Original Article

Arthroscopic repair of the meniscal injury using meniscal repair device

Tang Hengtao, Su Xuntong[1]

Abstract

Background: Total meniscus resection after meniscus tear usually leads to faster degeneration and osteoarthritis of the knee joint. Preservation and repair of the injured menisci are therefore of great clinical importance. The aim of this study was to evaluate the clinical effects of arthroscopic repair of meniscal injuries using the Fast-Fix device.

Materials and Methods: 96 patients (58 males, 38 females) with mean age of 24.3 years (range 12–46 years)) with a meniscus injury were treated with the Fast-Fix device under arthroscopy between July 2007 and June 2009. The right and left knees were involved in 46 and 50 patients respectively. In 12, 46 and 38 patients, the injury was located in the anterior horn, body and posterior horn respectively. In 38, 45 and 13 patients, it was in the red, red-white, and white regions, respectively. All-inside and outside-in techniques were used for these meniscal injuries. Criteria for successful surgery were no locking pain or swelling and a negative McMurray test.

Results: The mean followup period was 3.7 years (range 2–5 years). The surgical success rate was 91.7% (n = 88). The mean Lysholm score increased from 47.8 ± 10.4 preoperatively to 85.7 ± 12.8 postoperatively. The mean Tegner activity score was 7.4 ± 1.6 (range 5–9) preinjury, 2.1 ± 0.9 (range 0–4) preoperatively and 7.2 ± 2.2 (range 4–10) postoperatively ($P < 0.001$). A total of 92 patients (95.8%) returned to full-time work. The International Knee Documentation Committee score increased from 32.7 ± 10.7 (range 10.3–51.7) preoperatively to 82.5 ± 5.1 (range 65.1–91.2) postoperatively ($P < 0.001$).

Conclusions: The Fast-Fix system is an efficient, safe and effective suture technique for meniscal repair.

Key words: Fast-Fix, knee arthroscopy, meniscus, meniscus injury, arthroscopic repair

Mesh terms: Menisci, tibial, arthroscopy, arthroscopic surgical procedure

Introduction

The principal functions of an intact knee meniscus include transmitting load, increasing tibiofemoral congruency and stabilizing the joint.[1-4] Partial or complete meniscal resection may obtain good results in the short term after surgery; however, many researchers have reported the occurrence of degenerative arthritis during mid or long term followup. Jørgensen *et al*.[5] reported that 89% of patients undergoing complete meniscectomy had demonstrable degenerative changes on radiographs after a followup period of 14.5 years. Other studies obtained similar results.[6-10] If a meniscus is resected, it is likely that articular degeneration will eventually occur, so it is preferable to retain and repair the meniscus rather than resect it.

Improvements in arthroscopic surgical techniques have lead to meniscus preserving therapy. Many meniscal repair techniques and devices have been developed to facilitate meniscal repair.[11-13] Fast-Fix™ (Smith and Nephew Endoscopy, Andover, MA, USA) is one of the most popular meniscal repair devices. The aim of this study was to evaluate the clinical results of arthroscopic repair of various types of meniscal tears using the Fast-Fix™ Ultra system, applying standard all-inside or outside-in suturing techniques.

Materials and Methods

Ninety-six patients meeting our inclusion criteria underwent repair of their meniscal tears using the Fast-Fix™ Meniscal Repair Suture System and were successfully followed for a mean of 3.7 years between July 2007 and June 2011. The

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inclusion criteria were patients with acute or degenerative longitudinal, horizontal or radial meniscal tears in the red-red zone (<3 mm from the meniscocapsular junction) or red-white zone (between 3 and 5 mm from the meniscocapsular junction). There were no age restrictions. The exclusion criteria were patients with complex meniscal tears, serious defects, multiple longitudinal tears, longitudinal tears in the white zone >2 cm long, dissociated or fragmented menisci and fragile tears in which previous attempted repairs were unsuccessful. Patients with anterior cruciate ligament deficient knees were also excluded.

