A newly-developed guide can create tibial tunnel at an optimal position during medial meniscus posterior root repairs

Abstract

Background: During transtibial pullout repair of medial meniscus (MM) posterior root tears (MMPRTs), accurate tibial tunnel creation within the anatomic MM posterior root attachment seems critical. This study aimed to evaluate the tibial tunnel position created by a newly-developed Precision guide during pullout repair of MMPRTs.

Methods: In 40 patients who underwent transtibial pullout repairs, the tibial tunnel was created using the Unicorn Meniscal Root (UMR) (n=20) or Precision guide (n=20). Three-dimensional computed tomography images of the tibial surface were evaluated postoperatively, using Tsukada's measurement method. The expected anatomic center of the MM posterior root attachment was defined as the center of three tangential lines corresponding to anatomic bony landmarks. The expected anatomic center (AC) and the tibial tunnel center (TC) were evaluated using the percentage-based posterolateral location on the tibial surface. The difference in the mediolateral and anteroposterior percentage distance between the AC and TC was calculated, as was the absolute distance between the AC and TC.

Results: The mean AC was located 77.4% posterior and 40.1% lateral. The mean TC was similar in the UMR and guide groups. There was no significant difference in the mediolateral percentage distance (UMR 3.9% vs. Precision 3.6%, p=0.405), but a significant difference was observed in the anteroposterior percentage distance (UMR 3.5% vs. PRECISION 2.6%, p=0.031). The mean absolute distance between the AC and TC was 3.9 mm and 3.5 mm (UMR and Precision guide groups, respectively) (p=0.364).

Conclusions: The new PRECISION guide can create tibial tunnels in an optimal and stable position during pullout repair of MMPRTs.

1. Introduction

The posterior root of the medial meniscus (MM) can serve as an anchor for regulating meniscal shift during knee flexion and load bearing [1]. An MM posterior root tear (MMPRT) leads to accelerated degeneration of the knee joint articular cartilage by preventing conversion of axial load into hoop tension [2, 3]. Pullout repair of the MMPRT has become the established treatment to restore tibiofemoral contact areas and pressure [4, 5]. Recently, favorable clinical outcomes using transtibial pullout repair have been reported [6, 7].

Restoration of meniscus function and better outcomes are expected by the anatomic placement of the MM posterior root attachment in transtibial pullout repair of the MMPRT. A previous biomechanical study demonstrated that non-anatomic repair reattached 5 mm posteromedial to the native attachment does not restore the tibiofemoral contact area or contact pressures compared with the intact knee [8]. Besides, the tibial tunnel position close to the MM posterior root insertion could obtain an improved meniscal healing status or a better reduction in MM posterior extrusion at 90° knee flexion, which would suggest better meniscus function and possibly lead to prevention of osteoarthritis progression. [9, 10].

There have been some anatomic studies about the position of the tibial attachment of MM posterior insertion. A cadaveric study reported that the MM posterior root has its attachment at 9.6 mm posterior and 0.7 mm lateral to the apex of the medial tibial eminence (MTE) [11]. One histological study also demonstrated that the MM posterior insertion center is located 7.7 mm posterior to the MTE apex [12]. Several aiming guides have been reported to create the tibial tunnel within the MM posterior root attachment, because it is difficult to create an accurate tibial tunnel in the tight medial compartment [13, 14]. The recently-developed Unicorn Meniscal Root (UMR) guide (Arthrex, Naples, FL, USA) can enable us to set a guidewire more posteriorly, because of its point-contact aiming system, and to use only one guide on both knees [14]. The UMR guide can create favorable tibial tunnels at the MM posterior root attachment.

A newly-developed aiming guide, the Precision guide (Smith & Nephew, Andover, MA, USA), has been developed for more accurate tibial tunnel creation for pullout repair of MMPRTs (Fig. 1). The guide has a narrow, curving shape compatible with the medial intercondylar space, for improved control in the tight medial joint space. However, the performance of the Precision guide has never previously been compared with the UMR guide. The aim of this study was to compare the tibial tunnel position between the two meniscal root repair guides. We hypothesized that the newly-developed Precision guide can create the tibial tunnel at a better position compared to the UMR guide.

