Technical Note

Suture Anchor Repair for a Medial Meniscus Posterior Root Tear Combined With Arthroscopic Meniscal Centralization and Open Wedge High Tibial Osteotomy

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Abstract: Medial meniscus posterior root tear (MMPRT) is now attracting increased attention as a risk factor for the development of osteoarthritis. However, the healing rate after root repair by the suture anchor technique or the pull-out technique is still low. Here we report on a technique of MMPRT repair using suture anchor combined with arthroscopic meniscal centralization and open wedge high tibial osteotomy (OWHTO). The purposes of this technique are (1) to distribute the meniscal hoop tension between the root repair site and the centralization site and (2) to reduce the load on medial meniscus by OWHTO. The routine exposure for OWHTO with superficial medial collateral ligament release creates good visualization for arthroscopic root repair. The first anchor is inserted on the medial edge of the medial tibial plateau, and the second anchor is inserted on the root attachment through a posteromedial portal. After tying the knots, OWHTO could be performed without interference between the suture anchors and the screws of the plate for fixing the osteotomy. Although further follow-up is required, this technique could improve the outcomes after root repair, as well as have some technical advantages.

In recent years the meniscal function as a "hoop," which includes load bearing, shock absorption, and joint stability,[1] has received considerable attention. Once the circumferential fibers of the meniscus are destroyed, the hoop disruption would theoretically result in a functional meniscectomy.[2] Among various types of hoop disruptions, the medial meniscus posterior root tear (MMPRT) is common among Asian people who sit on the floor in deep knee flexion.[3-5] As a result of the MMPRT, extrusion of the medial meniscus from the joint space occurs, which may cause loss of articular cartilage and progressive medial osteoarthritis.[6]

Allaire et al.[2] reported that root repair was successful in restoring joint biomechanics to within normal conditions in their cadaveric study. Therefore, root repair could be an option for preventing osteoarthritis progression. However, clinically, Kim et al.[5] reported that the complete structural healing rate after root repair was 50% (11 of 22 knees) in the suture anchor group and 52.2% (12 of 23 knees) in the pull-out group. Seo et al.[7] reported that none of 11 menisci after pull-out repair showed complete healing on second-look arthroscopy.

In contrast, Koga et al.[8] reported the arthroscopic meniscal centralization technique using soft anchors for the lateral meniscus in order to restore the meniscus function. We first hypothesized that applying a meniscal centralization to the MMPRT repair could prevent osteoarthritis progression. Furthermore, Hwang et al.[3] reported that in addition to increased age, female sex, higher body mass index, and increased osteoarthritis grade, the greater varus mechanical axis angle would be the risk factor of MMPRT. Then we made a second hypothesis that improving a varus knee alignment by open wedge high tibial osteotomy (OWHTO) could

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Table 1. Pearls and Pitfalls

Preparation
Place the opposite leg lower than the operative leg for good visualization of the medial aspect.
Attach the AssistArm positioner to the operative side of the operation table.
Exposure for usual OWHTO with superficial MCL release.
Arthroscopy
A routine arthroscopic examination through ALP and AMP.
Make FAMP and PMP with an arthroscopic view.
Attach the operative foot to the AssistArm positioner.
Insert a JuggerKnot anchor for centralization on the medial edge of the plateau through the FAMP.
Create a mattress suture configuration at the margin between the meniscus and the capsule through the AMP.
Refresh the meniscal root attachment through the PMP.
Insert an anchor for root repair from the PMP.
Create a mattress suture configuration from through the AMP.
Tie a knot for centralization and then tie that for root repair.
Osteotomy
Perform OWHTO in the same way as the OWHTO without meniscal repair

ALP, anterolateral portal; AMP, anteromedial portal; FAMP, far anteromedial portal; MCL, medial collateral ligament; OWHTO, open wedge high tibial osteotomy; PMP, posteromedial portal.

increase the healing potential after MMPRT repair and decrease the retear rate. Here, in accordance with our 2 hypotheses, we performed suture anchor repair for an MMPRT combined with arthroscopic meniscal centralization and OWHTO. The pearls and pitfalls of this procedure are shown in Table 1.

Indication

This technique is indicated when a patient satisfies the following criteria[5]: (1) complete MMPRT with positive white meniscus sign and/or truncation sign on magnetic resonance imaging findings,[9,10] (2) acute onset by a trivial trauma history, (3) within 6 months from the onset, (4) meniscal extrusion width[11] of <5 mm, (5) patient age of <60, (6) medial compartment Kellgren-Lawrence grade I or II osteoarthritis, and (7) weight-bearing line ratio[12] of <50% and/or mechanical medial proximal tibial angle (mMPTA)[13] of <90°.

