



## Original research

## An Anatomic Study of the Relationship Between the Iliocapsularis Muscle and Iliofemoral Ligament in Total Hip Arthroplasty

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## ABSTRACT

**Background:** The preservation of soft tissues is an important factor for preventing dislocation after total hip arthroplasty. Anatomical studies have revealed that the inferior iliofemoral ligament (ILFL) contributes significantly to the native stability of the hip. This study aimed to investigate the anatomical structures of the iliocapsularis muscle (ICM) and ILFL from a surgical perspective.

**Methods:** In total, we assessed 50 hip specimens from 25 embalmed cadavers. The size and location of ICM and ILFL (at the upper, middle, and lower parts of the femoral head) were assessed in a neutral position. The ratio of ICM and ILFL widths to the femoral head was evaluated.

**Results:** The mean ICM and ILFL widths were 7.5 and 14.6, 12.0 and 14.2, and 12.8 and 15.2 mm at the upper, middle, and lower levels, respectively. The mean ICM thicknesses were 1.3, 9.0, and 9.1 mm at the upper, middle, and lower levels, respectively. The distributions of ICM and ILFL from the lateral edge of the femoral head were 21.1%–37.4% and 4.9%–36.5%, 9.5%–35.6% and 7.9%–38.7%, and 11.0%–38.7% and 9.5%–42.4% at the upper, middle, and lower levels, respectively.

**Conclusion:** ICM and ILFL were located at the anterolateral side of the femoral head, and the medial edge of the ILFL corresponded to that of the ICM. ICM can serve as a landmark for preserving ILFL in total hip arthroplasty using the anterior approach.

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## Introduction

Dislocation is a common complication of total hip arthroplasty (THA), and recurrent dislocation can be an indication for revision THA [1]. Although dislocation can occur due to several reasons, soft-tissue tension is a critical factor [2]. The use of the direct anterior approach (DAA) and the anterolateral approach in hip surgery has been increasing owing to the less invasive nature of surgical approaches [3]. When applying the anterior/anterolateral approach, whether exposure of the proximal femur is essential for the insertion of implant components and is ideal for the release of

soft tissues to achieve good exposure and joint stability remains controversial [4,5].

Recent anatomical studies have reported that the capsular ligament plays a repressive role in external and internal rotation [6,7] and traction force [8] of the hip joint. The capsular ligament comprises three primary fibrous ligaments: iliofemoral, ischiofemoral, and pubofemoral. The iliofemoral ligament consists of the superior and inferior branches, which are inserted together into the anterior inferior iliac spine (AIIS) of the pelvis, each extending out to attach along the intertrochanteric line of the femur. The inferior iliofemoral ligament (ILFL) is strained during hip extension and external rotation [9]. While the clinical importance of capsular ligament preservation for hip stability after THA is controversial [5], some studies claimed that the role of the ILFL was to facilitate stability after THA [7] and prevent excessive leg lengthening [8]. Although it is considered important, its actual anatomical structure is challenging to identify because of limitations in surgical view [10].

The iliocapsularis muscle (ICM) is a small muscle that originates from AIIS and is located distal to the lesser trochanter overlying the

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**Table 1**  
Demographic characteristics and anatomical structure variables.

Age at death (y)	84.0 ± 11.6 (58–99)
Sex	
Male	17 (40%)
Female	25 (60%)
Side	
Left	21 (50%)
Right	21 (50%)
Thigh length (cm)	42.0 ± 4.4 (33–51)
Femoral head diameter (mm)	46.1 ± 2.8 (41–53)

ILFL [11,12]. Recent studies have revealed its role in achieving stability and anatomical structure [13,14]. However, the clinical role of the ICM is only a speculation based on the results of anatomical and radiographic studies, and limited data are available on the anatomical structure of this muscle from a surgical viewpoint.

This study aimed to investigate the anatomical structures of the ICM and ILFL using the anterior/anterolateral approach. In addition, whether the ICM can serve as a landmark for preserving the ILFL in THA using the anterior approach was assessed.

