understanding that considers "patient-specific injury characteristics, given the lack of clinical detail in the database. (Block, 5)" In addition, in epidemiologic studies such as the one done on young athletes of the US Military Academy, the generalizability of their findings was limited due to their subjects being predominantly male. Moreover, given that even for a procedure such as a meniscectomy, "knee osteoarthritis can be observed as soon as 1-year" post-procedure, more research should be done as well for meniscal repair itself, to understand the limits of the procedure and its role in long-term outcomes (Block, 5).

The success rate of concurrent meniscal repair and ACLR, demonstrated by the MOON cohort 6-year follow-up study, was approximately 86%, and the KP ACLRR database study reported the healing rate of meniscus repair performed at ACLR to range from 65% to 96%. Moreover, findings of the IKDC long-term outcome evaluation study suggests that "meniscal repair should be undertaken where possible to improve the long-term outcome for patients with ACL-deficient knees and meniscal tears (Melton, 1733)." In this way, meniscal repair seems overall promising in providing comparably stable outcomes for patients in the long run. However, as mentioned above, the limitations in terms of time and parameters of these studies must be taken into consideration, and most importantly, more work should be done in the future to minimize the current failure rate of 14% for meniscal repair done in conjunction to ACLR (as reported by MOON cohort 6-year follow-up study). Furthermore, since the Matched Cohort study discovered an interesting result that meniscal repair yields better outcomes when conducted alongside ACLR, more research should be directed at understanding why this phenomenon occurs so as to make advancements in treatment plans for curing torn menisci in ligament-intact knees.

Conclusion

It is crucial for respective physicians in charge to make thorough evaluations on the knees of patients that sustain ACL injuries and conceive of a rational treatment plan for each patient based on their age and medical history of their knees, as well as severity, type, and location of their meniscal tears. However, the practice of undergoing meniscal repair operations concurrently with ACL reconstruction surgery seems to be a more suitable treatment option for meniscal tears that take place with ACL ruptures. Hence, such practice has been gaining more popularity in recent years, as opposed to meniscus being left in situ to self-heal, or meniscectomy performed.

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