



Original Article

Second look arthroscopic evaluation of repaired radial/oblique tears of the midbody of the lateral meniscus in stable knees

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ABSTRACT

Background: Radial/oblique tears of the midbody of the lateral meniscus significantly impair the ability of the meniscus to withstand the tibiofemoral load, requiring meniscal repair. However, healing status after meniscal repair has not been fully elucidated. This study aimed to evaluate arthroscopic findings after inside-out suture repair for isolated radial/oblique tears of the midbody of the lateral meniscus.

Methods: From 2011 to 2015, 18 consecutive patients with isolated radial/oblique tears of the midbody of the lateral meniscus underwent arthroscopic inside-out repair with the tie-grip suture technique. All knees were stable with no previous surgery. All patients were evaluated by second-look arthroscopy at six months postoperatively. Activities including jogging were not allowed until meniscal status was evaluated arthroscopically. To analyze factors associated with healing rates, age, time from injury to initial surgery, and tear zone were compared.

Results: Second-look arthroscopy revealed complete healing in four (22%) patients, partial healing in seven (39%), and failure to heal in seven (39%). Significant differences were observed for tear zone ($p < 0.0001$), but not for age and timing of repair.

Conclusions: Arthroscopic evaluation revealed that inside-out repair with the tie-grip suture technique for isolated radial/oblique tears of the midbody of the lateral meniscus achieved complete or partial healing only in 61% of patients. Satisfactory results were observed particularly in patients with tears extending to the vascular zone, whereas those with tears in the avascular zone failed to achieve healing. Therefore, the operative indication of inside-out repair for radial/oblique tears of the midbody of the lateral meniscus might be limited to tears extending into the vascular zone. Given that 39% of cases were arthroscopically considered a failure even if patients complained of no symptoms in daily life, decisions should be made carefully to allow patients to return to sports activities.

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1. Introduction

Radial/oblique tears of the midbody of the lateral meniscus significantly impair the ability of the meniscus to withstand the tibiofemoral load. This tear pattern is more common than

horizontal types in young athletes with stable knees [1]. Many athletes, especially at young ages, tend to continue playing with their menisci torn, even though their sports activities should be limited. A radial/oblique tear disrupts the circumferential fibers of the meniscus, which are the major collagen fibers within the meniscus that create resistance to hoop stresses [2,3]. This tear pattern has been reported to increase significantly the contact pressure, and decrease the contact area and in situ force of the lateral meniscus, compared to the native state [4–6]. Furthermore, although partial meniscectomy is considered the mainstay of treatment for radial/oblique tears, meniscectomy has unfavorable

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effects on contact mechanics [4]. Consequently, the incidence of degenerative and osteoarthritic changes increases markedly [7,8].

Recently, biomechanical studies have shown the importance of meniscal repair for radial tears of the lateral meniscus [5,9,10], and meniscal repair has been performed increasingly to preserve important meniscal functions instead of meniscectomy [11]. Furthermore, meniscal repair in conjunction with anterior cruciate ligament reconstruction has been performed at a higher success rate [12–14]. To the best of our knowledge, however, few studies have focused on healing status after repair for isolated radial/oblique tears of the midbody of the lateral meniscus. The present study thus aimed to evaluate arthroscopic findings after inside-out suture repair for radial/oblique tears of the midbody of the lateral meniscus, with a hypothesis that tears extending to the vascular zone would show good healing potential.

2. Materials and methods

From 2011 to 2015, 25 patients with isolated radial or oblique tears of the midbody of the lateral meniscus underwent inside-out meniscal repair under arthroscopic control, unless the torn site had a large defect. Of these, 18 patients (14 males and 4 females) provided consent to undergo second-look arthroscopy for the present study. This study was approved by the local ethics committee and was conducted according to the principles of the Declaration of Helsinki. All patients provided consent after being informed that their data would be included in a report to be submitted for publication. The average age of the patients was 18.5 years (range, 13–31 years). The causes of injury were sports in 15 patients and unknown in three. All patients had lateral knee pain and tenderness localized to the lateral joint line. All knees were stable. The average time from injury to initial surgery was 17.3 weeks (range, 11–708 days), and the average time from initial surgery to second-look arthroscopy was 6.2 months (range, 18–41 weeks). Patient demographic data are shown in Table 1. Tear zones were classified according to Cooper's classification, as follows: zone 1, which included the outer third of the meniscus; zone 2, which included the middle third; and zone 3, which included the inner third of the meniscus [15].

