Original Article With Video Illustration

Repair of Radial Tears and Posterior Horn Detachments of the Lateral Meniscus: Minimum 2-Year Follow-Up

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Purpose: The aim of this study was to show that repair of posterior radial tears and horn detachments of the lateral meniscus is possible and to assess the outcomes. **Methods:** A retrospective review of 24 patients who had repair of a posterior defunctioning tear of the lateral meniscus combined with anterior cruciate ligament reconstruction was undertaken. Patients completed a follow-up postal questionnaire that included Lysholm, subjective International Knee Documentation Committee (IKDC), and Tegner scoring systems. **Results:** Eight patients had suture repair of a lateral meniscal radial tear. The mean Lysholm, IKDC, and Tegner scores were 86.9 (SD, 11.6), 81.6 (SD, 13.9), and 5.8 (SD, 2.7), respectively, at a mean follow-up of 70.5 months (range, 29.0 to 168.0 months). Subsequent arthroscopy in 2 patients confirmed meniscal healing. Sixteen patients underwent a posterior horn reattachment. The mean Lysholm, subjective IKDC, and Tegner scores were 86.1 (SD, 13.3), 84.3 (SD, 17.0), and 6.5 (SD, 2.1), respectively, at a mean follow-up of 53.6 months (range, 26.0 to 116.0 months). Three patients had subsequent magnetic resonance imaging and/or arthroscopy that indicated meniscal healing. Two further patients had reinjury, and magnetic resonance imaging and/or arthroscopy showed that their repairs had failed. **Conclusions:** Posterior radial tears that extend to the capsule and posterior horn detachments of the lateral meniscus are frequently amenable to repair. In this study 22 of 24 repairs functioned successfully over a mean follow-up of 58.6 months (range, 26.0 to 168.0 months). **Level of Evidence:** Level IV, therapeutic case series.

The association between acute anterior cruciate ligament (ACL) injury and meniscal tears is well recognized.[1] The lateral meniscus is more vulnerable to detachment at the time of ACL injury when compared with the medial meniscus because of the mechanism of injury, where the lateral femoral condyle subluxates posteriorly on the tibia.[2,3] This can produce 2 patterns of meniscus tear: the more common longitudinal (circumferential) vertical tear or a disruption of the posterior horn by either a radial tear through the posterior horn or an avulsion of the horn from the tibia. This posterior horn pattern can often be associated with a second radial tear in the middle third of the meniscus.

Both posterior radial tears and posterior horn detachments (PHDs) defunction the lateral meniscus as a load-

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Table 1. *Lateral Meniscus Radial Tear and PHD Repairs*

	Radial Repair (n = 8)	Posterior Horn Reattachment (n = 16)
Associated injuries		
ACL disruption (fx)	8	16
PCL disruption (fx)	0	0
MCL disruption (fx)	2	2
LCL disruption (fx)	0	0
Medial meniscus tear (fx)	3	7
Lateral femoral condyle erosion (fx)	1 moderate	2 moderate and 3 severe
Lateral tibial surface erosion (fx)	1 moderate	1 moderate
No. of sutures [mean ± SD (range)]	1.9 ± 1.1 (1.0-4.0)	3.2 ± 0.9 (2.0-5.0)
Age at surgery [mean ± SD (range)] (yr)	29.0 ± 15.3 (16.0-58.0)	32.8 ± 13.3 (17.0-59.0)
Male/female (%)	62.5/37.5	75/25
Left/right (%)	37.5/62.5	50/50
Questionnaire response (%)	100.0	100.0

Abbreviations: PCL, posterior cruciate ligament; MCL, medial collateral ligament; LCL, lateral collateral ligament; fx, frequency.

bearing structure.[4] These tears disrupt the circumferential fibers of the meniscus, thereby preventing axial forces from being taken up as tension.[4] This results in meniscal extrusion and an increase in local contact pressure,[4-6] which ultimately predisposes the tibiofemoral articulation to the development of premature osteoarthritis.[7,8]

The posterior horn of the lateral meniscus is also an important secondary restraint to rotational laxity of the knee.[9,10] In addition, it plays a role in proprioception of the knee particularly with rotational movements.[11] Loss of this structure along with the ACL will thus also predispose the knee joint to recurrent instability. Despite these facts, many surgeons believe that these injuries are not amenable to repair.[12-15] Classically, arthroscopic meniscal repair has been undertaken for peripheral vertical tears, whereas other tears were either resected or left untreated.[16] Meniscectomy has been well documented to lead to premature osteoarthrosis.[17] It is for this reason that preservation of the meniscus has become a key component of modern arthroscopic knee surgery.[18]

We believe that radial tears that extend to the joint capsule and PHDs are repairable and that repair of these tears will restore some of the load-bearing function of the meniscus and protect the articular cartilage. The purpose of this study was to review the medium- to long-term outcomes of lateral meniscus radial tear repairs and posterior horn reattachments. We hypothesized that patients with radial tear repairs and posterior horn reattachments would function successfully.