2. Materials and Methods

2.1 Study design and population

This study obtained approval from the Institutional Review Board of our institution, and written informed consent was obtained from all patients. From March to August 2020, 46 patients who were diagnosed with MMPRT according to their magnetic resonance imaging findings were recruited. Patients who did not meet the operative indication for arthroscopic pullout repair of MMPRT (n=6) were excluded. In our study, operative indications were a femorotibial angle <180°, Outerbridge grade I or II, and Kellgren-Lawrence grades 0-II. Overall, 40 patients were included, and their data retrospectively investigated. We divided the patients into two groups to compare the tibial tunnel position when using the UMR guide (n=20) and the Precision guide (n=20).

2.2 Surgical procedures

A standard arthroscopic examination was performed using a 4-mm-diameter 30° arthroscope (Smith & Nephew) for both groups. For cases with a tight medial compartment, the outside-in pie-crusting technique of the medial collateral ligament was used. The root tear types were classified by measuring the remnant using a probe. A Knee Scorpion suture passer (Arthrex) was used to pass two No. 2 strong sutures vertically through the meniscal tissue. For two cinch stitches (TCS), the middle of the suture was placed in the jaw of the Knee Scorpion, then passed through the meniscus, self-retrieved, and removed from the passing device. The two free ends of the suture were then passed through the loop and tensioned to the meniscus surface. The first suture was placed in the inner area 10 mm from the MM posterior root. The second suture was placed in the outer area 4 mm from the MM posterior root. Thus, TCS was applied to the MM posterior horn and root (Fig. 2A). After MM posterior root attachment was confirmed, either a UMR guide or an PRECISION guide was placed at the center of the attachment area (Fig. 2B). A 2.4-mm guide pin (Smith & Nephew) was inserted, using the aiming device at a 45° angle to the articular surface, and a 4.0-mm cannulated drill (Arthrex) was used to overdrill. After removal of only the inner guide pin, the two sutures were pulled out through the cannulated drill by a suture relay technique using looped 2-0 nylon (Fig. 2C). After the expected tension (10 N) was applied by a spring tensioner at 30° of knee flexion, tibial fixation was performed using a bioabsorbable screw and anchor screw, as previously described (Fig. 2D) [15].

2.3 Three-dimensional computed tomography-based measurements

All patients underwent computed tomography (CT) at 1 week postoperatively. CT images were obtained with an Asteion 4 Multislice CT System (Toshiba Medical Systems, Tochigi, Japan) using 120 kVp and 150 mA and 1-mm slice thickness. CT reconstruction of the tibial condyles in the axial plane was completed using a three-dimensional (3D) volume-rendering technique (AZE Virtual Place software, Tokyo, Japan). Subsequently, 3D CT images of the tibial surface were evaluated using a rectangular measurement grid as described previously [16]. The image was rotated to visualize the superior aspect of the proximal tibia, with the internal/external rotation adjusted until the most posterior articular margins of both the medial and lateral tibial plateaus were placed on the horizontal level. The location of interested points on the tibial surface was assessed using a percentage-dependent method. The posterolateral location on the tibial surface was expressed as a percentage using Tsukada's method [17]. The expected anatomic center (AC) of the MM posterior root attachment was defined as the center of three tangential lines referring to three anatomic bony landmarks (anterior border of the posterior cruciate ligament tibial attachment, lateral margin of the medial tibial plateau, and retro-eminence ridge) of the triangular footprint of the MM posterior root (Fig. 3A). Tibial tunnel centers (TC) were determined as the central point of the circular or oval tunnel aperture. The difference in the mediolateral percentage between AC and TC [Δ M-L distance (%)] and in the anteroposterior percentage between AC and TC [Δ A-P distance (%)] were calculated and shown by the absolute value (Fig. 3B). Percentage distance between AC and TC was calculated according to the

Pythagorean theorem: (percentage distance)^2 = (Δ A-P distance)^2 + (Δ M-L distance)^2. The absolute distance between the AC and TC was also measured in mm.

2.4 Statistical analysis

Data were presented as means ± standard deviations. Differences between groups were compared using the Mann-Whitney U test. The significance level was set at $P < 0.05$. Two orthopedic surgeons independently measured the location of the expected anatomic center (AC) and tibial tunnel center (TC). Each observer performed each measurement twice, at least two weeks apart. The inter-observer and intra-observer reliabilities were assessed with the intra-class correlation coefficient (ICC). An ICC > 0.80 was considered to represent a reliable measurement.