Of the 96 patients (58 males and 38 females), the mean age at the time of surgery was 24.3 years (range 12–56 years). Surgery was performed at an average of 44 days (range 3 days – 1 year) after the knee injury. Forty right and 56 left knees were included, involving injuries to 44 lateral menisci and 52 medial menisci. Of these, 12, 46 and 38 meniscal tears were located in the anterior horn, body and posterior horn of the menisci, respectively [Table 1]. In addition, 38, 45, and 13 menisci were injured in the red, red-white and white regions, respectively. All-inside and outside-in suturing techniques were used in 84 and 12 cases respectively. A mean of 2 (range 1–4) Fast-Fix™ devices (sutures) were used for each patient, spaced at an interval of approximately 5–8 mm.

Preoperatively, the meniscal tear was diagnosed by physical examination findings. McMurray and Appley tests were routinely used to assess positive signs of a meniscal tear, such as locking, pain on palpation of the joint line, joint snapping and presence of an effusion. The Lysholm rating system, Tegner activity score and International Knee Documentation Committee (IKDC) activity score were recorded to evaluate knee function. All patients underwent preoperative magnetic resonance imaging (MRI) for evaluation and to provide a surgical reference, but the results of this imaging alone were not used to provide a definite diagnosis because of the possibility of false positives and false negatives.

The criteria used to define clinical success were the presence of Barrett criteria and/or arthroscopically verified meniscal healing. The Barrett criteria[14] included no joint locking or swelling, no pain on palpation in the joint space, free motion, and a negative McMurray test. If any of these conditions were noted, the result was classified as a failure.

Table 1: Types of meniscal tears

Type	Red	Red/white	White/white	Total
Longitudinal	13	22	8	43
Radial	21	18	3	42
Horizontal	4	5	2	11
Total	38	45	13	96

Ethical clearance was obtained for the study from the ethics committee of Zhengzhou University. All included patients provided written informed consent for participation in the study. Followup data were obtained by annual clinic visits, mailed questionnaires and telephone calls. Data regarding the results and adverse events were collected and recorded.

All-inside operative procedure

The all-inside technique was the most commonly used approach. In the red or red-white region, bucket handle tears parallel to the meniscocapsular junction, radial tears, horizontal tears and even transection injuries or defects were commonly sutured using the all-inside technique [Figure 1].

The tear position and type was first identified arthroscopically. If the tear was dislocated, as with a bucket handle tear, then reduction was performed. If the tear could be sutured, we used a meniscal rasp and shaver to freshen the tear edges because this stimulates vascular growth and wound healing. After determining the desired penetration with a meniscal depth probe, we trimmed the depth limiter of the Fast-Fix system accordingly. The Fast-Fix delivery needle (Fast-Fix Ultra) was introduced through the split cannula. We usually used a 30° angle needle to facilitate penetration. The needle pierced the surface of the inner meniscal fragment perpendicularly and was then advanced into the peripheral meniscal fragment to the end of the depth penetration limiter. A probe hook confirmed the stability of the suture and we observed the meniscal dynamic status when the

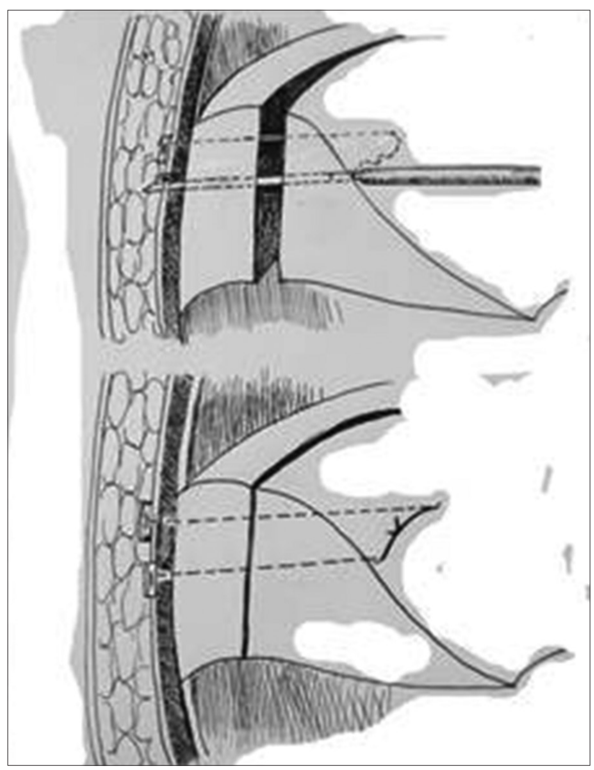

Figure 1: Diagrammatic representation of all-inside technique

knee joint was extended and flexed. We repaired the radial and horizontal tears similarly with the all-inside technique.