METHODS

We reviewed a single surgeon's database to identify cases of lateral meniscus repair in conjunction with ACL reconstruction. Between May 1994 and December 2005, a total of 1,689 ACL reconstructions were performed and 1,283 lateral meniscus tears identified. Lateral meniscus derangement occurred in conjunction with ACL reconstruction in 622 knees (619 patients). The pattern of lateral meniscus tear and associated injuries were noted (Table 1). Included in this series were 23 patients who had repair of posterior radial tears and 25 patients who had repair of PHDs of the lateral meniscus in conjunction with ACL repair. We believe that not all posterior radial tears require repair. If the untorn posterior horn still has a substantial attachment to the ligament of Wrisberg, then repair is not required and these patients were excluded. We only repair a tear that extends into the vascularized zone (Fig 1) and that would prove detrimental to the function of the knee if left untreated. Similarly, even if the posterior horn is avulsed from the tibia but there remains a substantial attachment of the body of the meniscus to the ligament of Wrisberg, then reattachment is not required and these patients were excluded. Also excluded were those in whom the quality of the tear did not have the ability to hold sutures and showed signs of degeneration.[18] After these criteria were applied, a total of 24 patients were eligible for retrospective review. The time from first injury to surgery for these patients ranged from 0.1 to 216.0 months (mean, 22.4 months).

The repair of choice for radial tears was the inside-out suture technique using a cannula and needle shut-

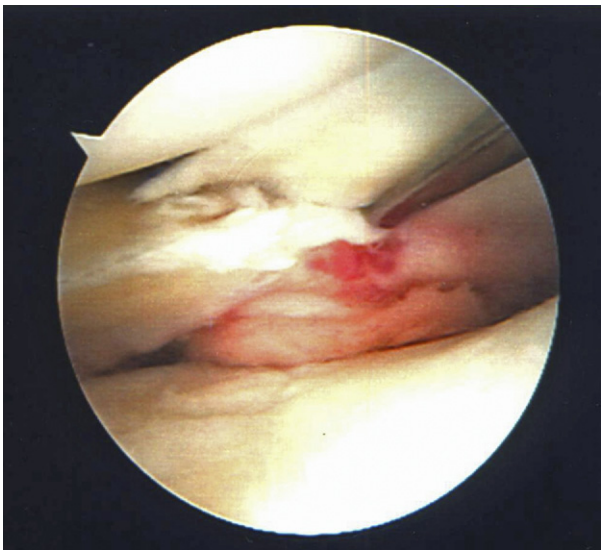

Figure 1. Repairable radial tear of lateral meniscus posterior horn extending into vascularized zone.

tle system.[18] A small posterolateral incision is made and deepened through the retinaculum to the level of the joint capsule at the joint line. Before passage of the sutures, the torn edges of the meniscus and local synovium are abraded with a rasp and the meniscal rim is pierced with an awl several times to promote bleeding. In most cases 2 or 3 sutures are placed in a horizontal fashion across the tear, 1 or 2 on the superior surface and 1 on the undersurface (Fig 2). TheFig

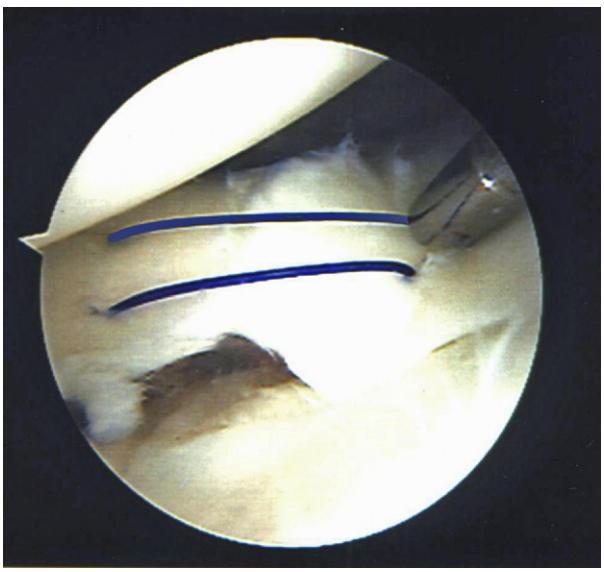

Figure 2. Horizontal sutures placed across radial tear.

