The Knee xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

The Knee

Effects of suture site or penetration depth on anchor location in all-inside meniscal repair

Ryohei Uchida [a,b], Tatsuo Mae [b,*], Kunihiko Hiramatsu [b], Ryo Iuchi [c], Kazutaka Kinugasa [b], Konsei Shino [c], Hideki Yoshikawa [b], Ken Nakata [b]

[a] Department of Orthopaedic Sports Medicine, Seifu Hospital, Osaka, Japan
[b] Department of Orthopaedic Surgery, Osaka University Graduate School of Medicine, Osaka, Japan
[c] Sports Orthopaedic Center, Yukioka Hospital, Osaka, Japan

ARTICLE INFO

Article history:
Received 26 October 2015
Received in revised form 6 April 2016
Accepted 22 June 2016
Available online xxxx

Keywords:
All-inside technique
Meniscal repair
Cadaveric study
Anchor location
Penetration depth

ABSTRACT

Background: To evaluate the effects of suture site or penetration depth on anchor location in all-inside meniscal repair.
Methods: Eight fresh-frozen cadaveric knees were evaluated after meniscal repair using eight FasT-Fix360 (FF360) devices (Smith & Nephew Endoscopy, Andover, MA) (16 anchors) for each knee. The penetration depth was 14 mm, the distance same from the periphery to insertion point, in four knees (Group A) and that in the remaining four knees (Group B) was 18 mm. The anchor location in two groups was evaluated after attentive dissection.
Results: Of 32 anchors for the medial meniscus, 94% were on the capsule, including the superficial medial collateral ligament (sMCL) in both groups. For the lateral meniscus, 47% anchors in Group A and 44% anchors in Group B were on the capsule. Total three anchors were over the lateral collateral ligament (LCL), whereas 15 anchors were behind the popliteus tendon (POP). Although all three anchors settled in the subcutaneous fat were in Group B, no significant difference was observed in anchor location between two groups.
Conclusions: Secure fixation to thin membranous tissue can be achieved for the medial meniscal repair using FF360, while some were located in/on bunchy LCL or POP in lateral meniscal repair. Only anchors with additional four-millimeter penetration depth were in the subcutaneous fat, although there was no effect of the penetration depth to anchor location.
Clinically, for lateral meniscal repair, penetrating toward POP/LCL should be avoided and four-millimeter deeper penetration depth might be a risk for the subcutaneous irritation.

1. Introduction

Meniscal repair is performed in order to preserve meniscus function and avoid osteoarthritic changes. The inside-out repair technique is considered as gold standard [1]. The Henning technique is one of the most common inside-out techniques, and is useful for repairing around the middle and posterior bodies of the meniscus. However, inside-out repair techniques, including the Henning technique, have technical difficulties with neurovascular risks associated with the additional posterior incisions. Therefore, an all-inside technique with no additional incisions and shorter surgical time has been developed and is widely being performed [2,3]. Nevertheless, this technique has some disadvantages. Cadaveric studies have reported that improper anchor placement can be associated with complications, such as irritation, neurovascular injury, or soft tissue damage, in clinical situations [4–7]. Therefore, to avoid these complications during all-inside meniscal repair, it is important to evaluate the association between the suture site and anchor location. Coen et al. investigated the anatomic placement during all-inside meniscal repair using T-Fix® (Acufex Microsurgical, Mansfield, MA, USA); [5] however, T-Fix® was difficult to fasten. Moreover, the effects of the penetration depth on the anchor location were unclear in their study, as the penetration depth was fixed.

Current devices, including FasT-Fix 360 (FF360) (Smith & Nephew Endoscopy, Andover, MA, USA), have been improved to allow variable compression across the tear. Moreover, the anchor size has been decreased to minimize meniscal damage. The present study investigated the association between the suture site and anchor location with two penetration depths using one of the newer suture-based devices: the FF360. The purposes of this study were: 1) to evaluate the effects of penetration depth on anchor location; and 2) to clarify the association between the suture site and anchor location during an all-inside

* Corresponding author at: Department of Orthopaedic Surgery, Osaka University Graduate School of Medicine, 2-2, Yamada-oka, Suita, Osaka 565-0871, Japan. Tel.: +81 6 6879 3552; fax: +81 6 6879 3559.
E-mail address: ta-mae@umin.ac.jp (T. Mae).

http://dx.doi.org/10.1016/j.knee.2016.06.012
0968-0160/

meniscal repair. The hypotheses were: 1) that the FF360 anchor gets hooked on dense soft tissues, including the superficial medial collateral ligament (sMCL), due to its small size and refined shape; and 2) that the ratio of anchors in/on superficial structures over the capsule increases with deeper penetration.

2. Material and methods

Eight fresh-frozen cadaveric knees were evaluated (mean age 66.4 years; range 63 to 70); there were three males and five females. All cadaveric knees were average size Caucasians knees; there were no ligamentous, meniscal, or cartilaginous injuries, including significant degenerative joint disease. After gradually thawing the knees at room temperature for 24 h, they were fixed by horizontally clamping the femur. Each meniscus was arthroscopically penetrated with a curved FF360, assuming the existence of a longitudinal tear placed 10 mm from the meniscal periphery. All entry points for the devices were 14 mm from the meniscal periphery; a scale on the probe measured the distance. Two surgeons with more than 20 years of experience performed the meniscal repairs with arthroscopic surgery using the anteromedial and anterolateral portals. A single surgeon uniformly placed both standard anteromedial and anterolateral portals at medial and lateral sides of the patellar tendon, with the knee placed in 90° flexion. The medial meniscal suture was performed with the knee placed in 10 to 15° of knee flexion, whereas the lateral meniscus was sutured with the knees placed in 70 to 80° of flexion. The flexion angle during meniscal repair was adjusted within the above-mentioned angles in order to accurately insert the device into the meniscus. The meniscal sutures, using the FF360 devices, were faithfully performed according to the manufacturer's recommendations [8].