3. Results

No significant differences between the UMR and Precision guide groups were observed in preoperative patient demographics (Table 1). The mean AC was located at a position of 77.4% posterior and 40.1% lateral (Fig. 4). The mean ACs were similar in each group (UMR guide: 79.8% posterior and 39.6% lateral position; Precision guide: 75.8% posterior and 35.9% lateral position) (Fig. 5, Table 2). The values of the inter-observer and intra-observer reliabilities were considered high, with mean ICC values of > 0.88 and > 0.92, respectively. There was no significant difference in percentage distance (5.6% and 4.6% in the UMR and Precision guide groups, respectively) or in Δ M-L distance (3.9% and 3.6% in the UMR and Precision guide groups, respectively), but a significant difference was observed in Δ A-P distance (3.5% and 2.6% in the UMR and Precision guide groups, respectively) (Fig. 6, Table 2). There was no significant difference in absolute distance between the two guides (3.9 mm and 3.5 mm in the UMR and Precision guide groups, respectively) (Table 2).

4. Discussion

This study demonstrates that the novel Precision guide can create a tibial tunnel position comparable to that created with the UMR guide. Thus, our hypothesis, that the Precision guide could create a tibial tunnel at a better position, was refuted. Tibial tunnels were created at an optimal position using either guide. We recommend the use of either guide for creating an accurate tibial tunnel during pullout repair of MMPRT.

The UMR guide has a more anatomic design and a longer curving arm than do conventional guides, so that the guide or guidewire can be inserted posteriorly [14]. It also has an all-in-one and free-aiming system for the medial joint space of both knees. The newly-developed Precision guide has several advantages for optimal tibial tunnel creation during pullout repairs in patients with MMPRTs. The narrower design enables the surgeon to easily operate the guide in the narrow medial joint space with good visualization. Additionally, an anatomically curved design compatible with the MTE and a tip type guiding system, which the guide pin directs to the guide tip, can create a tibial tunnel accurately and stably. These designs might account for the accurate tibial tunnel creation with a significantly reduced difference in Δ A-P using the PRECISION guide observed in this study. Furthermore, like the UMR guide, the Precision guide has an all-in-one and free-aiming system for the medial joint space of both knees. However, the UMR guide has a wider safety margin at the tip of the guide, to protect guidewire penetration, than does the Precision guide. We believe that surgeons can use either guide, depending on the suitability of each product for a given surgery. Besides, AC and TC were not completely matched using both guides in this study. This might be because of the PCL presence, located just posterior of the AC, which led to the poor visuality and operability during tibial tunnel creation.

Previous studies have demonstrated that the MM posterior root attachment has an oval or triangular shape, and that the radius of the provisional circle to identify the expected AC was 4–5 mm on 3D-CT images [18, 19]. Previous studies evaluating the location of the TC has demonstrated that the UMR guide can create the TC 4.1 mm from the AC, on average [14]. In the present study, the absolute AC–TC distance was 3.8 mm for the UMR guide, and 3.5 mm for the Precision guide, indicating that either guide can create a tibial tunnel within the MM posterior root attachment. One previous study demonstrated that the AC–TC distance is significantly correlated with the postoperative meniscal healing status, and that tunnel creation within 5.8 mm of the AC is desirable for achieving improved meniscal healing [9]. Another study demonstrated that lower percentage distance between AC and TC was related with more effective the reduction in MM posterior extrusion at 90° of knee flexion [10]. These studies support that the creation of a tibial tunnel close to the anatomic attachment of the MM posterior root might be related with the better meniscus function and prevention of the osteoarthritis progression. Both the Precision and UMR guides can create tibial tunnels at reliable positions with high accuracy.

The present study has several limitations which should be acknowledged. First, the sample size was small; further studies with larger sample sizes are required to draw firm conclusions. Second, the relationship between the TC and clinical outcomes was not evaluated postoperatively. Third, the aiming guide's location might differ among patients, which might have induced some biased results. Finally, the optimal TC remains unclear, and it possibly differs according to the tear site. Further biomechanical or clinical studies to determine the desirable tibial tunnel position, according to the tear site of the MM posterior root, are needed.

5. Conclusions

The new Precision guide can create tibial tunnels in an optimal and stable position during pullout repair of MMPRTs. Either the Precision or the UMR guide can be used, according to the surgeon's preference.

Conflicts of interest

None.

References

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Figure legends

Fig. 1 Aiming guides. (A) UMR guide and Precision guide for both knees. (B) The upper side of both guides. (C) The underside of both guides. (D) Precision guide attaching with handle and guidewire.