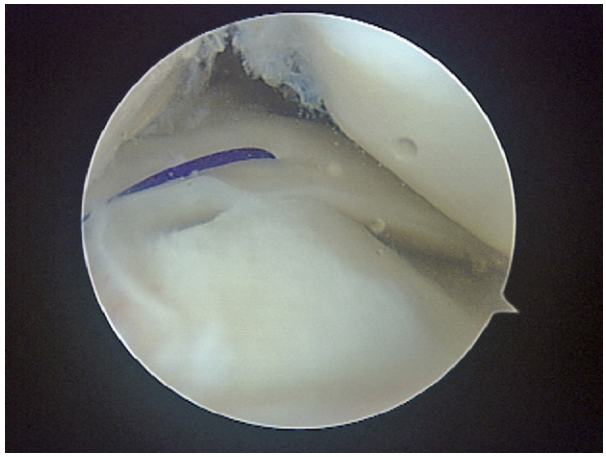

Figure 3. Repaired PHD avulsion.

3). sutures are retrieved through the lateral incision and tied over the capsule deep to the retinaculum. In some cases an all-inside technique was undertaken by use of the FasT-Fix device (Smith & Nephew, Andover, MA). We believe that the inside-out technique of meniscal repair is the gold standard because it allows the surgeon to feel the tension of the sutures and that this technique should be performed preferentially. However, it is technically difficult and potentially dangerous to the neurovascular structures to perform inside-out suturing for the most posterior section of the meniscus. Therefore, for large tears, a combination of inside-out and all-inside techniques at the very posterior section is used. If the tear only involves the very posterior section, an all-inside technique is used.

We consider that a PHD causes a deficiency of the lateral meniscus if the tear involves the ligament of Wrisberg or if the ligament is absent. In these cases, repair was undertaken. The repair of a PHD involves only a few extra steps during a routine ACL reconstruction (Video 1, available at www.arthroscopyjournal.org). The tibial tunnel for the ACL graft is drilled in the usual manner. The avulsed posterior horn is probed and grasped to determine whether it is mobile enough to reattach to the tibia immediately posterior and medial to the lateral tibial spine. This is best done with the knee in the "figure 4" position. By use of a chondrotome shaver, a small groove is created from the tibial tunnel to the posteromedial area of the lateral tibial spine. This is most easily done by using the chondrotome through the medial portal and resting it against the lateral tibial spine with the cutting blade directed toward the tibia. In this po-

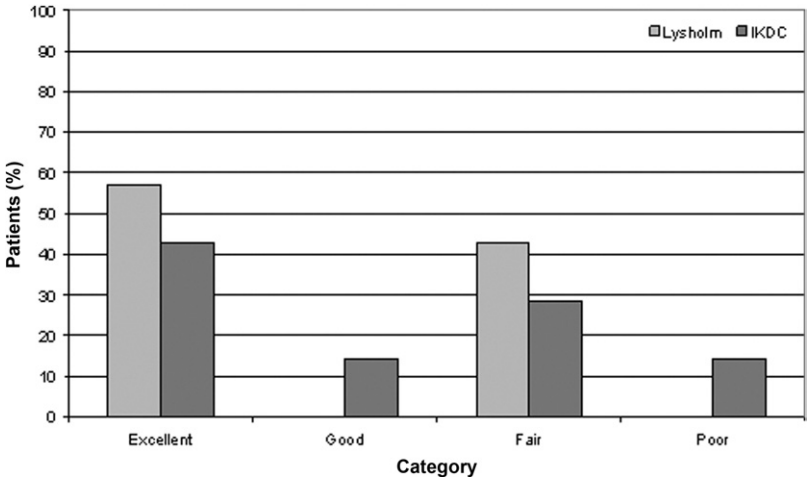

FIGURE 4. Lysholm and subjective IKDC questionnaire scores for patients who had radial tear of lateral meniscus repaired.

sition the blade is directly in the line of the tibial tunnel. With the shaver in reciprocating mode, the soft tissues and soft cortical bone are removed. This creates a shallow trough with a bleeding bone base extending from the intra-articular aperture of the tibial tunnel to the attachment point of the posterior horn of the lateral meniscus.