Surgical Technique

Preoperative Setup and Preparation

The operation was performed in a supine position under general anaesthesia. The opposite leg is placed lower than the operative leg for good visualization of the medial aspect of the knee. The AssistArm positioner (CONMED, Largo, FL) was attached to the operative side of the operation table for leg holding during arthroscopy. After the sterilization and draping, our routine exposure for OWHTO using reversed curved oblique incision[14] was made. The pes anserinus was elevated and the superficial medial collateral ligament (MCL) was then completely released (Fig 1D and Video 1).

Centralization and Root Repair

A standard arthroscopic examination was performed through anterolateral portal (ALP) and anteromedial portal (AMP), and the situation of the medial meniscus was confirmed using a probe (Fig 2A). A far anteromedial portal (FAMP) was then made with an arthroscopic view from the ALP, just proximal to the medial meniscus. Subsequently a posteromedial portal (PMP) was made under view through the ALP using 30° arthroscope or through the AMP using 70° arthroscope (Video 1).

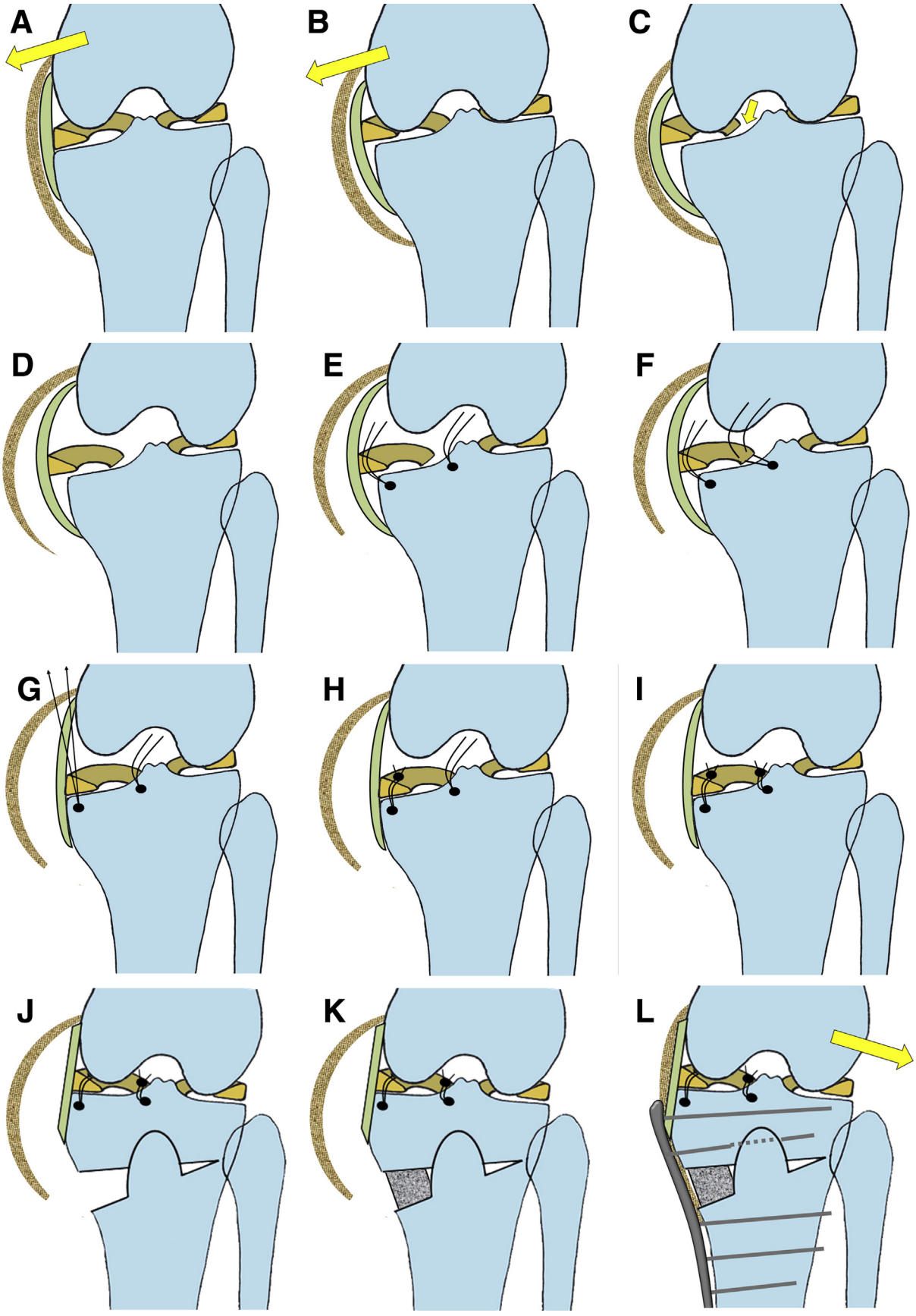
After making the portals, the operative foot was attached to the AssistArm, which makes it possible to maintain desired distraction without requiring assistance. A JuggerKnot soft anchor (Zimmer-Biomet, Warsaw, IN) with 1.4-mm diameter was inserted on the medial edge of the medial tibial plateau through the FAMP (Figs 1E, 2B, and 3). An AcuPass (Smith and Nephew, Andover, MA) with a nylon loop was inserted through the AMP, and the medial meniscus was penetrated at the margin between the meniscus and the capsule according to Koga et al.[8] Then a mattress suture configuration was created by suture relay technique (Fig 1E), and the passed sutures were retrieved from the FAMP (Video 1).