Fig. 2 Arthroscopic view during surgery. (A) Two cinch stitches are applied. (B) A 10-mm line is set beside the posterior peak of the medial tibial eminence. (C) Suture relay technique for pullout repair. (D) After repair.

Fig. 3 The location of the anatomic center (AC) and the tunnel center (TC). (A) The small yellow and blue circles indicate the expected AC and TC, respectively. (B) The large yellow circle is shown making contact with three anatomic bony landmarks.

Fig. 4 The mean position of the medial meniscus posterior root anatomic center was 77.4% posterior and 40.1% lateral (yellow square) on three-dimensional computed tomography images of the tibial surface. The white squares indicate the location in each case.

Fig. 5 Respective locations of anatomic and tibial tunnel centers. The yellow square denotes the mean anatomic center; the black circle, the mean UMR guide tibial tunnel center; and the orange triangle, the mean Precision guide tibial tunnel center.

Fig. 6 Respective difference in percentage distance between the anatomic center and the tunnel center. The yellow square denotes the mean anatomic center. The black and orange circles denote the mean difference in percentage distance using the UMR and Precision guides, respectively.

Table 1. Patient demographics and clinical characteristics

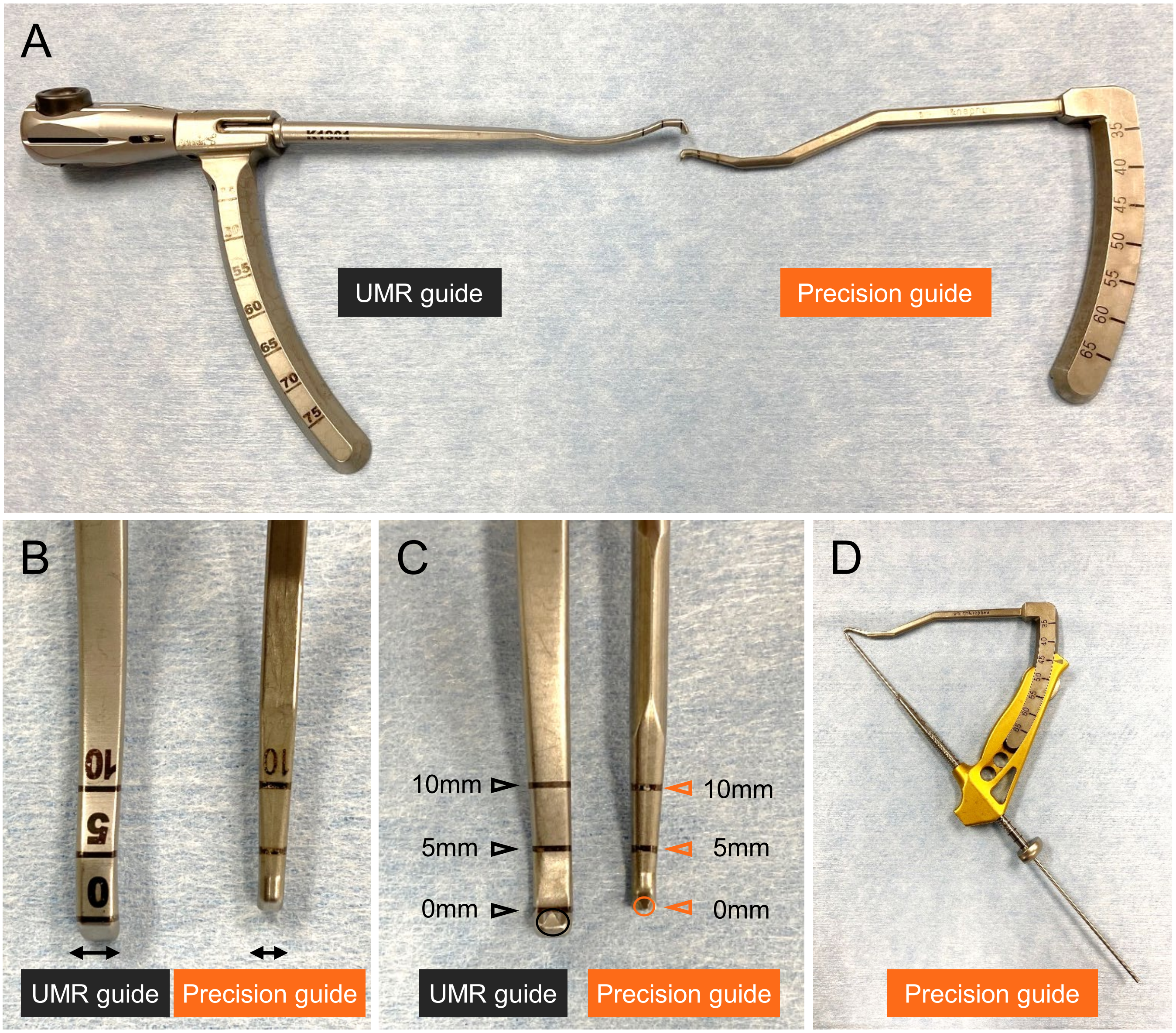
Characteristic	UMR guide	Precision guide	P value
Number (knees)	20	20	
Gender (male/female)	2/18	2/18	n.s.
Age (years)	64.6 ± 12.3	66.0 ± 7.1	n.s.
Height (m)	1.55 ± 0.1	1.54 ± 0.1	n.s.
Weight (kg)	62.2 ± 10.6	63.5 ± 11.4	n.s.
Body mass index (kg/m^2)	26.0 ± 4.4	26.3 ± 5.5	n.s.
Duration from injury to operation (days)	72.5 ± 50.1	71.4 ± 60.4	n.s.
Root tear classification (Type 1/2/3/4/5)	4/15/0/1/0	3/14/0/3/0	n.s.
Postoperative femorotibial angle (º)	177.4 ± 1.7	177.6 ± 2.0	n.s.