By use of a Caspari suture punch or a similar device, 2 or 3 sutures are passed through the detached horn of the meniscus (Fig 3). If possible, a further suture is placed in the posterior capsule immediately posterior to the torn lateral meniscus. The free ends of the sutures are drawn through the ACL tibial tunnel with a suture grasper. By pulling on the sutures, the posterior horn is advanced onto the previously created groove in the proximal tibia.

The ACL graft is pulled through the tibial tunnel, and before graft fixation in the tibia, the meniscal sutures are tensioned under direct vision. The ACL graft is then fixed in the tibia with an interference screw (RCI; Smith & Nephew), and the sutures are passed through the tibial periosteum and tied.

We sent questionnaires containing International Knee Documentation Committee (IKDC) subjective,[19] Lysholm,[20] and Tegner[21] scoring systems to all 24 patients who had repair of radial tears (8 patients) or PHDs (16 patients). A total of 24 questionnaires were returned (100% response rate). All clinic records were reviewed in detail, Lachman test results from postoperative consultations were noted, and additional questions were asked concerning further injury, treatment, investigation, or intervention.

RESULTS

Radial Tear Repairs

The 8 patients who had radial tear repairs scored 86.9 ± 5.7 (mean ± 95% confidence interval [CI]), 81.6 ± 6.8 (mean ± 95% CI), and 6.0 ± 1.3 (mean ± 95% CI) for the Lysholm, subjective IKDC, and Tegner questionnaires, respectively, at a mean follow-up of 70.5 months (range, 29.0 to 168.0 months) (Fig 4). Five patients returned to their primary sporting activity within a mean of 10.0 months after surgery (range, 9.0 to 12.0 months). All of these were at high levels (1 at national level [Tegner score of 10.0], 2 at state level [Tegner scores of 9.0 and 9.0], and 2 at club level [Tegner scores of 5.0 and 4.0]). Lachman tests for the 8 patients were negative at a mean clinical postoperative follow-up of 6.8 months (range, 3.0 to 11.7 months). Five patients complained of some symptoms since surgery (pain, stiffness, or swelling) but none requiring further treatment or investigation.

Two patients had a further arthroscopy, one at 47.0 months for trochlear groove chondral damage after an injury and the other at 52.0 months for lateral femoral condyle chondral damage. In both cases the radial tear of the lateral meniscus was seen to be healed.

Posterior Horn Detachments

The 16 patients who had posterior horn repairs scored 86.1 ± 6.5 (mean ± 95% CI), 84.3 ± 8.3 (mean ± 95% CI), and 6.7 ± 1.2 (mean ± 95% CI) on the Lysholm, subjective IKDC, and Tegner questionnaires, respectively, at a mean follow-up of 53.6 months (range, 26.0 to 116.0 months) (Fig 5). Twelve

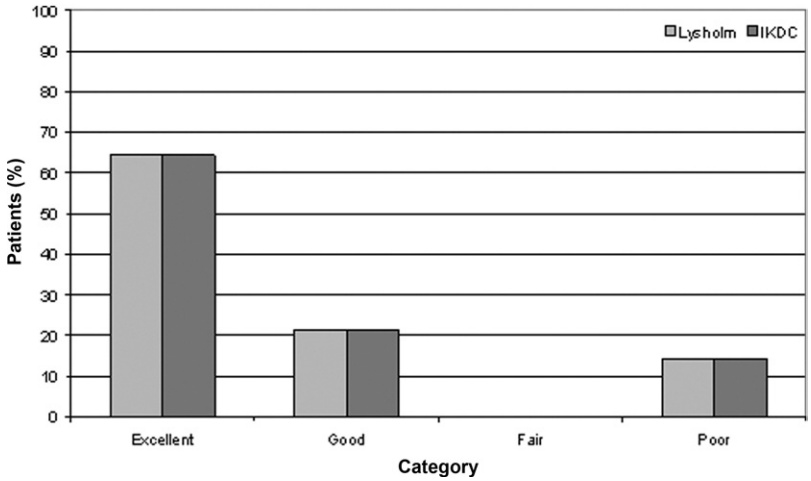

FIGURE 5. Lysholm and subjective IKDC questionnaire scores for patients who had PHD of lateral meniscus repaired.

patients returned to their primary sporting activity after a mean recovery period of 9.4 months (range, 4.0 to 12.0 months). Of these patients, 4 returned to an elite level (2 at national level [both with Tegner scores of 10.0] and 2 at state level [both with Tegner scores of 9.0]). Five patients returned to a lower sporting level compared with before injury (Tegner scores of 9.0, 8.0, 7.0, 6.0, and 6.0). Three patients remained active within their chosen sport (Tegner scores of 8.0, 5.0, and 4.0). Lachman tests for the 16 patients were negative at a mean clinical postoperative follow-up of 7.4 months (range, 3.0 to 20.0 months).