## Material and methods

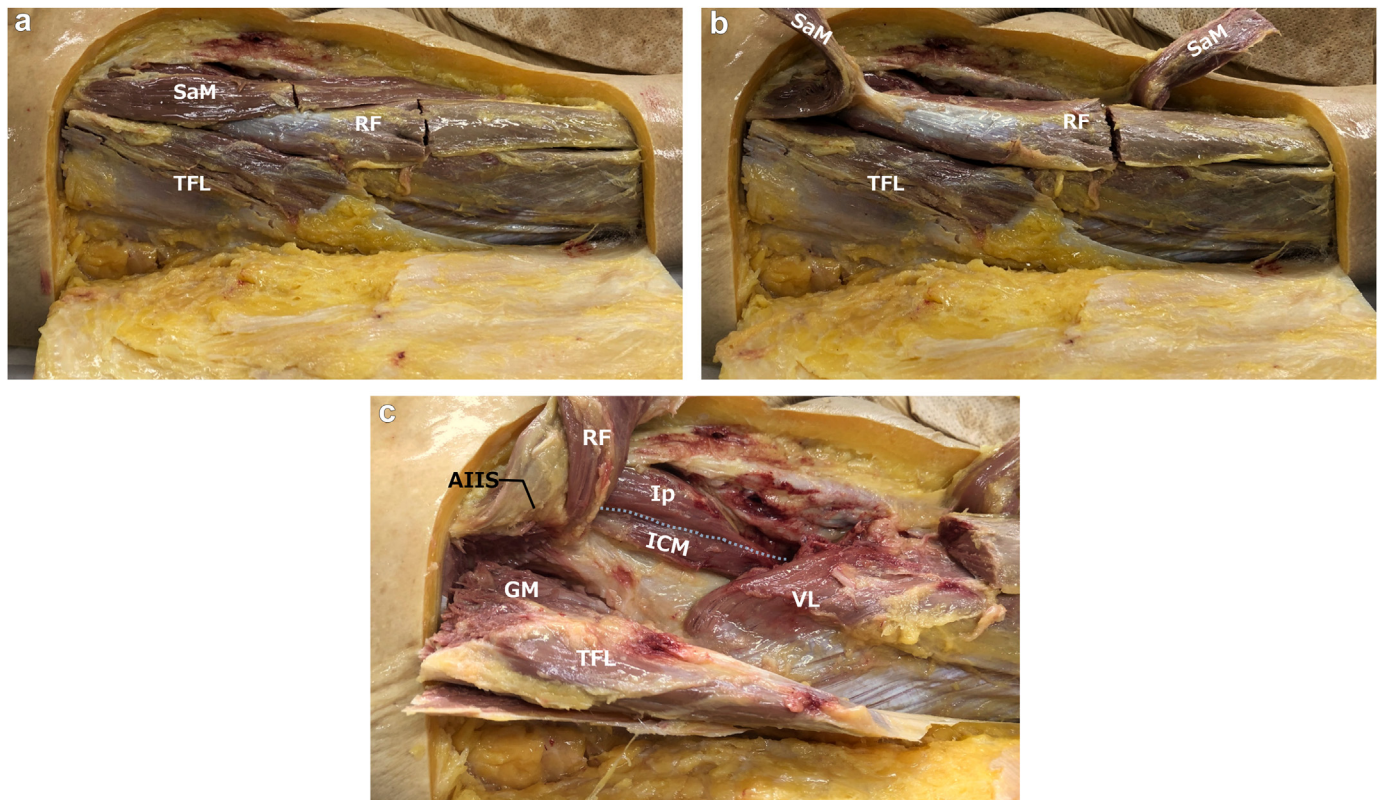
This study was performed in accordance with the principles of the Declaration of Helsinki, and it was approved by the institutional

review board of our university. Written informed consent was obtained from all patients before death.

At the clinical anatomy laboratory of our institution, 50 hip specimens from 25 embalmed cadavers (10 men and 15 women) were used in this study. Eight hips were excluded because of bilateral contracture and a previous surgery. In total, 40 hips were paired; the remaining 2 hips were unpaired because the contralateral hips were excluded because of a previous surgery. The mean age of the specimens at death was 84.0 (range: 58–99) years (Table 1). There was no case of osteoarthritis or previous trauma upon visual inspection.

All cadavers were dissected while in the supine position, with each lower leg in the neutral position. The skin and subcutaneous tissue were removed from the top of the iliac crest to the middle thigh (Fig. 1a). The sartorius muscle and tensor fasciae latae were peeled and removed from the anterior superior iliac spine (Figs. 1b and 2a). The rectus femoris and iliopsoas muscles were identified proximally and transected distally (Fig. 1c). After arthrotomy around the hip, ICM was found attached to AIIS and was overlying the anterior hip capsule (Figs. 1d and 2b). Subsequently, ILFL was detected anteromedial to the femoral head (Fig. 1e, f, 2c, and d). After assessing ICM and ILFL, each hip was dislocated, and the capsule was resected to obtain a whole view of the femoral head.

A reference line parallel to the femur was drawn at the lateral edge of the femoral head. The distance from the line to the lateral and medial edges of ICM and ILFL were measured. The width and thickness of ICM and the width of ILFL were assessed while in the



**Figure 1.** (a–e) Lateral view of the right hip in a neutral position. (a) The anterior and lateral superficial skin and subcutaneous tissue were dissected. (b) The SaM and TFL were resected. (c) After cutting and flipping the RF, the boundary (blue dashed line) between ICM and the IP could be identified. After dividing the boundary and separating the ICM and the IP, the IP was turned up. (d) ICM was attached to the capsule over the entire length. (e) After cutting and peeling ICM from the capsule, the capsule was cut out, thereby leaving the ILFL. (f) A schematic diagram of ICM and the ILFL in the anterior aspect of the hip. ICM was surrounded by the red line. Moreover, ILFL was the area surrounded by the yellow line. AIIS, anterior inferior iliac spine; C, capsule; DH, direct head of the rectus femoris muscle; FH, femoral head; GM, gluteus medius muscle; ICM, iliocapsularis muscle; ILFL, inferior iliofemoral ligament; IP, iliopsoas muscle; RF, rectus femoris muscle; RH, reflected head of the rectus femoris muscle; SaM, sartorius muscle; TFL, tensor fasciae latae muscle; VL, vastus lateralis muscle.

