Meniscal repair has been the subject of much innovation as investigators have demonstrated the crucial role that the meniscus plays in load transmission, shock absorption, joint stability, and improving nutrition to the articular surface. Techniques have evolved from early reports of open meniscal repair by DeHaven to modern all-inside repair. Meniscal repair using suture placed “inside-out” has become the gold standard to which other techniques are compared, with 10-year success rates of approximately 90% when performed with concurrent anterior cruciate ligament reconstruction (ACLR) and anterior cruciate ligament reconstruction (ACLR).

Numerous all-inside devices have been developed to simplify meniscal repair by avoiding the need for a separate incision and thereby decreasing operative time and the risk of neurovascular injury. Although short-term success rates for one commonly used rigid all-inside device have ranged from 88% to 100%, long-term follow-up has revealed deteriorating outcomes, with a success rate of only 71%. In addition to lower success rates, the rigid “second generation” all-inside devices have been associated with inflammatory reaction, cyst formation, migration, breakage, and chondral injury.

The newer “third generation” all-inside devices use suture to place compression across the tear and provide flexible fixation to help prevent chondral wear. One of these devices, the RapidLoc (Mitek, Westwood, Mass), uses either a 2-0 Ethibond or 2-0 Panacryl suture (DePuy Mitek Inc, Raynham, Mass) between a poly-L-lactic acid scaffold.
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(PLLA) “backstop” and either a PLLA or polydioxanone (PDS) “top hat.” Although this device has been shown to have comparable biomechanical characteristics to suture techniques under cyclic loading and initial pull-out strength, no studies to date have investigated its clinical success.

The purpose of this study was to determine the healing rate of all-inside meniscal repair using the RapidLoc device in patients undergoing concurrent ACLR. The secondary goal of this study was to determine the predictive variables for failure of meniscal repair using this device. We hypothesized that the RapidLoc has an intermediate-term meniscal healing rate equivalent to published results with the inside-out suture technique in patients undergoing concurrent ACLR.

METHODS

Retrospective analysis was performed for 75 meniscal tears in 66 consecutive patients undergoing ACLR and meniscal repair with the RapidLoc device. The Human Investigation Committee at the University of Virginia approved the study. An explanatory letter was sent to each patient describing the purpose of the study. Patients meeting exclusion criteria included those with multiligament reconstruction (1 patient), younger than 18 years at the time of follow-up (5 patients), postoperative infection (1 patient), hybrid repairs using both all-inside and inside-out techniques (4 patients), and reinjury resulting in ACL graft rupture (1 patient). Eight patients were lost to follow-up. These exclusions resulted in 54 meniscal tears in 46 patients for analysis.

All patients underwent meniscal repair with the RapidLoc in the context of ACLR between February 2001 and May 2003. At the time of this study, only the RapidLoc with the PLLA “top hat” was commercially available and was used exclusively. We chose the nonabsorbable suture combination to avoid potential problems with differential absorption rates between the suture and “top hat.” The procedures were performed by the senior author (D.R.D.) at the outpatient surgery center affiliated with the university hospital. The ACLR was performed using either bone–patellar tendon–bone (BTB) or hamstring (HS) autograft, and all meniscal tears were deemed amenable to repair according to length, stability, shape, and zone of tear.

The technique for tear preparation included use of an arthroscopic rasp on both the superior and inferior parameniscal capsule before repair to optimize healing. The technique for the insertion of the RapidLoc included piercing the meniscal fragment with the application needle attached to the handle, advancing the needle across the tear to the silicone sleeve (which acts as a depth limiter), and deploying the “backstop.” The suture was then pulled to ensure fixation of the backstop, followed by advancing the “top hat” over the suture with the use of a specific knot pusher until tension was created in the suture to achieve compression across the repair (Figure 1).

The rehabilitation protocol was unchanged from that of an isolated ACLR. Patients were allowed immediate crutch-assisted weightbearing and range of motion from 0° to 60° in a hinged long leg brace for 2 weeks postoperatively. The brace was then discontinued, and range of motion was advanced as tolerated. Return to sport was at 6 months or when isokinetic quadriceps strength was within 10% of the contralateral leg, whichever was sooner.