Of the 16 patients undergoing PHD repair, 5 underwent further investigations during the follow-up period. One patient underwent magnetic resonance imaging (MRI) (24 months) for an injury that occurred while playing rugby football. The MRI scan showed the posterior horn of the lateral meniscus to be intact. Another patient underwent both MRI (13 months) and arthroscopy (15 months) for persisting joint effusion. No meniscal abnormalities were present, and there was no evidence of a PHD. It was also noted that the articular cartilage showed no new damage. A third patient underwent arthroscopy (4 months) for investigation of medial pain. No pathology was found, and the posterior horn of the lateral meniscus was firmly attached. A fourth patient had MRI (39 months) for lateral knee pain. The scan indicated that the posterior horn of the lateral meniscus appeared to be intact; however, there was subchondral damage to the lateral femoral condyle. It was unclear from the history as to whether this was because of a single episode of trauma or ongoing degeneration; nonetheless, failure of the repair could not be ruled out in this case. A final patient had an arthroscopy (3 months) performed for medial pain, and the lateral meniscus was found to be intact. This same patient then had a further injury while skiing, with ongoing symptoms of swelling and pain. Arthroscopy was performed (26 months), showing an intact ACL graft and a large medial meniscus tear, which was treated with a partial meniscectomy; the posterior horn of the lateral meniscus was found to be detached and was left untreated because it did not fit the criteria for repair (the tear was frayed and would not have been able to hold a suture).

DISCUSSION

The lateral femoral condyle subluxates posteriorly over the tibia at the time of ACL disruption in the majority of cases. This can deform the lateral meniscus to the extent that it may tear. There are persistent patterns of lateral meniscus tears. One common pattern is disruption of the posterior horn. This may take 2 forms: a radial tear, which may or may not extend to the capsule and thus to the vascular zone, or a PHD from the tibia.

Radial tears and PHDs of the lateral meniscus effectively defunction the meniscus as a load-bearing structure by reducing the capacity to resist hoop stresses.[22] Historically, these tears have been either resected or left untreated, raising the likelihood that degenerative change will develop in the knee over time.[17,23] Repair techniques for these tears have been described for the lateral[2,3,12] and medial meniscus.[24,25]

All repairs undertaken in this study were performed in conjunction with an ACL reconstruction. It is believed that both the hemarthrosis that occurs in conjunction with an ACL reconstruction and controlled

closed-chain rehabilitation aid the meniscal repair process.[1,13,26,27]

The results indicate that both radial tears and PHDs of the lateral meniscus are amenable to repair in conjunction with an ACL reconstruction. Many patients have returned to sports that place a high demand on meniscal repair (soccer, rugby, and netball). None of these patients has reported any recurrent meniscal symptoms (clicking, locking, instability, swelling, or pain) that required treatment. This is highly suggestive of meniscal healing and is further supported by subsequent arthroscopy, which showed gross meniscal healing in 4 cases, and MRI, which showed no evidence of meniscal disruption in 2 cases.

Seven patients had professional and semiprofessional sporting careers before injury. All these patients returned to their sport within 12 months (3 patients with a Tegner score of 10.0 and 4 patients with a Tegner score of 9.0). It could be considered that because of increased time spent training and playing, this subgroup of patients would put the most stress on the repaired menisci and that they would be at higher risk of failure. However, none of these patients provided subjective symptomatic evidence that could be attributable to meniscal pathology in the follow-up period.

With regard to defunctioning injuries of the lateral meniscus and their subsequent repair, comments have been made regarding repair of both radial tears and PHDs[2,3,6,13]; however, few follow-up studies have been conducted.[28] This is not surprising considering that this is a relatively rare group of injuries.

Our advancements over the years of practice outlined in this study have included the use of forage and diamond rasping before the passing of sutures. We believe this to better prepare the meniscus for healing. In addition, before the availability of a reliable all-inside device, the operating surgeon used the inside-out technique as far as possible and then left the very posterior section unrepaired.