The attachment of the meniscal root was abraded by a radiofrequency ablation probe and a motorized shaver through the PMP. A JuggerKnot was inserted into the attachment from the PMP (Figs 1E, 2C, and 3). A mattress suture configuration was created by using the Scorpion (Arthrex) from the AMP (Fig 1F and Video 1).

The passed sutures for the centralization were first tied through the FAMP by use of a self-locking sliding knot without cannula (Figs 1 G and H and 2D). The posterior root can be automatically reduced to the original attachment by tying the first knot. The sutures for the root repair were then tied in the same way through the FAMP (Figs 1I, 2E, and Video 1).

OWHTO

Once all the arthroscopic procedures were completed, OWHTO could be performed the same as OWHTO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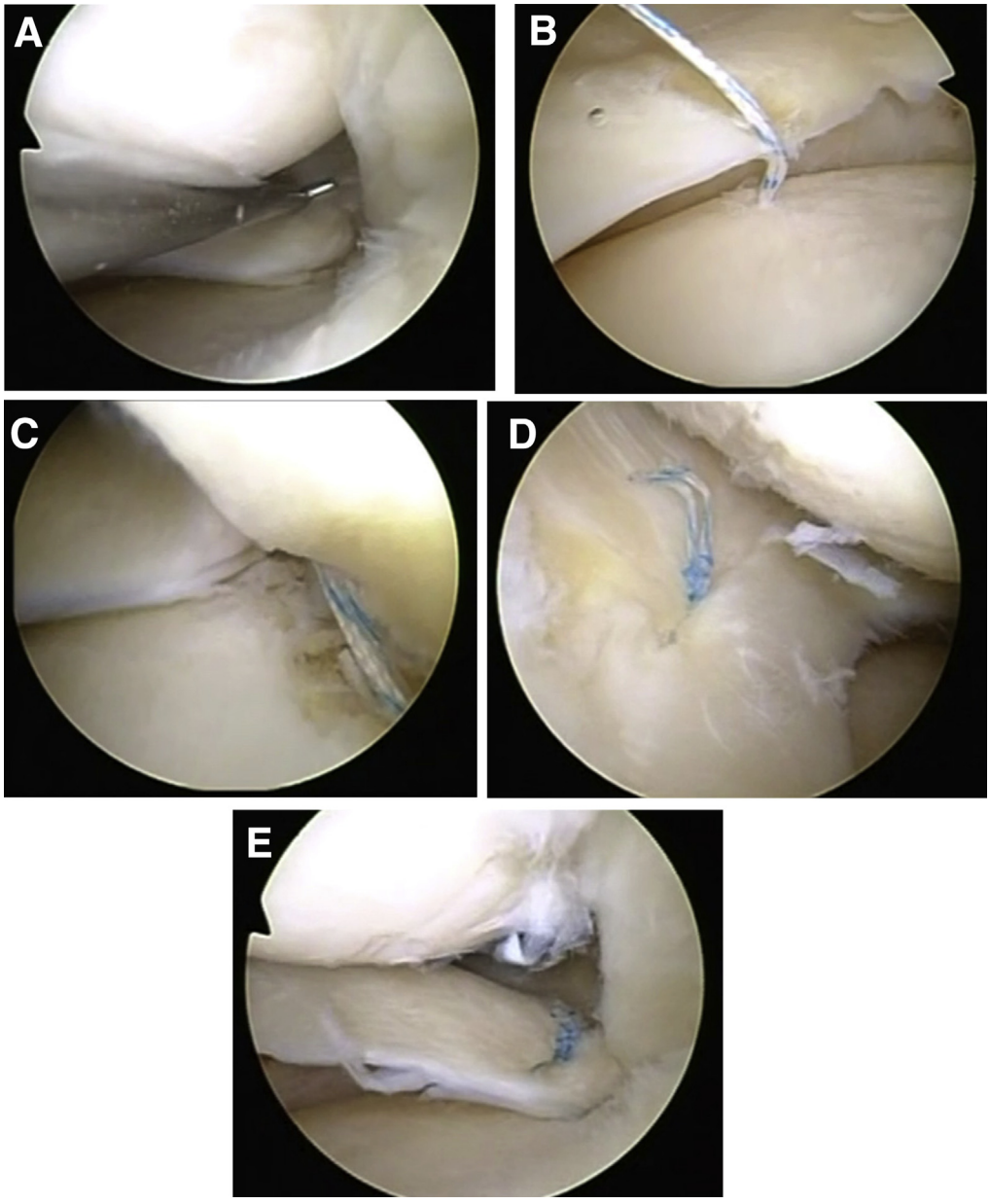