Meniscal body transection was sometimes deemed a contraindication for the all-inside suture technique. We attempted to suture the tear using two Fast-Fix devices during arthroscopy and were able to recover the crescent-shape of the meniscus [Figure 2a-c].

Outside-in

We generally use the outside-in technique to repair certain kinds of anterior horn and posterior horn longitudinal tears, especially the former, because the all-inside suture technique is difficult to perform on these injuries. In our study, there were 12 cases with anterior horn injury, which were all longitudinal tears parallel to the capsule in the red. For other types of anterior horn injuries, other methods should be used.

For the outside-in approach, we first punctured the knee joint with a 2-mm syringe needle in the position corresponding to the anterior horn tear and then directed the needle to the tear fragment. We subsequently made an 8-mm skin incision near the syringe puncture point, leaving the capsule intact. The light source of the arthroscope radiated inside-out, and the capsule was semitransparent, so we were able to observe the neurovascular bundles and avoid injuring them. The Fast-Fix needle punctured the capsule, entered the joint space, and released the first anchor by puncturing the anterior horn tear segment with a gentle rotation motion. The needle was then withdrawn and reinserted into the joint cavity 5-mm lateral to the first puncture, placing the second needle perpendicular to the tear. The gold trigger was then slid forward to advance the second anchor. Both anchors were beneath the anterior horn. After the second anchor was in place, the delivery needle was removed from the joint, leaving the free suture ends, and the self-sliding knot outside of the capsule [Figure 3a-c]. Finally, the pretied self-sliding knot was tightened with the aid of the knot pusher/suture cutter. Arthroscopic examination confirmed that the meniscus tear segments were juxtaposed and repaired. The knots were tightened outside the capsule and the excess suture was cut with the knot pusher/suture cutter or arthroscopic scissors. The same suture technique was also used for posterior horn tears [Figure 3a-c]. In this group, the injury area of the anterior horn was located in the red-red zone (<3 mm from the meniscocapsular junction) and all injuries were longitudinal tears parallel to the capsule in the red-red region. After freshening the tear edges, the tear segments were located 1–3 mm from the capsule if our two puncture points were 1–2 mm from the tear edge. We fastened the pretied self-sliding knot outside the capsule, and the anchors adhered firmly to the inferior surface of the meniscus. As observed through the arthroscope at the end of surgery, the anchors were depressed in the soft meniscus. The suture position was outside the weight bearing zone of

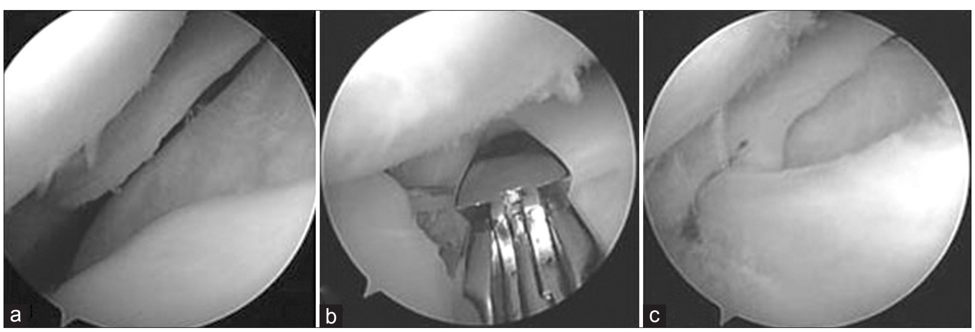

Figure 2: Arthroscopic view (a) The lateral meniscus was transected approximately 10 mm; the chondral damage had occurred in the tibial plateau. (b) We made an auxiliary incision through the patellar tendon to allow grasper tongs to grab the far end of the meniscus. (c) Both stumps were sutured together and then smoothened along the meniscal rim