Work conducted by Messner and Gao[2] does in part support our reasons for undertaking repair in the context of an ACL reconstruction. This study used rabbit models to investigate the effect of transection of meniscotibial ligaments. They found that the joint expressed osteogenic changes, similar to those of complete meniscectomy, within 6 to 12 weeks after transection of either the anterior or posterior insertional ligament.

It has been shown that higher rates of degenerative changes to the articular cartilage are seen in conjunction with radial tears.[14] There is conflicting evidence in the literature regarding the capacity of the radial tear to heal. Anatomically, the inner one-third is avascular and is incapable of healing spontaneously.[14,22,29] It has been shown that radial tears have a low intrinsic cell density and a limited ability to provoke the stimulus for biological repair.[14] Port et al.[30] reported that in a repaired goat meniscus, the scar regained only 40% of the original meniscal strength. Newman et al.[31] showed that the fibrovascular repair scar possessed inferior histologic and mechanical properties when compared with intact meniscus. Mesiha et al.[14] showed that healed tears have a higher risk of retear because of the low intrinsic cellularity. In contrast, van Trommel et al.[32] attempted radial repair in 5 patients using fibrin clot in association with inside-out sutures. On second-look arthroscopy at 3 to 6 months, 3 patients showed excellent healing and 2 showed partial healing. Three of these patients also had MRI investigation at a mean of 71 months, showing 2 repairs to be fully healed and the other to have partial healing. Noyes and Barber-Westin[33] undertook repair of meniscal tears extending into the vascular zone. Two radial tears had a follow-up arthroscopy: one had healed, and the other had failed.

Fitzgibbons and Shelbourne[16] stated that posterior detachments can be left alone with little or no clinical sequelae. We believe this to be true if the ligament of Wrisberg is intact, but no study has specifically assessed this. Hamada et al.[34] recently presented a single case report on their experience of repairing an avulsion injury of the posterior horn of the lateral meniscus, showing that healing is possible. Griffith et al.[35] presented a case report of the surgical repair of a posterior root avulsion fracture of the medial meniscus in a female adolescent basketball player, which resulted in normal knee function at 3 years' follow-up. A technique and evidence for repairing a posterior horn of the medial meniscus were also presented by Marzo and Kumar.[36]

It is the senior author's experience that many posterior horn radial tears will heal spontaneously. Evidence for this can be seen at arthroscopy in the first few weeks after such an injury. However, in these cases the tear healing is not anatomic with granulation tissue spanning the gap. The meniscus appears to be well healed when viewed many months later but is not at the correct length. Similarly, posterior horn avulsions appear innocuous when viewed a long time after the injury, because the meniscus simply appears (or is considered on probing) to have a deficient attachment. It is suggested, though not proven, that such defunctioning of the lateral meniscus can lead to early degeneration of the lateral compartment in areas not affected by the initial bone bruising from the original injury. In addition, a defunctioning of the pos-

terior horn of the lateral meniscus can lead to increased rotational instability of the knee, thus predisposing patients to failure of an ACL reconstruction and to further degeneration.

There are 3 major limitations of this study that must be considered when one applies these findings to clinical practice. First, we acknowledge that different repair techniques have been undertaken for the meniscal repairs, and therefore a bias may exist with respect to success of the repair. Second, only 50% of cases of radial tear and PHD were considered appropriate for repair/reattachment; hence, a bias exists in our patient population. Third, the examination of choice by which to assess meniscal healing is second-look arthroscopy; however, it is not ethically appropriate to perform arthroscopic procedures where they are not clinically indicated. We were able to arthroscopically assess 5 patients when treating unrelated injuries in the same knee; the remaining patients were assessed by MRI and/or clinically based questionnaire. Thus we have assumed a lack of clinical symptoms or signs over our follow-up time frame to imply functional success of the repair. The only true measure of meniscal tissue healing would be histologic examination, which is not ethically possible in patients.

CONCLUSIONS

Posterior radial tear or PHD of the lateral meniscus occurs frequently in the setting of an acute ACL disruption or a subsequent instability episode. We have shown that some posterior radial tears and PHDs of the lateral meniscus are amenable to repair and that a repaired tear can function successfully. Our follow-up of these patients did not indicate any persistent symptoms or signs to suggest failure of the repair or related arthritic degeneration. We believe this provides evidence, at least in part, for extending the scope of meniscal repair to include treatment of radial tears and PHDs.

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