Outcomes After Meniscal Repair Using the Meniscus Arrow in Knees Undergoing Concurrent Anterior Cruciate Ligament Reconstruction

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Purpose: To determine the healing rate of meniscal repair using the Meniscus Arrow (Bionx, Blue Bell, PA) in patients undergoing concurrent anterior cruciate ligament (ACL) reconstruction and to evaluate patient outcomes with the International Knee Documentation Committee (IKDC) form and a visual analog scale (VAS). **Type of Study:** Case series with outcomes analysis. **Methods:** We retrospectively analyzed 38 consecutive patients with 39 meniscal tears in knees undergoing concurrent endoscopic ACL reconstruction whose menisci were repaired with the Meniscus Arrow system. All meniscal tears were deemed amenable to repair according to length, stability, morphology, and zone of tear. There were 31 medial and 8 lateral meniscal tears, with an average tear length of 2.1 cm. An average of 2.5 arrows were used to repair each tear. All 39 tears were located in the posterior horn of the meniscus or extending into the body of the meniscus from the posterior horn. Follow-up was assessed by clinical examination, the knee disorders subjective history, VAS, and the IKDC evaluation form. Reconstructed ACL laxity was assessed by KT-2000 arthrometry and clinical evaluation. **Results:** At an average follow-up of 2.3 years (range, 18-39 months), 32 patients have been surveyed to date. The success rate was 90.6% (29 of 32 patients) with 3 patients going on to arthroscopic partial meniscectomy. KT-2000 arthrometry showed that sagittal knee laxity was less than 3 mm in all reconstructed knees. Clinical criteria for success in the rest of the repaired menisci included (1) the absence of locking, catching, or giving way; (2) no history of recurrent effusions; (3) no joint line tenderness; (4) a negative McMurray test; and (5) no subsequent surgical procedures on the repaired meniscus. Additionally, the VAS showed the ability of these patients to return to a high level of activity, including competitive sports, without symptoms suggestive of a meniscal tear. The IKDC showed normal or nearly normal function of all success knees. **Conclusions:** The study shows that a high rate of meniscus healing can be achieved by the all-inside, bioabsorbable Meniscus Arrow system in conjunction with ACL reconstruction. Also, patients have excellent function of their knee and are able to return to a high level of activity. Our healing rates are comparable to those previously reported with the inside-out suture techniques without the need for an additional posterior incision that would increase operative time and risk to neurovascular structures. **Key Words:** Meniscus repair—Bioabsorbable—All-inside—Arrow.

Since the advent of open meniscal repair pioneered by DeHaven,[1] many arthroscopic techniques have been reported.[2-5] The recent introduction of all-inside repair using biodegradable fixation devices has sparked interest in the realm of meniscal repair. By avoiding the need for a separate incision, all-inside repairs offer a simplified technique with a theoretical decreased risk to neurovascular structures and decreased operative time compared with the inside-out and outside-in techniques. There is some concern that the insertion techniques are so much simpler that surgeons may compromise indications for meniscal repair. The Bionx Meniscus Arrow (Bionx, Blue Bell, PA), introduced in 1996, was used in this study for all-inside meniscal repair in a consecutive series of

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patients undergoing concurrent anterior cruciate ligament (ACL) reconstruction.

Overall, meniscal healing rates vary according to the stability of the knee joint. ACL-deficient knees show meniscal healing rates of approximately 30% versus roughly 60% for ACL-stable knees. For knees undergoing concurrent ACL reconstruction, the average meniscal healing rate ranges from 83% to 93%[4-6] with inside-out or outside-in suture techniques.

To our knowledge, there has been no intermediate-term study documenting the healing rate of menisci repaired with any of the all-inside repair devices, including the Meniscus Arrow. The purpose of this study was to attempt to determine the healing rate of all-inside meniscal repair in patients undergoing concurrent ACL reconstruction. Also, we assessed patient outcomes with the International Knee Documentation Committee (IKDC) form and a visual analog scale (VAS) to further evaluate the subjective and clinical success of this repair technique.