Values are presented as mean ± standard deviation or number. UMR, Unicorn Meniscal Root; n.s., not significant.

Table 2. Location of anatomic center and tibial tunnel center

	UMR guide	**Precision guide**	**P value**
Anatomic center, %			
Posterior, %	77.4 ± 2.8	77.5 ± 3.3	n.s.
Lateral, %	40.7 ± 2.1	39.5 ± 2.4	n.s.
Tunnel center, %			
Posterior, %	76.8 ± 5.1	75.8 ± 3.7	n.s.
Lateral, %	37.3 ± 3.4	35.9 ± 3.1	n.s.
Percentage distance, %	5.6 ± 1.9	4.6 ± 1.8	n.s.
Δ A-P distance, %	3.5 ± 1.6	2.6 ± 1.4	0.031*
Δ M-L distance, %	3.9 ± 2.3	3.6 ± 1.8	n.s.
Absolute distance, mm	3.9 ± 1.1	3.5 ± 1.5	n.s.

Values are presented as mean ± standard deviation. UMR, Unicorn Meniscal Root; A-P, anterior-posterior; M-L, medial-lateral; n.s., not significant. *P < 0.05.


A
UMR guide
Precision guide
B
UMR guide
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C
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5mm
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UMR guide
Precision guide
D
Precision guide