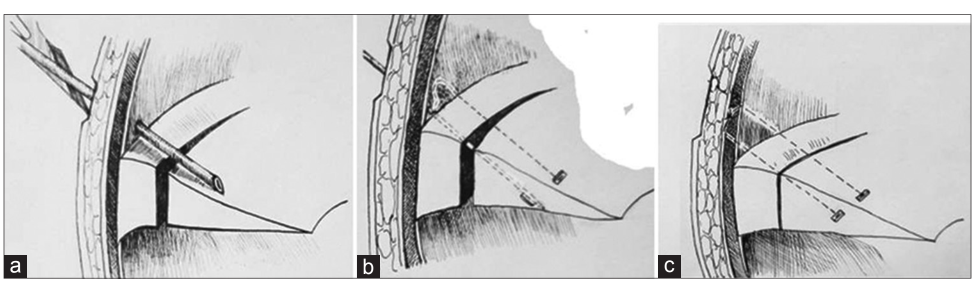

Figure 3: Diagrammatic representation of outside-in technique – (a) A 2-mm syringe needle was used to determine the puncture point and direction for making an incision. (b) After releasing the first anchor, we withdrew and reinserted the needle into the joint cavity to puncture the meniscus segment 5-mm lateral to the first insertion point. (c) When the second anchor was in place, the delivery needle was removed from the knee joint, leaving the free end of the sutures and the self-sliding knot outside the capsule. The knot was tightened with a knot pusher/suture cutter

the joint. We also used a probe hook to confirm the stability of the anchors.

Rehabilitation

Postoperatively, all patients underwent routine rest, ice, compression, elevation (RICE) therapy and used a hinged brace. Active motion was restricted between 0° and 60° for the first 3 weeks after surgery and between 0° and 90° in the fourth week; this was followed by an increase in the range of motion (ROM) between 0° and 120° for another 2 weeks. Continuous passive movement (CPM) was begun earlier, starting shortly after the acute response to the operation regressed (at 3–4 days postoperatively). ROM of passive knee joint flexion was applied according to this program: 90° in the first week, 100° in the second week, 110° in the third week, and 120° in the fourth week.

All patients with a meniscal body injury were restricted from weight-bearing until 2 weeks after surgery. In the third week, 25% weight-bearing was allowed, followed by 50% and 75% weight-bearing in the fourth and fifth weeks. The patients progressed to full-weight-bearing by 6–8 weeks postoperatively. With anterior horn injuries, the full-weight straight-knee movement was permitted shortly after the operation. Jogging was permitted after the 10th postoperative week, and full activity was allowed at 6 months for all patients.

Statistical analysis

Statistical analyses were performed using SPSS version 13.0 (SPSS Inc, Chicago, IL) for Windows. Data are shown as mean ± standard error of the mean, except where indicated otherwise. The Student's *t*-test was used to compare continuous variables. The Chi-square test was used to evaluate the differences in clinical outcomes between potential associated factors. *P* values below 0.05 were accepted for statistical significance.

Results

A total of 96 patients who underwent meniscus repair with the Fast-Fix device were followed for a mean of 3.7 years (range 2–5 years). All patients underwent postoperative MRI scans at their final followup. There were no complications, such as infection, or neurovascular injury, during the perioperative period. In this group, no anchor failed and no loose body was detected in the anterior horn suture until the present time. At the last followup visit, we found no symptoms of meniscal tears in 88 patients (91.7%). Of the eight patients with surgical failures, 2 (2.0%) had symptoms (joint locking and/or snapping) and a positive McMurray test at 6 and 11 months postoperatively. Arthroscopic reexploration of these patients identified anchor loosening or exfoliation into the joint space; one was successfully treated by reinserting the suture, and the other underwent partial meniscectomy. Five patients (5.2%) had tenderness on palpation of the joint line; one of these patients also had a positive McMurray test. No other patients had locking or snapping throughout followup. One patient (1.0%) sustained a sports injury 13 months after the first operation, which required a second operation for anterior cruciate ligament reconstruction.