Fig 2. Arthroscopic findings of the root repair combined with the meniscal centralization. (A) Arthroscopic view of the left knee from the anteromedial portal with valgus stress applied. A torn meniscal root can be easily identified because of the complete superficial medial collateral ligament release during the open wedge high tibial osteotomy. (B) Arthroscopic view from the anterolateral portal. A JuggerKnot anchor is inserted on the medial edge of the medial tibial plateau. (C) Arthroscopic view from the anteromedial portal. A JuggerKnot anchor is inserted into the attachment of the posterior root of the medial meniscus. (D) Arthroscopic view from the anterolateral portal. After tying the knot of the medial anchor, the medial meniscus can be centralized. (E) Arthroscopic view from the anteromedial portal. Due to the meniscal centralization, the root can be reattached to the original position without excessive tension.

Fig 1. Schemas for each surgical step and the concept of this procedure. (A) In a case with the medial tilt of the tibial plateau, or when the mMPTA is $<90°$, the femur may slip medially. (B) Tensile stress is applied to the medial meniscus by the slipped femur. (C) The posterior root of the medial meniscus can be torn by the repetitive tensile stress. (D) Before the arthroscopic procedure, the superficial medial collateral ligament is completely released. After the release, the medial joint space can be easily opened by valgus stress during surgery. (E) The first suture anchor is inserted on the medial edge of the medial tibial plateau, and the second anchor is inserted on the attachment of the meniscal root. The sutures of the first medial anchor are passed at the margin between the meniscus and the medial capsule. (F) The sutures of the second posterior anchor are passed at the margin between the meniscus and the posterior capsule. (G) The posterior root can be easily reduced to the original attachment by pulling the sutures of the medial anchor. This is the principle of the centralization technique. (H) The sutures of the medial anchor are tied using a knot pusher. (I) The sutures of the posterior anchor are then tied in the same way. The 2 anchors distribute the hoop tension each other. (J) Osteotomy and gap opening are performed in a usual manner. (K) After inserting 2 bone substitutes into the gap, the medial collateral ligament is then repaired. (L) The femur may slip laterally after lateral tilt of the tibial plateau has been achieved with an open wedge high tibial osteotomy. This may reduce the tensile stress of the medial meniscal hoop.