2.1. Surgical technique

An arthroscopic evaluation was performed using two standard anterior knee arthroscopy portals. After evaluating ligament and chondral statuses, the procedure for meniscus tear repair was carried out. The torn edge of the meniscus and adjacent synovium were refreshed with a rasp to promote healing with an adequate vascular supply. The inside-out technique was used in all patients with 2–0 non-absorbable sutures. After a skin incision (3–4 cm in length) was made at the lateral aspect of the knee, the iliotibial tract was retracted upward, and the biceps tendon was retracted downward. The lateral head of the gastrocnemius was retracted posteriorly. Then, the retractor was placed to protect the common peroneal nerve. All sutures were tied against the joint capsule

(transcapsular suturing). We used the 'tie-grip suture' technique to restore the hoop structure (Fig. 1) [16]. This technique involves the use of at least four sutures: two stay sutures placed vertically, and two suture loops placed horizontally. Vertical sutures are necessary as grips to prevent cutting and slipping of the following horizontal sutures. When a defect between the torn edges of the radial tear of the meniscus was detected, a fibrin clot was introduced into the defect or horizontal suture was first performed to put the torn edges close. The fibrin clot was prepared with 20–30 ml of peripheral blood from the patient, which was aspirated after deciding to use it for meniscal repair. Blood was placed in a sterile beaker and stirred gently with a glass stick for 5 min. After fibrin clot formation, it was placed on sterile gauze and allowed to solidify.

Postoperatively, the knee was immobilized in a knee brace at 20° flexion for two weeks. After two weeks, range of motion (ROM) exercise was started. At six weeks postoperatively, partial weight bearing was allowed, and at eight weeks, full weight bearing was allowed. Activities including jogging were not allowed until after six months.

2.2. Evaluation methods

Second-look arthroscopy was performed with the same portals used in the initial surgery. Meniscal healing was classified as previously reported [17,18]. In brief, if there was no visible surface defect with complete synovial coverage, it was classified as complete healing. If there was a small defect with synovial coverage over more than half of the torn area, it was classified as partial healing. If there was a large defect with synovial coverage over less than half of the torn area, it was classified as failure to heal. The chondral status was also evaluated. Postoperative physical examinations, such as ROM, knee ballottment, joint line tenderness, and catching or locking sensation, were assessed at the time of second-look arthroscopy. To analyze factors associated with healing rates, age, time from injury to initial surgery, and tear zone were compared.

2.3. Statistical analysis

Statistical analysis was performed using SPSS (SPSS Inc., Chicago, Illinois). The chi-square test and Mann–Whitney U test were used to evaluate differences in healing rates between associated factors. A *p*-value less than 0.05 was considered statistically significant.

3. Results

At second-look arthroscopy, four (22%) menisci showed complete healing (Fig. 2), and seven (39%) showed partial healing (Fig. 3); the remaining seven (39%) failed to achieve healing (Fig. 4) (Table 2). When considered a failure, the torn lesion or remaining flap was trimmed.

Table 3 shows the effects of each factor on healing rates. Tear zone showed significant differences ($p < 0.0001$). With regard to tear types (Fig. 5), all simple, complete radial tears achieved complete healing, while only one and four complete oblique tears (i.e., torn with a curved split extending to the peripheral rim) achieved complete and partial healing, respectively (Fig. 6). Three patients with simple partial radial tears achieved partial healing, and one was considered a failure, while all patients with partial oblique tears (i.e., torn with a flap-tear split located in the inner rim) failed to achieve healing. Other factors including age and timing of repair showed no significant differences.

Since no sports activities, including jogging, were allowed, none of the patients complained of pain and sensation of catching or

Table 1
Patient demographic data.