Recently, quality-of-life measures were assessed in patients undergoing arthroscopic partial meniscectomy.[7] Although the procedure was excellent in alleviating pain, swelling, and other symptoms, substantial disability was noted in functional activities, including running, jumping, kneeling, and squatting. Thus, the need to safely and effectively repair the torn meniscus is further underscored by not only providing biomechanical stability but also by improving the patient's quality of life.

METHODS

Between December 1996 and November 1998, 41 consecutive patients with 42 meniscal tears underwent repair with the Meniscus Arrow system while undergoing concurrent endoscopic ACL reconstruction. All procedures were performed by the senior author (D.R.D.) at the outpatient surgical center affiliated with the university hospital. Three patients were eliminated from the study to eliminate any confounding variables. One patient was a Workers' Compensation case, the second patient had a knee dislocation with concurrent posterior cruciate ligament reconstruction, and the third patient had residual complete laxity of the medial collateral ligament. This left a total of 39 meniscal tears in 38 patients for analysis.

The ACL was reconstructed with central-third bone–patellar tendon–bone autograft in all cases. All meniscal tears were deemed amenable to repair according to length, stability, morphology, and zone of tear.[5,8] An arthroscopic rasp was used to produce parameniscal abrasion before repair to optimize healing.[9] The technique for insertion of the arrow included placing the arrow with the cannula 2 to 3 mm from the tear edge. Care was taken to not place the arrow obliquely so the arrow would not abut the tibial plateau or rub against the femur. The arrow was gently tapped to a depth at which the surface of the meniscus was slightly indented by the head of the arrow. All arrows were inserted with hand instruments per the manufacturer recommendations.

The study population consisted of 27 male and 11 female patients. Tear morphology included 32 vertical, longitudinal tears and 7 bucket-handle tears. Thirty-one tears were in the medial meniscus, and 8 tears were in the lateral meniscus. Fourteen meniscal tears were less than 2 centimeters, 24 were between 2 and 3 cm, and 1 was greater than 3 cm. The average tear length was 2.06 cm. Any stable tears less than 1 cm were not repaired. The chronicity of the tear was designated from the time of the suspected trauma to the time of the repair; 6 weeks marked the transition from acute to chronic. Sixteen meniscal tears were repaired in the acute time period (range, 1.7 to 6 weeks) and 23 were chronic repairs (range, 2 to 48 months).

The number of arrows used depended on the number required to achieve a stable meniscal repair (Fig 1). One arrow was used in 8 menisci, 2 arrows in 13 menisci, 3 arrows in 11 menisci, 4 arrows in 5 menisci, 5 arrows in 1 meniscus, and 6 arrows in 1 meniscus. The average number of arrows used was 2.51 arrows per meniscal repair. Arrow sizes ranged from 10 (14.3%) to 13 (80.6%) to 16 (5.1%) mm with predominant usage of the 13-mm Meniscus Arrow.

Cooper's classification system for the location of the meniscal tear was used in this study.[10] With this system, the meniscus is divided into circumferential and radial zones. No tears deemed amenable for repair were located in the white-white avascular zone. Six tears were at the menisco-capsular junction, 7 were in the red-red zone, and 26 were in the red-white zone. All tears were located in the posterior horn of the medial or lateral meniscus (zones A and F) or extending from the posterior horn into the body of the respective meniscus.