Lysholm, Tegner, and IKDC rating systems were used to determine knee function and patient activity levels [Table 2]. The mean postoperative Lysholm score of the operated knees was 85.7 ± 12.8 (range 51–100), which was significantly better than the mean preoperative value of 47.8 ± 10.4 (range 25–62) ($P < 0.001$, paired *t*-test). The mean preinjury Tegner activity score was 7.4 ± 1.6 (range 5–9) and the mean preoperative Tegner score was 2.1 ± 0.9 (range 0–4), which increased postoperatively to 7.2 ± 2.2 (range 4–10) ($P < 0.001$). A total of 92 patients (95.8%) had returned to full time work by the time of the last followup. The IKDC score increased from 32.7 ± 10.7 (range 10.3–51.7) preoperatively to 82.5 ± 5.1 (range 65.1–91.2) postoperatively ($P < 0.001$).

Outcomes were not significantly associated with any of these factors, including chronicity of the injury; patient age; or length, zone, or location (anterior horn, body, or posterior horn) of the tear [Table 3].

Discussion

Meniscectomy was initially viewed as a simple and at least in the short term, effective approach to treat meniscus injuries. With the recognition that meniscectomy carried the latent risk of cartilage degeneration and osteoarthritis in the long term, new approaches to correct meniscus injuries were developed. At present, most experts recommend meniscus preservation or reconstruction techniques whenever possible. Repair techniques generally fall into three categories: Inside-outside, outside-inside, and all-inside. Compared to other techniques, the all-inside approach became popular because it is a less invasive and simpler surgical technique with a shorter surgical time and minimal surgical risk. Many all-inside meniscal repair techniques have been described.[15]

Table 2: Preoperative and postoperative clinical scores

Scale	Preoperative score	Range	Postoperative score	Range	*P*
Lysholm	47.80±10.4	25-62	85.7±12.80	51-100	<0.001
IKDC	32.7±10.7	10.3-51.7	72.51±8.1	55.1-86.2	<0.001
Tegner	2.1±0.9	0-4	8.1±1.2	4-10	<0.001

Data are mean±SE of the mean. IKDC=International Knee Documentation Committee, SE=Standard error

Table 3: Factors potentially associated with clinical outcomes after meniscus repair

Factor	Success (n=88)	Failure (n=8)	Total (n=96)	χ^2 (P)
Chronicity				
>4 weeks	38	5	43	χ^2=1.106 (0.292)
<4 weeks	50	3	53	
Age				
>35 years	41	4	45	χ^2=0.034 (0.853)
<35 years	47	4	51	
Zone				
Red-red	38	0	38	χ^2=5.773 (0.055)
Red-white	39	6	45	
White-white	11	2	13	
Length of tear				
>20 mm	29	3	32	χ^2=0.001 (0.970)
<20 mm	51	5	56	
Location of tear				
Anterior horn	12	0	12	χ^2=1.487 (0.475)
Body	41	5	46	
Posterior horn	35	3	38	

Data are number of patients (%). Success was defined according to the Barrett criteria

Fast-Fix is one of the most popular recently-developed meniscal repair devices. Biomechanical research reported that Fast-Fix exhibits superior biomechanical characteristics.[16-18] Fast-Fix is a suture-based and self adjusting approach that uses two 5-mm PLLA suture anchors, connected via a preloaded, pretied, self sliding, self-locking knot of No. 0 nonabsorbable braided polyester suture. In the procedure, after inserting the two anchors, the pretied self sliding knot is tightened with the aid of a knot pusher, which further compresses the torn meniscal segments together. The device is delivered via an arthroscopic insertion needle. The needle can be straight or curved at a 30° angle. The auxiliary components include a split sheath insertion cannula to avoid soft tissue tangling and a separate knot pusher/suture cutter.