Figure 1

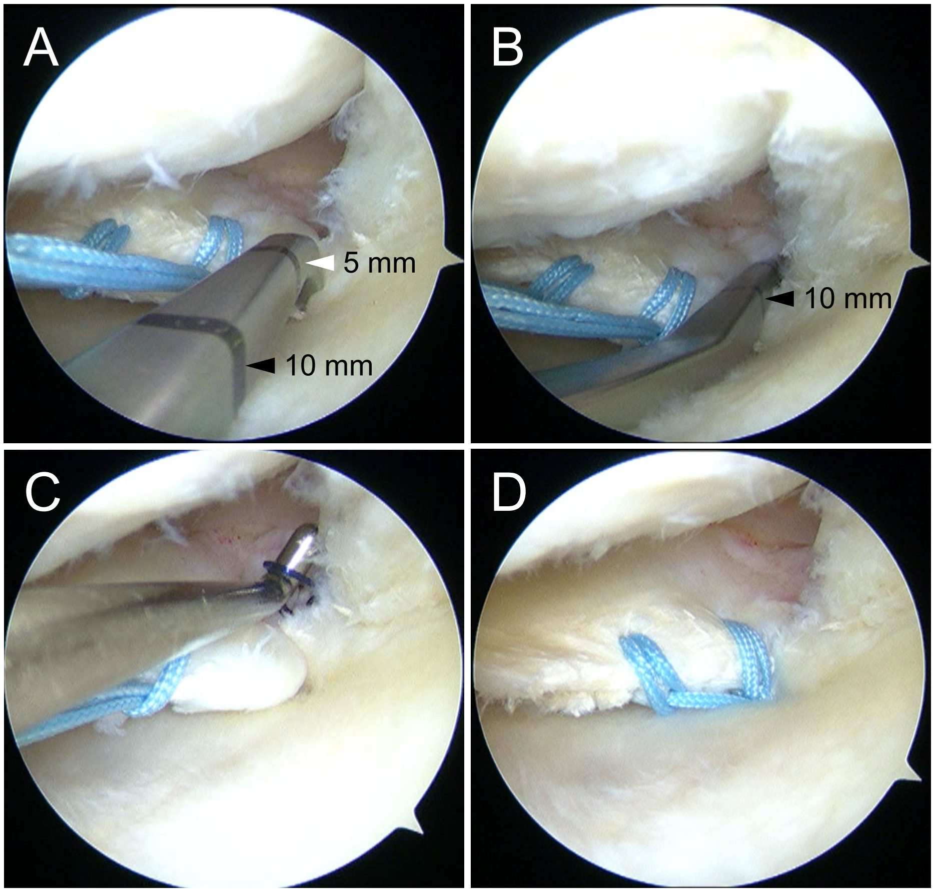
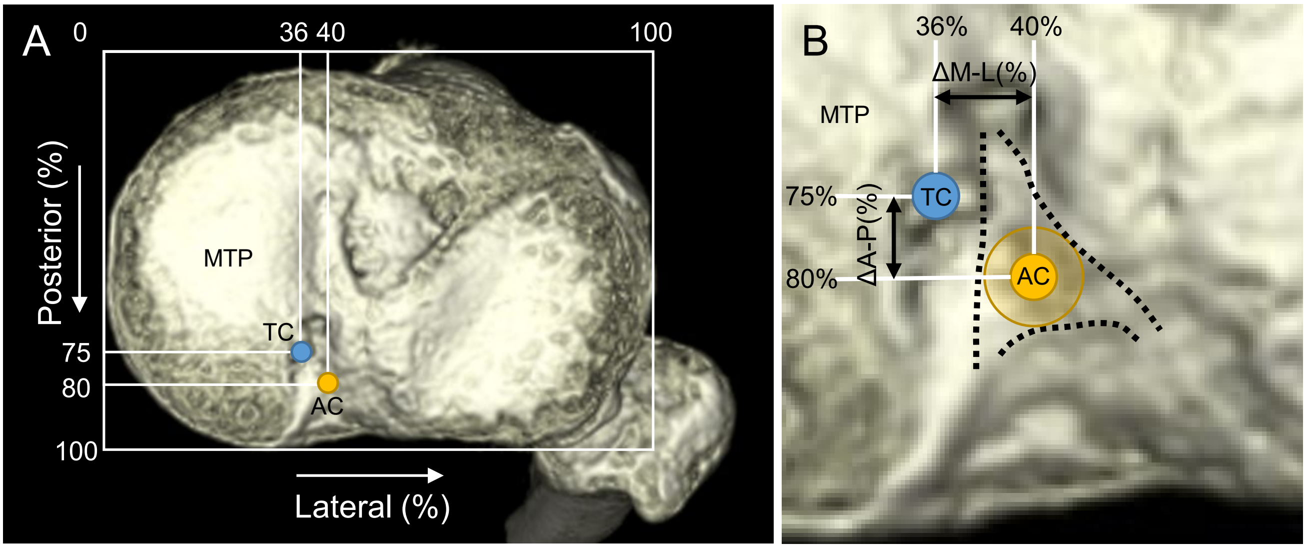