Figure 1. A, RapidLoc device with “backstop” (right end) and “top hat” (left end) with 2-0 Panacryl suture (in between). B, device loaded in application needle. C, drawing showing final position of 3 RapidLocs.
Patients with at least 2 years’ follow-up were evaluated for symptoms suggestive of a meniscal tear. Follow-up assessment included the International Knee Documentation Committee (IKDC) subjective form and the Knee Disorders Subjective History visual analog scale (VAS) to characterize the outcome of the knee reconstruction. The VAS, as proposed by Flandry et al to analyze the success of meniscal repair, has been shown to correlate with other scoring methods such as the Noyes, Larsen, and Lysholm scales, while eliminating the bias introduced by examiner questioning.

Patients were asked to return for a clinical examination to include evaluation for an effusion and joint line tenderness as well as a McMurray test. The status of the ACLR was evaluated by physical examination and with KT-1000 arthrometry. Patients with symptoms consistent with failure were evaluated with MR arthrography and repeat arthroscopy. These patients failed the clinical criteria for success with (1) locking, catching, or giving way; (2) history of recurrent effusions; (3) joint line tenderness; and/or (4) a positive McMurray test result. Patients requiring meniscectomy of the repaired meniscus were considered to have a failed result. If the patient was unable to return to the clinic, telephone interviews were conducted to complete the aforementioned questionnaires (23 interviews were conducted). A review of the hospital and office records was used to compile a historical database. So as to eliminate any interviewer bias, a qualified examiner who was uninvolved with the index procedure performed the follow-up assessment.

Data analysis was performed with SPSS 12.0 (SPSS Inc, Chicago, Ill). Univariate categorical analysis was by Pearson χ² tests and Fisher exact tests. Univariate continuous analysis was by 2-tailed t tests with equal variances and Mann-Whitney U tests. An α value of .05 was considered significant for all tests. Multitest correction of the Bonferroni type was used to account for the use of multiple univariate tests; this correction modifies the significant α value according to the number of tests run.

RESULTS

Forty-six of 49 (93.9%) patients were evaluated at a mean follow-up of 34.8 months (range, 24-50 months). Five repaired menisci required subsequent arthroscopic meniscectomy. This result represents a success rate of 90.7% (49/54).

All tears were located in either the red-red (5 tears) or the red-white (49 tears) zones and were of vertical (46 tears), bucket-handle (4 tears), or multiplanar (4 tears) type. Bucket-handle tears were defined as those meniscal tears that were displaceable with a probe into the notch. There were 29 medial meniscal tears and 25 lateral meniscal tears. All tears involved the posterior horn, with varying amounts of extension into the body of the meniscus. The length of tear averaged 1.8 cm (range, 1.0-3.5 cm); a mean of 1.8 RapidLoc devices (range, 1-4 devices) were used to accomplish the repair. The study population consisted of 24 men and 22 women, of which 34 had a BTB graft and 12 had an HS graft. The interval of time between knee injury and meniscal repair (chronicity) averaged 3.1 months (range, 0.5-36 months).

Figure 2. Intraoperative photographs (A) after injury, (B) after RapidLoc repair, and (C) 14 months after repair. The suture is faintly visible at final follow-up, with tissue overgrowing the “top hat.”
Second-look arthroscopy of 3 patients with symptoms consistent with failure revealed healed repairs at 4, 8, and 14 months (Figure 2). All failures had an intact ACL graft confirmed during arthroscopy. The mean KT-1000 arthrometer side-to-side difference at 30 lb of displacement was 0.82 mm (range, −1.25 to 3.5 mm) for all patients. Using the criteria of DeHaven et al,7 all of the meniscal repair failures occurred in stable knees. No evidence of chondral damage from the RapidLoc implant was noted in the 8 knees undergoing repeat arthroscopy.