Indications for meniscal repair should be in accordance with the condition of the meniscus. Most scholars[19-21] suggest suturing tears in the red-red (<3 mm from the meniscocapsular junction) or red-white (between 3 and 5 mm from the junction) zones. Studies suggest that meniscal tears in the avascular zone do not have the capability to heal spontaneously, whereas the vascularized peripheral one third of the meniscus has a greater healing potential because a blood supply is essential for tissue repair. Nevertheless, tear extension into the avascular area is not an exclusion criterion. Rubman *et al*. reported that 80% of 198 meniscal tears extending into the avascular zone remained asymptomatic at followup after surgical repair.[22] The chance of healing is increased if either the tear is located in the vascularized area or if access to blood elements is created.[23] Many techniques have been reported to promote healing of vascular and avascular areas, including trephination, fibrin blood clots, fibrin glue, and meniscal rasping. We agree with Noyes and Barber-Westin,[24] who repaired meniscus tears that extended into the avascular zone with good results. If there is any possibility to save the meniscal tissue, then we should try our best to recover the original meniscal shape and avoid simple resection, even if the tear extends into the avascular zone.

In the current study, two patients had symptom (joint locking and snapping) recurrence at 6 and 11 months postoperatively and arthroscopic reexploration identified anchor loosening or exfoliation into the joint space; one was successfully treated by overhauling the sutures and the other by partial meniscectomy. To avoid anchor dislocation, the needle tip must penetrate the surface of the meniscus fragments and be withdrawn from the meniscus with a gentle oscillating motion, leaving the anchors; if the rim of the meniscal fragment is too fragile to suture, we should not be reluctant to remove it. Some patients developed stiffness and muscle atrophy of the operative knee because of poor compliance with early stage rehabilitation training. Physical therapy needs to be initiated immediately after surgery. The "RICE" principle, combined with early-stage no or partial weight-bearing, is helpful in facilitating recovery.

We believe that a meniscal repair that is asymptomatic postoperatively does not always reflect true meniscal healing, which is only verifiable by second look arthroscopy. Postoperative MRI was not performed unless clinical evaluation suggested a failure of the meniscal repair; this was a limitation of our study. Nevertheless, Morgan *et al*. reported that clinical examination is a reliable method of evaluating the status of repaired menisci.[25] We also combined the examination with strict criteria to determine the clinical results. The clinical results of the present series were similar to those of previous reports. After a mean followup of 3.7 years, our success rate was 91.7% (88 of 96 patients) using the criteria of Barrett *et al*.[14] The mean preinjury Tegner activity score was similar to that of postoperative score. By the last followup, 92 patients (95.8%) had returned to full-time work.

There are no vessels and nerves in the medial portion of the meniscus; they exist in the peripheral portion. When the meniscus is torn, symptoms of pain originate from the torn meniscus causing drag across the joint capsule and shearing in the tibio femoral joint. Accordingly, we consider that the key point in achieving clinical cure is to make all efforts to restore meniscal continuity and original shape by suturing or meniscoplasty.

Usually, we use the outside-in technique to repair anterior horn injuries, which in this study were all longitudinal tears parallel to the capsule in the red or red-white region. When the knots were tightened outside the capsule, the anchors fastened the anterior horn to the capsule. The anchors were beneath the meniscus and all patients felt soreness or pain on palpation around the suture area for 3 months postoperatively. However, there were no other complications, such as locking, or pain in hyperextension. With active local therapy, these symptoms gradually resolved, so that at the last followup, all patients obtained good results.

Conclusion

Meniscal repair with the Fast-Fix meniscal repair system provides excellent clinical results in the vast majority of patients, with a success rate of 91.7% in this relatively short term followup study; this is comparable to the success rates of traditional suture techniques. Long term followup studies are needed to determine whether the repaired menisci will maintain structural and functional integrity over time. In addition, we found that the Fast-Fix system has the advantage of avoiding neurovascular complications. An acceptable cure rate using this device can be expected, even in chronic tears, tears extending into the red-white zone, and patients more than 30-years-old. The Fast-Fix system is an efficient, safe and effective suture technique for meniscal repair.

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