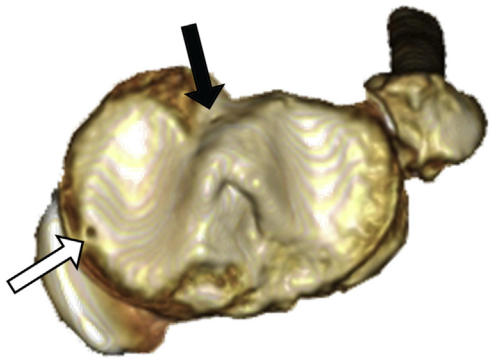

Fig 3. Three-dimensional computed tomography of the postoperative tibial articular surface The black arrow and the white arrow indicate the anchor hole for the root repair and anchor hole for the centralization, respectively.

without meniscal repair. Tomofix small (Synthes GmbH, Solothurn, Switzerland) or TriS (Olympus Terumo Biomaterials, Tokyo, Japan) was used for the fixation, and a bone substitute (Osferion 60, Olympus) was filled into the opening gap[12] (Figs 1 J, K, and L and 4 A and B). The intended weight-bearing line ratio was 62% of the width of the tibial plateau.[14]

Postoperative Rehabilitation

Although range of movement exercises were started 2 days after surgery, flexion over 90° was restricted until 4 weeks postoperatively. A standard protocol of partial and full weight bearing was started at one and 3 weeks after surgery, respectively.[14] Despite the same weight-bearing protocol as the OWHTO without meniscal repair, wearing a brace for keeping the knee in extended position was encouraged when the weight bearing started.

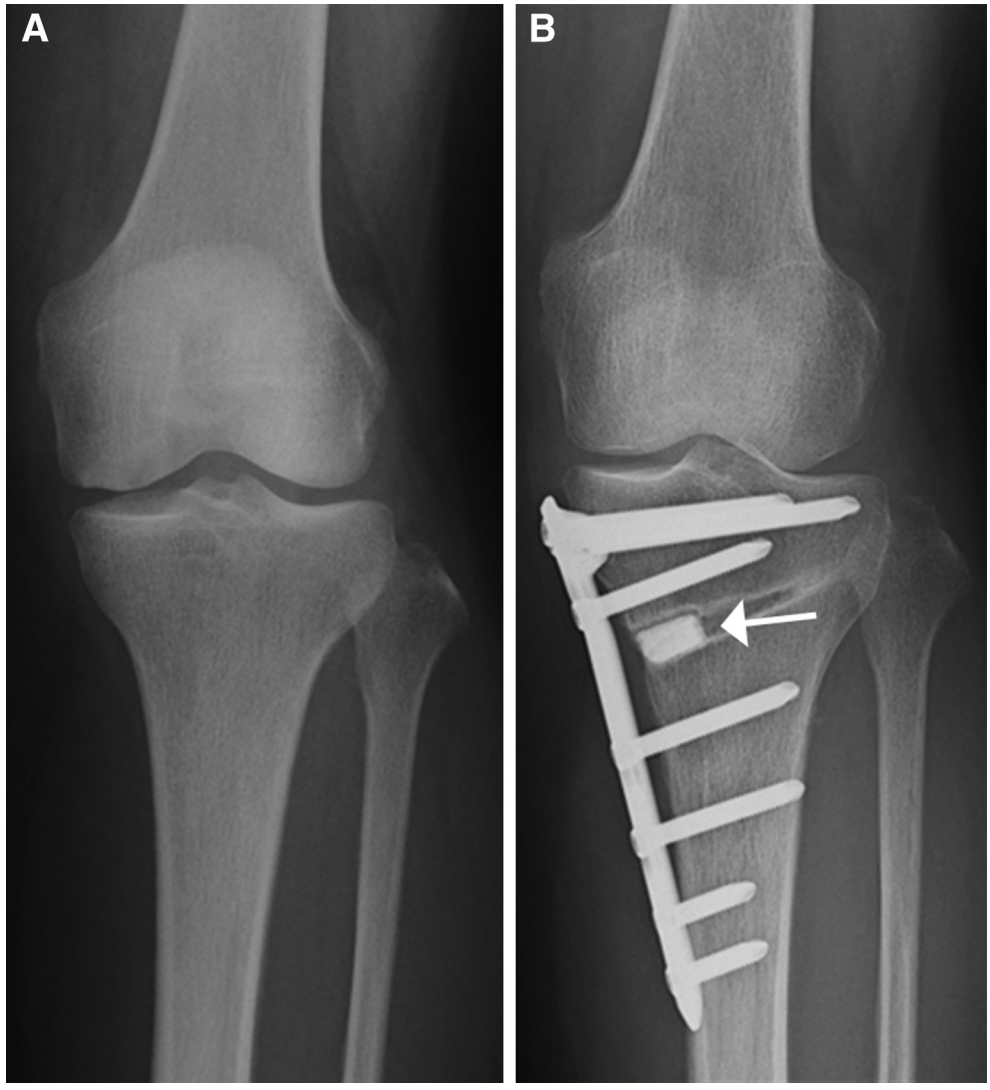

Fig 4. Anteroposterior standing radiographs of the left knee. (A) The preoperative x-ray shows Kellgren-Laurence grade I osteoarthritis with 87° of mMPTA. (B) The mMPTA was corrected to 92° on the x-ray one month after surgery. The white arrow indicates the bone substitutes. mMPTA, mechanical medial proximal tibial angle.[13]