The results of the univariate analysis are presented in Table 1. For a significance cutoff of \( P < .05 \), predictive variables for failure included chronicity longer than 3 months, bucket-handle tears, multiplanar tears, and tear length greater than 2.0 cm. The results for nonparametric analysis of continuous variables by Mann-Whitney \( U \) tests and categorical variables by Fisher exact tests did not differ from the parametric analysis. After multittest correction of the parametric analysis, chronicity was no longer significant, but bucket-handle tears, multiplanar tears, and tear length greater than 2.0 cm remained significant predictors (corrected \( \alpha = .0045 \)). As a clinical outcome variable, IKDC score only bordered on significance \( (P = .058) \) between healed and failed repairs before multittest correction. For healed patients, there was a significant negative correlation between chronicity and IKDC score (Pearson correlation \( r = -.43, P = .002 \)).

Analysis by \( t \) tests of VAS scores between patients with healed and failed tears revealed that their responses differed significantly on only 3 questions of the VAS instrument: Question 3, “Do you have swelling in your knee?” \( (1.85 \pm 1.82 \text{ vs } 4.80 \pm 3.63, \text{ respectively}; P = .003) \); Question 16, “Do you have problems running?” \( (1.55 \pm 1.15 \text{ vs } 3.40 \pm 1.95, \text{ respectively}; P = .003) \); and Question 21, “Do you have night pain?” \( (1.10 \pm 0.37 \text{ vs } 2.20 \pm 2.68, \text{ respectively}; P = .007) \). After multittest correction, no question was significantly different (corrected \( \alpha = .0018 \)).

**DISCUSSION**

The reported healing rates for meniscal repairs in knees undergoing concurrent ACL reconstruction range from 83% to 93% using either the inside-out or outside-in suture technique.5,14,16,20,29 Any new meniscal repair device must be measured against this standard. Using an all-inside
All-inside techniques with rigid second-generation devices have found short-term success, but the meniscal arrow in particular has been associated with deteriorating long-term results and complications associated with this implanted device.\textsuperscript{1,2,21,25,28,31,33} In our series, with an average of 34.8 months’ follow-up, we had a success rate of 90.7% for meniscal healing. This figure is comparable with the healing rates reported with the gold standard inside-out repair technique when the ACL is concomitantly reconstructed and the healing environment optimal.

Analysis of the predictive variables for failure yielded expected results, with larger multplanar tears repaired at a longer interval from the time of injury being more likely to result in failure. More specifically, our best results with this all-inside device were in tears less than 2.0 cm in length and repaired less than 3 months after injury. In addition, complex tears such as the bucket-handle and multplanar types were statistically less likely to heal when repaired with this device. It is important to recognize, however, that this study population was undergoing concurrent ACLR. With higher meniscal repair healing rates encountered in this setting, this study cannot be extrapolated to ACL-stable knees, which would need to be studied separately. Although we did not examine it with this study, we suspect that similar results might also be encountered with inside-out suture techniques in tears with these characteristics. Also, 3 of the 4 patients with repair failures suffered a new injury after their repair (3, 6, and 14 months postoperatively). The mechanism of injury was not severe and did not result in disruption of their ACL graft based on physical examination, KT-1000 arthrometry, or direct visualization of the graft during their meniscectomies. One of the patients with a reinjury was found to have a failed medial repair but a well-healed lateral repair during arthroscopy. Whether the new injuries were the cause of the failures (retear of a healed meniscus) or were simply coincidental cannot be determined, although the patients manifested symptoms after their new injuries.

The IKDC and VAS instruments are useful outcome measures for both the ACL reconstruction and meniscal repair. Although comparison of the IKDC scores in failures to healed repairs did not reach statistical significance, it closely approached it ($P = .058$). The IKDC form has been found to be a reliable and valid knee-specific measure of symptoms, function, and sports activity that is appropriate for patients with a wide variety of knee problems.\textsuperscript{13} Although this test has been shown to be useful in the evaluation of meniscal injuries, it is not specific for this injury. Lower scores could indicate morbidity associated with articular cartilage lesions, osteoarthritis, and patellofemoral pain. Because these variables are difficult to control, we cannot attribute the lower IKDC scores in this study to repair failure alone. The negative correlation between IKDC score and chronicity of repair is expected, as those patients with a longer interval between injury and repair may have developed associated morbidity from secondary changes to their articular cartilage. The VAS form was useful as a standardized method of screening patients for multiple causes of morbidity associated with the knee. The 28-question form showed the ability of the patients to return to a high level of activity without symptoms suggestive of a meniscal tear. Although analysis of most questions did not reveal significance when comparing patients with healed and failed repairs, there was a significant difference in these 2 groups with regard to knee swelling, problems running, and night pain for univariate tests, although no question remained significant after multistest correction. It is also important to recognize that despite these clinical determinations of an asymptomatic meniscal repair, some of the repairs may not have healed or may only have partially healed and could be symptomatic in the future.