Each medial meniscus was divided into the following four areas: anterior (M1) and posterior (M2) of the middle portion, and anterior (M3) and posterior (M4) of the posterior portion. For the lateral meniscus, the meniscus was divided into four areas: mid portion of the lateral meniscus just anterior to the popliteal hiatus (L1), the area in front of the popliteal tendon (POP) (L2), the area posterior to POP in the posterior part of the popliteal hiatus (L3), and the area posterior to the popliteal hiatus (L4) (Figure 1). One horizontal mattress suture with two anchors was uniformly placed in each area with a five-millimeter interval between anchors. The penetration depth in four knees was 14 mm, which was the same distance from the periphery to insertion point on the meniscus (Group A); the depth in the remaining four knees was 18 mm, which was four millimeters more than the distance from the periphery to insertion point on the meniscus (Group B) (Table 1). In the manufacture's guide, a depth of 14 mm is usually adequate in the average-sized knee, and thus a depth of 14 mm was applied to evaluate the anchor location. During meniscal repair, all insertion points were exactly determined after confirmation that the distance from these insertion points at the meniscus to its posterior capsule was 14 mm. When determining insertion points, a depth of 18 mm is always deep enough for penetration behind the capsule. As the present study also wanted to evaluate the effect of the penetration depth on anchor location, a depth of 18 mm was also applied.

Table 1
The characteristic of cadaver in each group.

	Group A	Group B
Number of the knee	4	4
Age	66.0 ± 1.6	66.8 ± 2.6
Sex Male:female	2:2	3:1
Side Left:right	2:2	3:1

Furthermore, as 16 devices and 32 anchors were applied to the medial or lateral meniscus in each group, a total of 64 devices with 128 anchors were used for the sutures. After the meniscal sutures, two surgeons worked together to evaluate the anchor location by performing attentive dissection, beginning with skin removal. The anchor location was evaluated in the following four layers: 1) Layer A A: subcutaneous layer including fat; 2) Layer B: ligamentous and musculotendinous layer, including the superficial medial collateral ligament (sMCL), posterior oblique ligament (POL), lateral collateral ligament (LCL), and POP; 3) Layer C: capsular layer, including the deep medial collateral ligament; and 4) Layer D: intra-articular layer, including the meniscal body.

Statistical analysis was conducted to compare the number of anchors in each layer (layers A to D) between the two groups. Furthermore, the anchor location in each area was evaluated between the two groups. For both statistical analyses, the Chi-squared test was adapted. P-values of <0.05 were considered statistically significant.

3. Results

With regard to the layers of the anchor location, 72% of anchors in Group A and 69% in Group B were located in layer C at the medial meniscus, whereas six percent of anchors in Group A were placed in layer D, and six percent in Group B were located in layer A. At the lateral meniscus, 94% of anchors in Groups A and B were located in layers C

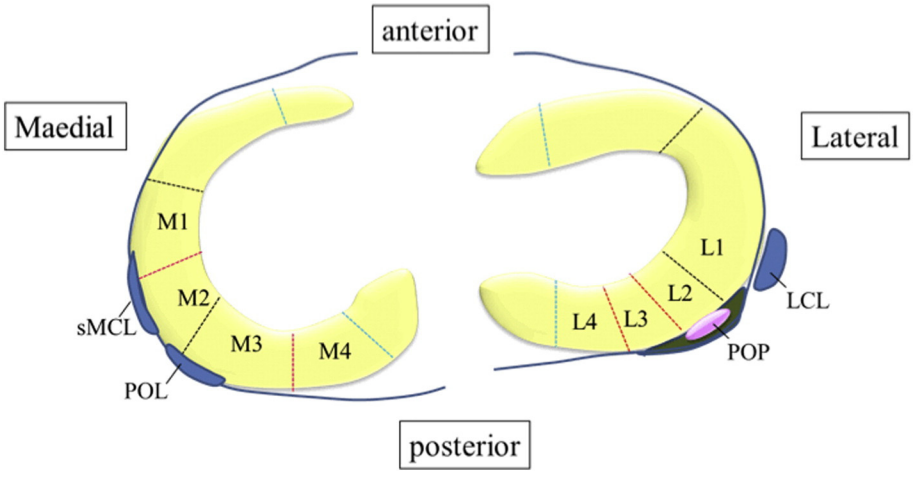

Figure 1. Separated area of the suture site in both medial and lateral menisci of the right knee. Four areas in the medial meniscus: anterior (M1) and posterior (M2) of the middle portion, and anterior (M3) and posterior (M4) of the posterior portion. Four areas in the lateral meniscus: area anterior to POP (L1), area in front of POP (L2), area posterior to POP in front of the popliteal hiatus (L3), and area posterior to popliteal hiatus (L4) sMCL: superficial medial collateral ligament, POL: posterior oblique ligament, LCL: lateral collateral ligament, POP: popliteus tendon.

Please cite this article as: Uchida R, et al, Effects of suture site or penetration depth on anchor location in all-inside meniscal repair, Knee (2016), http://dx.doi.org/10.1016/j.knee.2016.06.012