Number of patients	18
Sex (M/F)	14/4
Age (years)	18.5 (13–31)
Time from	
Injury to initial surgery	17.3 weeks (11–708 days)
Initial surgery to second look surgery	6.2 months (18–41 weeks)

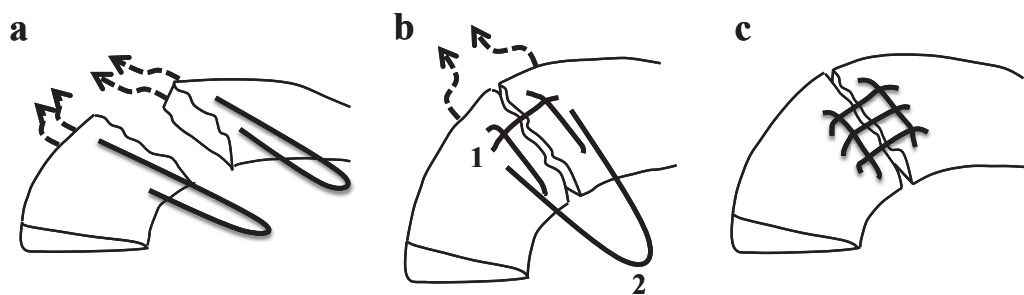


Fig. 1. Sequential diagram of the 'tie-grip' suture technique. (a) Two stay sutures placed vertically, (b) starting from outer region, two or three loops placed horizontally or crossways, and (c) complete tie-grip suture.

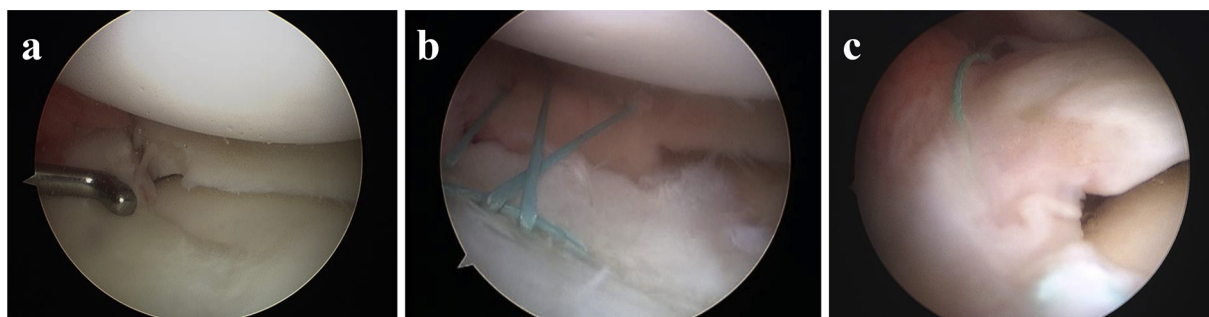


Fig. 2. (a) Radial tear extending to the vascular zone in a 19-year-old male. (b) Tie-grip suture with crossway sutures. (c) Second-look arthroscopic view at five months showed complete healing.

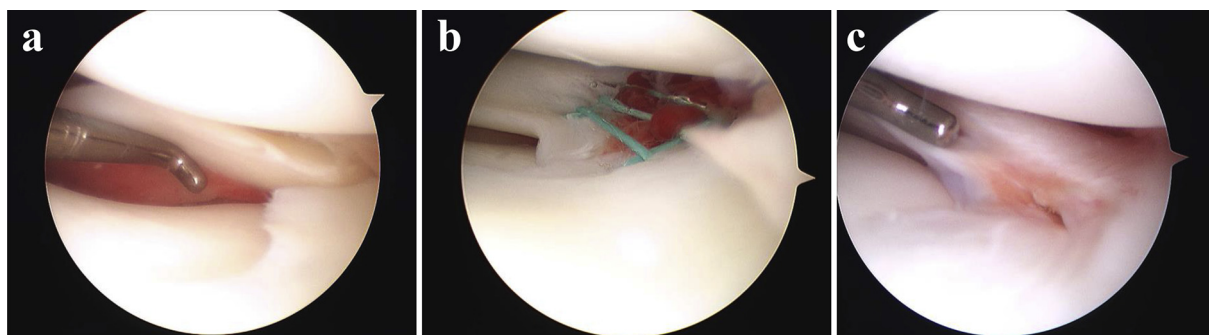


Fig. 3. (a) Radial tear extending into the vascular zone in a 15-year-old female. (b) Tie-grip suture with a fibrin clot. (c) Second-look arthroscopic view at seven months showed partial healing.