With the numerous reports of complications associated with rigid all-inside meniscal repair devices, it is important to emphasize the lack of evidence of chondral injury during this study’s second-look arthroscopy of the RapidLoc. Although only 3 patients with successful repairs underwent the second-look arthroscopy, the remaining healed patients were asymptomatic in comparison with those suffering complications from rigid all-inside devices.\textsuperscript{1,2,21,25,28,31,33} The question remains whether this finding may be attributable to the “third-generation” design of the flexible all-inside fixation, using suture to span the meniscal tear. Biomechanical analysis of the design has demonstrated this technique to be a good alternative to conventional suture techniques, with the RapidLoc in particular revealing characteristics comparable with horizontal inside-out suture.\textsuperscript{14,35} Cadaveric evaluation of the 2 most commonly used commercially available third-generation devices has revealed some technical pitfalls. These include a potential neurovascular risk from the depth of the needle-stick with the FasT-Fix (Smith & Nephew Inc, Andover, Mass) and entrapment of the popliteus tendon and superficial medial collateral ligament with the RapidLoc or the FasT-Fix.\textsuperscript{22,24} The authors of the RapidLoc study pointed out, however, that the entrapment of the soft tissue structures is unlikely to represent a significant clinical problem and is also commonly encountered with the inside-out suture technique.\textsuperscript{22}

The potential shortcomings of this study include different aspects of its design. A prospective, randomized study with a direct comparison to inside-out suture techniques would clearly be ideal and provide a higher level of evidence. Although not as powerful, this retrospective analysis reveals important clinical information that may be useful in operative decision making in the treatment of a common problem. The evaluation of patients’ subjective symptoms to determine healing of their repairs leads to the criticism that failed repairs may be asymptomatic and therefore underrecognized. This study is a clinical assessment of healing only, and the true healing rate cannot be known for certain without second-look arthroscopies. The patients lost to follow-up also bring to question the impact of their potential outcomes on the results of the study. At their last follow-up, all these patients were clinically healed (mean follow-up time, 4.6 months). Assuming all these patients continued to be clinically healed at 24 months yields a healing rate of 91.6%; assuming that all these patients failed yields a healing rate of 83.1%. Finally, it is possible that a follow-up longer than 2 years will yield diminished results, and it
should be recognized that the inside-out suture technique remains the standard until these results are revealed.

Previous authors have clearly illustrated the importance of meniscal preservation.\textsuperscript{8,15,12,14,17,19,27} The inside-out suture technique can be challenging, particularly for surgeons with less experience or with less-experienced assistants. All-inside meniscal repair devices offer a way of overcoming that obstacle. The goal for all-inside devices is to provide the dual benefits of a durable repair and minimal invasiveness. The newer third-generation devices are being used with increasing frequency but, to date, lack follow-up studies to determine their rate of success. Although this is not a direct comparison with the gold standard inside-out suture technique, the intermediate-term results for the all-inside technique using this device are equivalent to those quoted in the literature for the inside-out technique. Because of the paucity of published studies with any of the all-inside devices, it is impossible to conclude that these devices are better than the thoroughly studied inside-out techniques. Nonetheless, all-inside suture techniques are commonly employed, especially in the presence of a concomitant ACL reconstruction. To our knowledge, this study provides the longest clinical follow-up in the literature of patients undergoing meniscal repair with the RapidLoc during concurrent ACLR. Predictive variables for failure of meniscal repair using this technique should be considered during operative decision making. Based on our statistical analysis of variables, the ideal tear for repair with this RapidLoc device appears to be 2 cm or less, vertical, involving the posterior horn, and earlier than 3 months after injury. However, we cannot extrapolate these results to isolated meniscal repair with an intact ACL, where healing rates are known to be substantially less.\textsuperscript{3}

REFERENCES


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