Follow-up was assessed by both subjective and objective means. The history and physical examination specific for the meniscus was used to evaluate the success of the repaired menisci. These criteria included the absence of locking, catching, or giving way; no history of recurrent effusions; no joint-line tenderness; a negative McMurray examination; and no

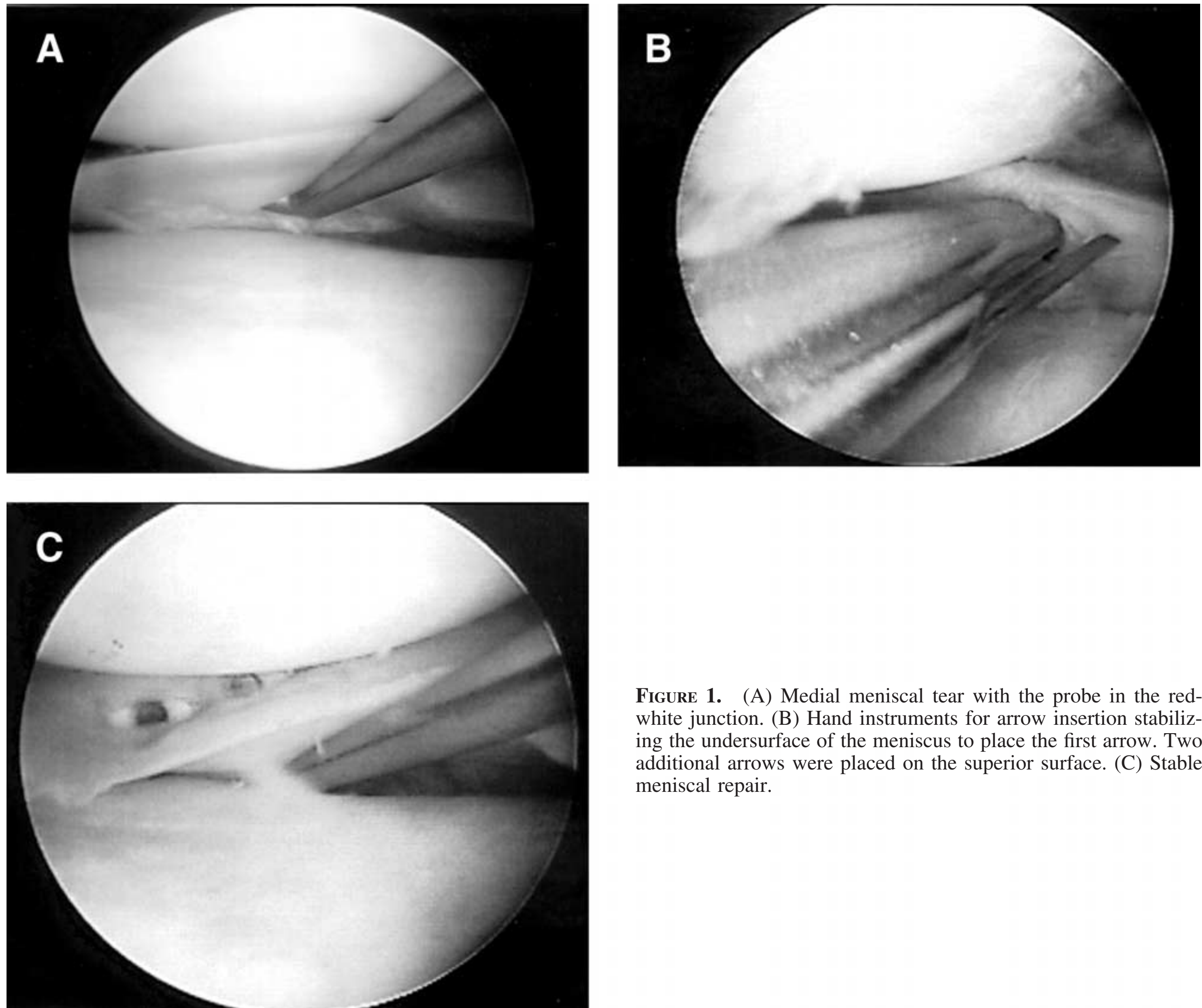

Figure 1. (A) Medial meniscal tear with the probe in the red-white junction. (B) Hand instruments for arrow insertion stabilizing the undersurface of the meniscus to place the first arrow. Two additional arrows were placed on the superior surface. (C) Stable meniscal repair.

subsequent surgical procedures on the repaired meniscus. Along with clinical examination using the Lachman test and the anterior drawer test, objective measurements were done with the KT-2000 to assess the stability of the ACL reconstruction.