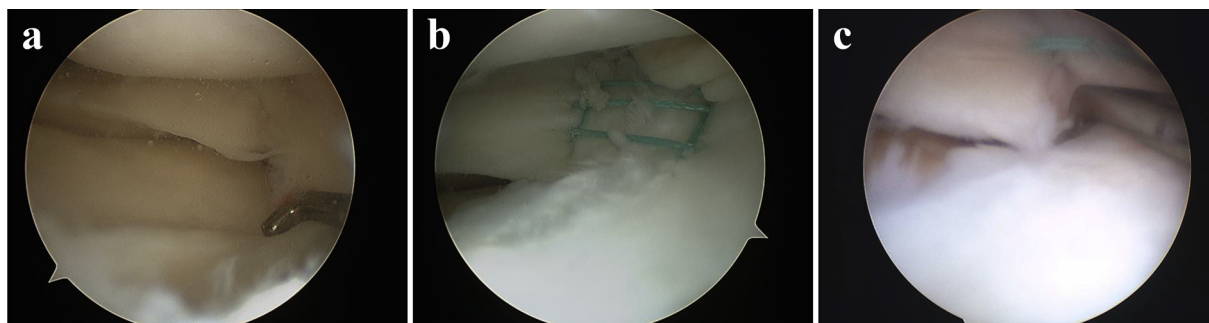


Fig. 4. (a) Radial tear remaining in the avascular zone in a 22-year-old male. (b) Tie-grip suture with three horizontal sutures. (c) Second-look arthroscopic view at six months showed no healing.

Table 2
Healing rates.

	Complete healing	Partial healing	Failure
N (%)	4 (22)	7 (39)	7 (39)

Table 3
Effects of factors on healing rates.

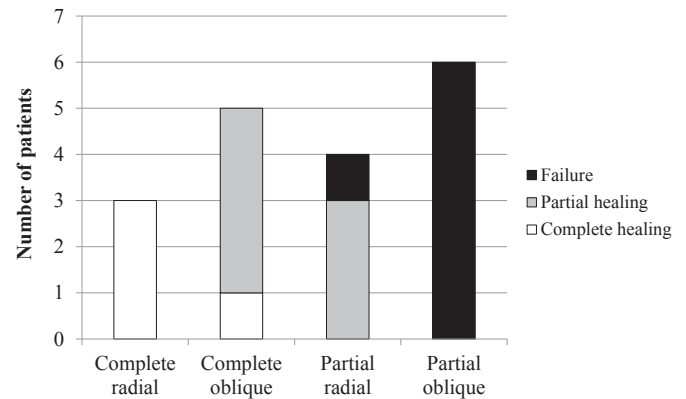
Factor	Complete healing	Partial healing	Failure	Significance (p value)
Age (years)	20.0 ± 6.6	17.7 ± 2.8	19.1 ± 1.7	N.S.
Time from injury to repair (weeks)	5.9 ± 3.4	26.8 ± 35.2	13.6 ± 9.0	N.S.
Tear zone				<0.0001
1, 2, 3	4	4	0	
2, 3	0	3	7	

locking at the time of second-look arthroscopy. During physical examinations, no patients showed ROM restrictions, ballottment sign, or joint line tenderness at second-look arthroscopy (average 26.5 weeks). No complications associated with initial or second-look arthroscopy were noted. No de novo chondral damage was observed between initial surgery and second-look arthroscopy.

4. Discussion

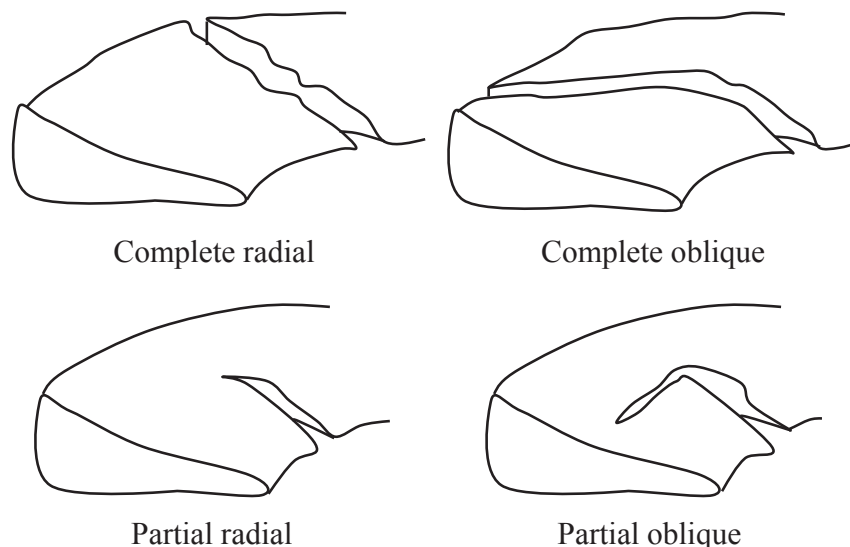
In the present study, second-look arthroscopy revealed that complete healing could be achieved with inside-out meniscal repair for complete radial/oblique tears of the midbody of the lateral meniscus. Most importantly, meniscal healing was achieved only in patients with tears extending to the vascular zone, whereas those with tears in the avascular zone failed to achieve healing as previously reported regarding other tear patterns [19–22].