Table 2. Advantages and Disadvantages/Risks/Limitations

Advantages
1. Advantages of simultaneous OWHTO
The lateral tilt of the tibial plateau created by OWHTO may reduce the tensile stress of the medial meniscal hoop.
A relatively early weight-bearing protocol for meniscal repair can be applied because the repaired meniscus can be spared from weight-bearing by the load-shifting effect of the OWHTO.
A wide visual field for posterior root repair can be provided by complete superficial MCL release for OWHTO.
2. Advantages of simultaneous arthroscopic meniscal centralization
The posterior root can be easily reduced to the original attachment by meniscal centralization.
The anchor for centralization distributes the hoop tension at the root repair site.
By using the soft-anchor technique rather than the pull-out repair technique, the interference between the screws of the plate and the string for the pull-out procedure can be avoided.
Disadvantages/risks/limitations
The process/mechanism of the bone-meniscus junction healing at the root repair site is still unclear.
Meniscal centralization may have the risk of limiting the normal motion of the meniscus.
Proving the superiority of this procedure over simple OWHTO without root repair/centralization may be difficult because the mid-term results of simple OWHTO may be sufficiently good.
The hoop tension enhancement during deep knee flexion cannot be reduced by OWHTO.

MCL, medial collateral ligament; OWHTO, open wedge high tibial osteotomy.

Discussion

The concept of this procedure is demonstrated in Figure 1, and the advantages as well as the disadvantages, risks, and limitations are shown in Table 2. There are several advantages to simultaneous OWHTO (Table 2). When the mMPTA is <90°, the tibia may be pushed laterally because of the shearing force exerted during weight bearing (Figs 1 A and B and 4A). In other words, the femur may slip medially with extrusion of the medial meniscus (Fig 1 C and D). Therefore, creating an mMPTA over 90° or a lateral tilt of the proximal tibia by OWHTO are important to decrease the hoop tension after root repair (Table 2, Figs 1 J, K, and L and 4B), which may lead to a reduction in the retear rate. Owing to the lateral tilt and the load-shifting effect of the OWHTO, a relatively early weight-bearing protocol may be applied following meniscal repair (Table 2). Technically, complete superficial MCL release (Fig 1D), which is essential in OWHTO,[15] enables easier medial joint opening during arthroscopic MMPRT repair (Table 2).

There are some advantages of simultaneous arthroscopic meniscal centralization as well (Table 2). As the gap between the meniscal stump and the root attachment can be closed by meniscal centralization (Fig 1G), the posterior root can be easily reduced to the original attachment (Table 2 and Fig 2E). The anchor for centralization distributes the hoop tension at the root repair site (Table 2), which may reduce the retear risk. Additionally, by using the soft-anchor technique rather than the pull-out repair technique, the interference between the screws of the plate and the string for the pull-out procedure can be avoided (Table 2 and Fig 1L).

The disadvantages, risks, and limitations of the combined procedure are listed in Table 2. They include the following: (1) the process/mechanism of the bone-meniscus junction healing at the root repair site is still unclear; (2) as indicated by Koga et al.,[8] meniscal centralization has an associated risk of limiting normal motion of the meniscus; and (3) despite the necessity of further follow-up, proving the superiority of this procedure over simple OWHTO without root repair and centralization may be difficult because the midterm results of simple OWHTO may be sufficiently good. Finally, the deep knee flexion during weight bearing in Asian people is reported to be one of the causes of root tear.[3-5] This could be explained by femoral roll-back in the sagittal plane, because the meniscal hoop is pressed posteriorly on the femoral condyle. Even if lateral tilt was achieved, the hoop tension enhancement during deep knee flexion described above could not be reduced.

In conclusion, suture anchor repair for an MMPRT combined with arthroscopic meniscal centralization and OWHTO may have the possibility of improving outcomes after root repair, as well as have technical advantages.

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