The IKDC form for knee evaluation was used to characterize the outcome of the knee reconstruction.[11] Additionally, patients completed a VAS proposed by Flandry et al.[12] to analyze the degree of success of the meniscal repair by effectively recording subjective data (Fig 2). This knee disorder's subjective history VAS was shown to correlate with other scoring methods, such as the Noyes, Larsen, and Lysholm knee scales, while eliminating bias introduced by examiner questioning. The VAS also fostered a broader range of responses than traditional categoric responses.

An explanatory letter was sent to each patient describing the purpose of the study. The patients were requested to return to the clinic for a subjective and objective evaluation. If the patients were unable to return to the clinic, telephone calls were placed so that the questionnaires could be completed. A review of the office and hospital records was used to compile the historical database. The clinical follow-up examination and IKDC rating were performed by another qualified evaluator to avoid any interviewer bias.

The rehabilitation protocol was identical to our isolated ACL reconstruction postoperative rehabilitation. Patients were allowed weight bearing as tolerated and immediate range of motion, quad sets, and straight leg raising exercises. A hinged, postoperative long-leg brace was worn for the first 2 weeks. Closed-chain

KNEE DISORDERS SUBJECTIVE HISTORY

NAME: ______________________________

HISTORY: ______________ DATE: ___________ SIDE: L R

INSTRUCTIONS

For each question, shade in a box between the two descriptions which you think describes your knee **relative** to the two extremes. Please complete both sides of this form.

1. How often does your knee hurt?
   Never [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Daily even at rest

2. How bad is the pain at its worst?
   None [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Severe, requiring pain pills every few hours

3. Do you have swelling in your knee?
   Never [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Daily, even at rest

4. Does your knee give way or buckle?
   Never [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] I must guard my knee to prevent giving way even with normal everyday activity

5. Does your knee lock up so you are unable to straighten it?
   Never [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] I must guard my knee to prevent locking even with normal everyday activity

6. Does your knee catch or hang up when moving?
   Never [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] I must guard my knee to prevent catching even with normal everyday activity

7. Is your knee stiff?
   None [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] I can barely move my knee because of stiffness

8. Are you able to walk on level ground?
   No problem [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Unable

9. Are you able to walk on rough ground, inclines, or negotiate curves?
   No problem [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Unable

10. Do you need crutches, cane, or walker to walk?
    Never [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Always

11. Do you feel grinding when your knee moves?
    None [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Severe

12. Do you have problems twisting or pivoting on your injured knee?
    None [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Unable

FIGURE 2. Visual analog scale.

13. Do you have problems carrying heavy objects because of your knee?
None ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

14. Do you have problems climbing stairs?
None ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

15. Do you have problems going down stairs?
None ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

16. Do you have problems running?
None ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

17. Do you have problems decelerating (slowing down) after running or jogging?
None ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

18. Do you have problems cutting (changing directions while running by pivoting on affected knee)?
None ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

19. Do you have problems jumping?
None ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

20. Do you have problems taking part in competitive sports?
None ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

21. Do you have night pain?
None ☐☐☐☐☐☐☐☐☐☐ Severe

22. Do you have problems kneeling?
No problem ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

23. Do you have problems squatting?
No problem ☐☐☐☐☐☐☐☐☐☐ Unable ☐ Not attempted

24. Do you have problems getting in and out of a car?
No problem ☐☐☐☐☐☐☐☐☐☐ Unable

25. Does your knee ache while you are sitting?
Never ☐☐☐☐☐☐☐☐☐☐ Always

26. Do you have problems getting in or out of a chair?
No problem ☐☐☐☐☐☐☐☐☐☐ Unable

27. Do you have stiffness or discomfort when you first start to walk?
None ☐☐☐☐☐☐☐☐☐☐ Always

28. Do you have problems turning over in bed?
None ☐☐☐☐☐☐☐☐☐☐ Unable

FIGURE 2. Visual analog scale.