This study has a strong advantage, as meniscal healing was evaluated arthroscopically. There are many reports on meniscal healing as assessed by MRI; however, MRI assessment remains difficult as signal changes at the repair site could not be distinguished between scar tissue and the remaining tear [23–25]. In contrast, arthroscopic assessment enables evaluation of synovial coverage on the repair site and stability using probes. Thus, second-

**Fig. 6.** Healing results for each tear pattern.

look arthroscopy has been considered the gold standard for evaluating the healing status of repaired menisci [26]. A few studies have reported on second-look arthroscopy after repair of complete radial tears [13,27,28], but the number of patients who underwent second-look arthroscopy was small relative to all patients in these studies. Therefore, the present study targeted all patients who had undergone second-look arthroscopy after repair of not only complete radial/oblique tears but also partial tears.

In the present study, tear zone was considered an important factor, as in the cases of other tear patterns [19–22]. If a tear extended into the vascular zone, complete or partial healing could be obtained. Although the number of patients was small to examine statistically, difference of healing rate with regard to tear extending direction was investigated (Fig. 5). Complete healing could be obtained in all simple, complete radial tears, but only one of five in complete oblique tears. These results suggest that inside-out repair using tie-grip suture could stabilize simple radial tears, whereas in the cases of oblique tears, mechanical stability could not be obtained even with sufficient vascular supply. On the other hand, none of the partial tears remaining in the avascular zone achieved complete healing; only three achieved partial healing, and the remaining seven were considered a failure. Regarding tear types, partial healing could be obtained in almost all of the simple partial

**Fig. 5.** Classification of radial/oblique tears of the midbody of the lateral meniscus.

radial tears, but all patients with partial oblique tears were considered failure. Oblique tears might be too complex to suture each end of the torn edge with transcapsular sutures. Taken together, these results suggest that sufficient vascular supply is an important factor to promote healing, and that the tie-grip suture technique might be limited with regard to oblique tears with transcapsular suturing.

Choi et al. reported that meniscal repair for radial tears of the midbody of the incomplete discoid meniscus may be effective and useful [27]. In the present study, three of 18 patients who had incomplete discoid menisci achieved complete healing. Based on these results, radial tears of the incomplete discoid meniscus might be repairable, partially due to their large, substantial body that allows for secure suturing. However, as discoid menisci, including incomplete discoid menisci, have an abnormal structure and are considered vulnerable, careful observation should be continued.

There are several limitations in this study. First, postoperative evaluations were performed only at six months, and no patients were allowed to return to their sports activities. Thus, no clinical scores were available. Second, X-ray (including long-leg alignment) and MRI evaluations were not included in this study because this study focused on second-look arthroscopy. Further assessments, including return to sports or post-operative MRI, should be performed in future. Third, although a preliminary clinical data has already been reported [16], biomechanical study about tie-grip suture has not been reported yet. Fourth, the number of patients was small to examine statistically. Fifth, there was no control group (i.e., patients who had undergone meniscectomy).

In summary, arthroscopic evaluation revealed that inside-out repair using the tie-grip suture technique for isolated radial/oblique tears of the midbody of the lateral meniscus achieved complete or partial healing only in 61% of patients. Satisfactory results were obtained particularly in patients with tears extending to the vascular zone, whereas those with tears in the avascular zone failed to achieve healing. Therefore, the operative indication of inside-out repair for radial/oblique tears of the midbody of the lateral meniscus might be limited to tears extending to the vascular zone. Given that 39% of cases were arthroscopically considered a failure even if patients complained of no symptoms, decisions should be made carefully to allow patients to return to sports activities, while continuing careful observation.

Conflict of interest

The authors report no conflict of interest.

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