Figure 2


A
0
36 40
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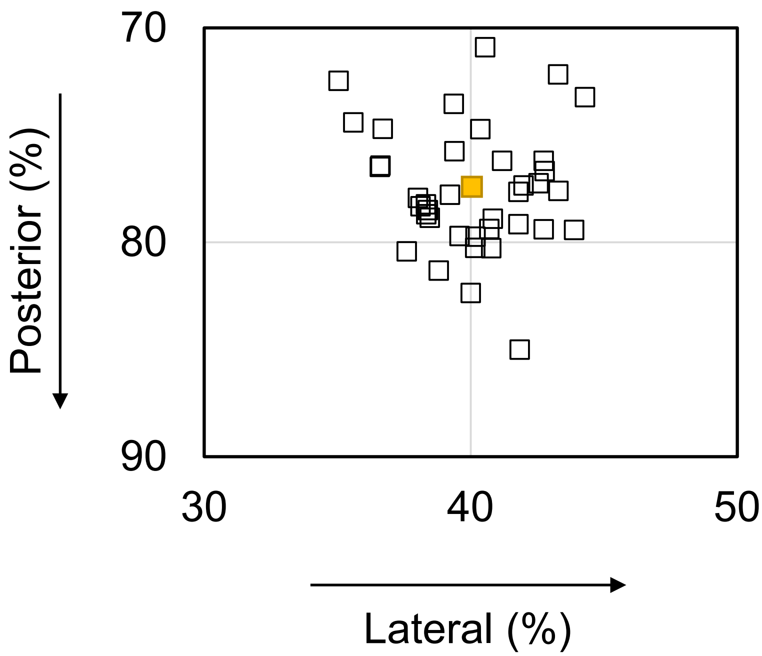
AC

Figure 3



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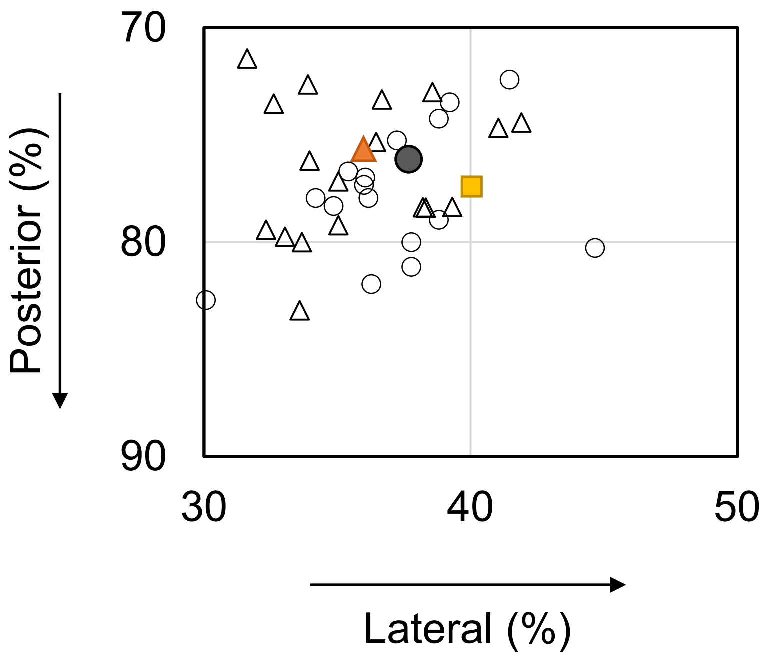

Figure 5

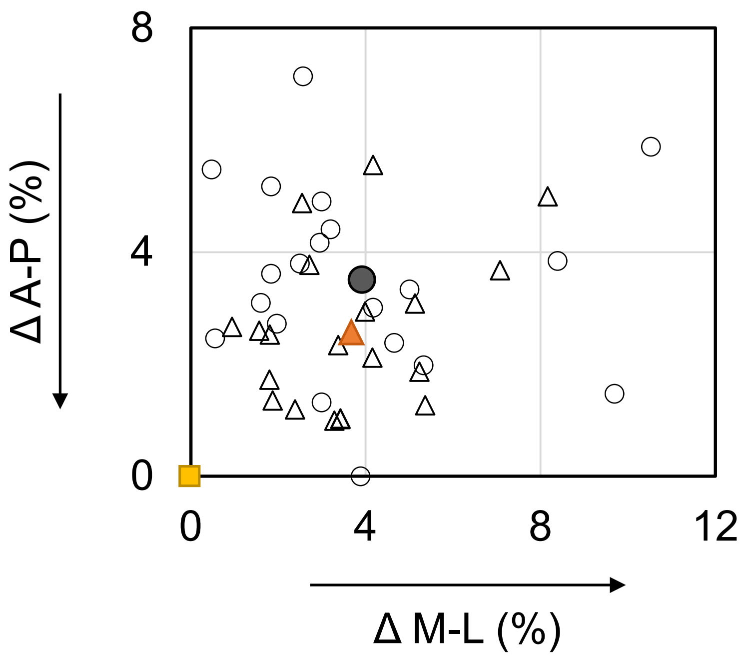

Figure 6