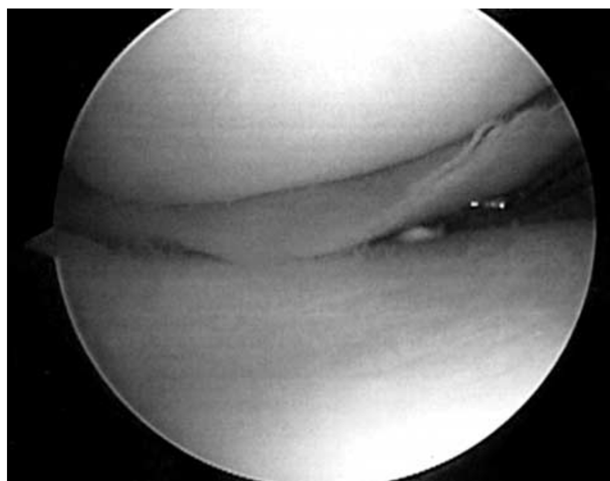

Figure 3. Two and one-half years after repair, the medial meniscus is healed without signs of chondral injury.

quadriceps strengthening began 1 to 2 weeks postoperatively, and lateral activities were initiated at 2 months. Open-chain quadriceps strengthening from 40 degrees of flexion to terminal extension was started at 3 months, followed by straight ahead jogging at 4 months, agility drills at 4 to 5 months, and a full return to sports at 6 months or sooner if symmetric quadriceps strength was attained. Functional ACL braces were not prescribed.

RESULTS

At an average follow-up of 2.3 years (range, 18-39 months), 32 patients (84.2%) were surveyed with a total of 32 menisci repaired. Twenty-four of these patients returned to the clinic for a subjective and objective evaluation, whereas 8 patients had a subjective evaluation only. The clinical success rate for meniscal repair with the Meniscus Arrow was 90.6% (29 of 32 menisci). One patient's clinical success was confirmed by repeat arthroscopy without any evidence of an arrow remnant (Fig 3). Three patients went on to arthroscopic partial meniscectomy of the unhealed meniscus. The arrows were embedded within the meniscal tissue and removed with the torn meniscus. There was no evidence of arrow-induced articular cartilage surface damage in any of these patients. The clinical examination and patient report showed that the reconstructed knees were stable with an intact ACL graft. Sagittal knee laxity testing determined by KT-2000 arthrometry confirmed that the side-to-side difference at 30 lb of force was less than or equal to 3 mm in all knees (average, 0.73 mm; range, −2.0 to 3.0 mm).

The IKDC evaluation form grades patients' knees from A to D, with A designated as normal, B as nearly normal, C as abnormal, and D as severely abnormal. The overall grade of the knee was determined by the lowest subgroup grade. The subgroups of the IKDC were the (1) patients' subjective assessment; (2) symptoms including pain, swelling, and giving way; (3) range of motion compared with the nonoperated side; and (4) ligament evaluation including varus, valgus, anterior, and posterior stability. For the 8 patients evaluated only by telephone, only the first 3 criteria were used. Of the successful repairs, 11 knees were graded overall as normal and 18 as nearly normal. Joint-line tenderness was found in 4 patients with 1 patient complaining of medial joint-line tenderness and 3 patients complaining of patellofemoral pain. The patient with the medial joint-line tenderness underwent repeat arthroscopy as described previously, and a healed meniscal repair was observed without evidence of residual arrow material or chondral damage (Fig 3). Graft-site morbidity was felt to account for the patellofemoral pain. For the unhealed menisci, 1 knee was deemed to be abnormal, and 2 knees were severely abnormal. History and physical examination in these patients with the nonhealing menisci confirmed the presence of a recurrent effusion, mechanical symptoms, and joint-line tenderness in all 3 of these patients. A positive McMurray sign with pain was seen in 2 of the failed repairs.

For the patients with a clinically healed meniscus, the subjective VAS showed the ability of these patients to return to a high level of activity without symptoms suggestive of a meniscal tear. These patients could participate in sports that included rigorous activities such as jumping, cutting, running, and pivoting with a mean score of 1.19 (range, 0-7). The range for this segment of the VAS was from 0 to 10, with the lower end of the scale indicating patients without any problem participating in sports, whereas the upper end of the scale included patients that were unable to take part in sports. The mean scores for decelerating, cutting on the affected extremity, and jumping were 1.12 (range, 0-7), 1.23 (range, 0-7), and 1.31 (range, 0-8), respectively, with higher scores denoting difficulty performing the aforementioned activity. The majority of the complaints registered by the patients according to the VAS involved difficulty kneeling (mean, 2.43; range, 0-9) and patellofemoral pain while squatting (mean, 2.02; range, 0-8), which

are more suggestive of graft-site morbidity than meniscal problems.

The 3 failed repairs all occurred in the red-white zone of the meniscus. This zone has the lowest healing rate of tears amenable to repair as reported by Scott et al.[9] Two of the patients were men, and 1 was a woman. All tears were 1.5 to 2 cm in length, and all 3 involved the medial meniscus. Lateral meniscus tears are known to have a slightly higher healing rate compared with medial meniscus tears.[13] Two of the menisci were repaired with 2 13-mm arrows, and the third tear was repaired with 3 13-mm arrows. One tear was repaired acutely, whereas the other 2 were repaired in the chronic time period. All 3 of these patients underwent partial medial meniscectomy of the nonhealing medial meniscus with resolution of symptoms. Of note, their ACL grafts were found to be intact and stable.

DISCUSSION

The overall healing rate for meniscal repair in knees undergoing concurrent ACL reconstruction is 83% to 93% given the repair techniques currently available (inside-out and outside-in techniques). However, results as low as a 74% healing rate have been shown.[6] The all-inside repair technique is appealing because of its relative ease compared with other arthroscopic meniscal repair procedures. Additionally, the number of assistants required for the repair, the time required to reconstruct the meniscus, and the risk to the posterior neurovascular structures should all be reduced with the all-inside technique.[14] In our series, with an average of 2.3 years of follow-up, we had a clinical success rate of 90.6% for meniscal healing. This healing rate is comparable to those previously reported with the inside-out technique when the ACL is simultaneously reconstructed.

Although initially thought of as a vestigial remnant until the middle of the 20th century, the crucial role that the meniscus plays in load transmission, shock absorption, joint stability, and improving nutrition to the articular surface continues to be elucidated.[2,3,13,15-17] Greater than 10-year follow-up of repaired menisci by Johnson et al.[15] showed that knees with menisci successfully repaired did not have a statistically significant increased risk of radiographic changes indicative of osteoarthritis. The role that the meniscus plays in the biomechanical stability of the knee is also well documented. The medial meniscus is a secondary stabilizer of the knee joint.[18] A significant increase in the anteroposterior translation of the ACL-deficient knee was observed after total medial meniscectomy. Total meniscectomy was also found to cause a 2- to 3-fold increase in contact stress across the knee,[19] and removal of as little as 16% of the meniscus increased the articular contact forces by 350%.[20] Furthermore, the need to be more aggressive in repairing medial menisci has been shown by Fitzgibbons and Shelbourne[13] and also by Talley and Grana.[21] Both cite the decreased ability of the medial meniscus to heal spontaneously or remain asymptomatic and the higher propensity for a medial meniscus tear to propagate. Meniscal tear morphology, which occurs with ACL tears, is usually amenable to repair because there appear to be fewer complex and degenerative tears with an acute ACL lesion.[22]

Biomechanical studies with fresh bovine menisci comparing horizontal suture versus a different bioabsorbable arrow showed no statistically significant difference in failure load between the 2 groups.[23] All failures occurred at the repair site. Rimmer et al.,[24] however, have shown superior pullout strength of vertical suture compared with horizontal suture,[24] and vertical sutures are currently considered the strongest repair construct.[4,25] Independent testing by Barber and Herbert[25] has shown that most all-inside repair devices, including the arrow, have load-to-failure strengths that are below the value for both horizontal and vertical sutures. However, it is not known how much strength is required to achieve meniscal healing. The answer to that question probably differs for isolated meniscal repairs with inferior healing rates compared with repair in conjunction with ACL reconstruction, as in this study. Furthermore, a cyclic load, and not a single load as used in these previous studies, may cause different failure mechanics for a meniscus in a clinical setting with different results.

The ability to assess meniscal healing at follow-up is a difficult task. Precise information of the status of the meniscus can be obtained from second-look arthroscopy,[26,27] which may or may not always correlate with clinical success. However, few patients who are asymptomatic will want a second operation. In this study, we used the examination specific for the meniscus to evaluate for the success of a meniscal repair. Serial testing with the IKDC and the VAS provided additional confirmation to help determine the true status of the repaired meniscus. The VAS was instrumental in emphasizing the quality of life that these patients maintained after their meniscal repair. Not only were they able to have an asymptomatic knee, but they also were able to compete at a high level of activity with most patients returning to their respective

sports. Despite these clinical determinations of an asymptomatic meniscal repair, it is possible that some of the repairs had not healed or were partially healed and could be symptomatic in the future.

Emphasis should also be placed on the rehabilitation protocol. Although isolated meniscal repair often involves a 4-week period of non–weight bearing activity, the postoperative rehabilitation in these patients undergoing concurrent ACL reconstruction with meniscal repair is unchanged from our routine ACL protocol. The associated hemarthrosis with ACL reconstruction provides a milieu filled with chemotactic and growth factors essential for meniscal healing. Accelerated ACL rehabilitation has been used by others in patients undergoing concurrent ACL and meniscal reconstruction.[28]

Reports of complications with the Meniscus Arrow include case reports of breakage with loss of fixation occurring anywhere from 2 to 6 months postoperatively and even a dislodged arrow appearing as a subcutaneous foreign body.[29-31] The manufacturer reports that the Bionx self-reinforced polylactic acid arrow typically maintains structural integrity for approximately 6 months and fully resorbs by 3 years. Additionally, transient posterior knee pain has been associated with this implant. This was attributed to local irritation by the arrow and usually resolved by the sixth postoperative month, correlating with partial resorption of the arrow.[32] Chondral injury after meniscal repair with bioabsorbable arrows has been reported, possibly because of improper positioning of the Meniscus Arrow.[33,34] The surface of the meniscus should be dimpled by the head of the arrow below the surface of the surrounding meniscus to avoid any impingement on the femoral condyle. At the initiation of this study, the gun instruments were not available to be used on our patient population. In general, we prefer the hand instruments to the gun inserter because the hand instruments allow better reduction of the meniscal tear using the stylet through the straight cannula. Furthermore, the hand instruments allow additional impaction of the arrow to dimple the surface of the meniscus to avoid leaving the head of the arrow proud. The arrow must not be placed obliquely into the meniscus because the tip of the arrow could impinge on the tibial surface creating a rigid post with secondary mechanical abrasion to the femoral surface. Similarly, the arrow should be rotated horizontally and parallel to the meniscus to avoid catching the femoral condyle with the corner of the head. Proper surgical technique is crucial in repairing a meniscus with any system.

For patients who are found to have a meniscal tear amenable to repair while undergoing concurrent ACL reconstruction, the Meniscus Arrow provides an excellent, minimally invasive tool in meniscal repair. Healing rates are comparable to those previously reported in the literature with the inside-out technique. These similarities in healing rates do not apply to ACL-unstable or ACL-stable knees not undergoing concurrent ACL reconstruction. With the lower healing rates found in these scenarios, the added strength of a suture construct possibly with permanent material would remain the standard against which any new techniques must be measured.

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