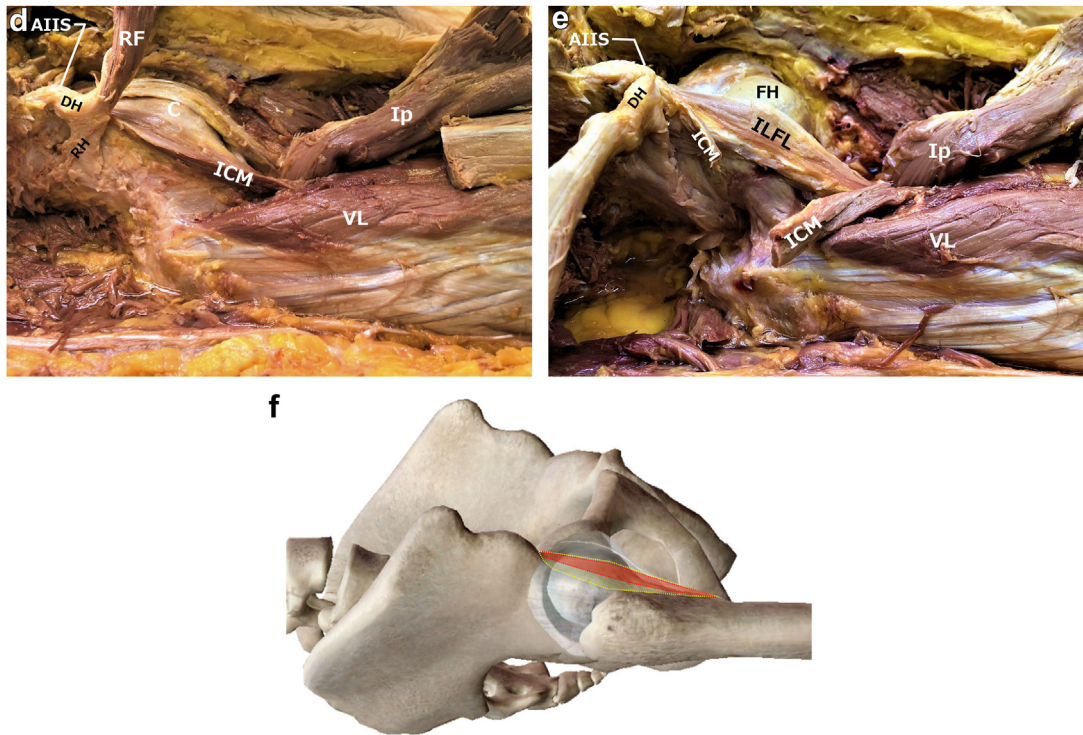


Fig. 1. (continued).

neutral position. Hence, the ICM and ILFL widths corresponded to the distance between the lateral and medial edges. These measurements were performed at the upper, middle, and lower parts of the femoral head using a digital caliper with the hip at 0° flexion, 0° abduction, and neutral rotation (Fig. 2d). The femoral head diameter was measured after hip dislocation.

Each measurement was conducted by two board-certified hip surgeons, and the average was obtained for analysis. The intraclass correlation coefficient (ICC) was used to evaluate the interobserver reliability of each measurement.

The distance from the reference line and the ICM and ILFL widths were compared using the *t*-test. The ratio of the ICM and ILFL widths to the femoral head diameter in each hip was calculated to minimize the impact of femoral head size and identify the distribution. The Pearson correlation coefficient was assessed to determine the association between the width and thickness of the ICM at the middle level and the femoral length and femoral head diameter. An ICC of 1 indicated perfect reliability; >0.80, very good reliability; >0.60, good reliability; and >0.40, moderate reliability [15]. A two-sided *P* value of <0.05 was considered significant, and all results were calculated using the SAS for Windows (version 9.4; SAS Institute).

## Results

The thigh length and femoral head diameter are shown in Table 1. The distance from the reference line, ICM and ILFL widths, and ICM thickness values are shown in Table 2. ICM and ILFL significantly differed in terms of the distance from the reference line to the lateral edge and width at the upper level ( $P < .001$ , respectively) and at the middle and lower levels ( $P = .003$  and  $P = .002$ , respectively). The ratio of the ICM and ILFL widths to the femoral head diameter are shown in Figure 3. The distributions of

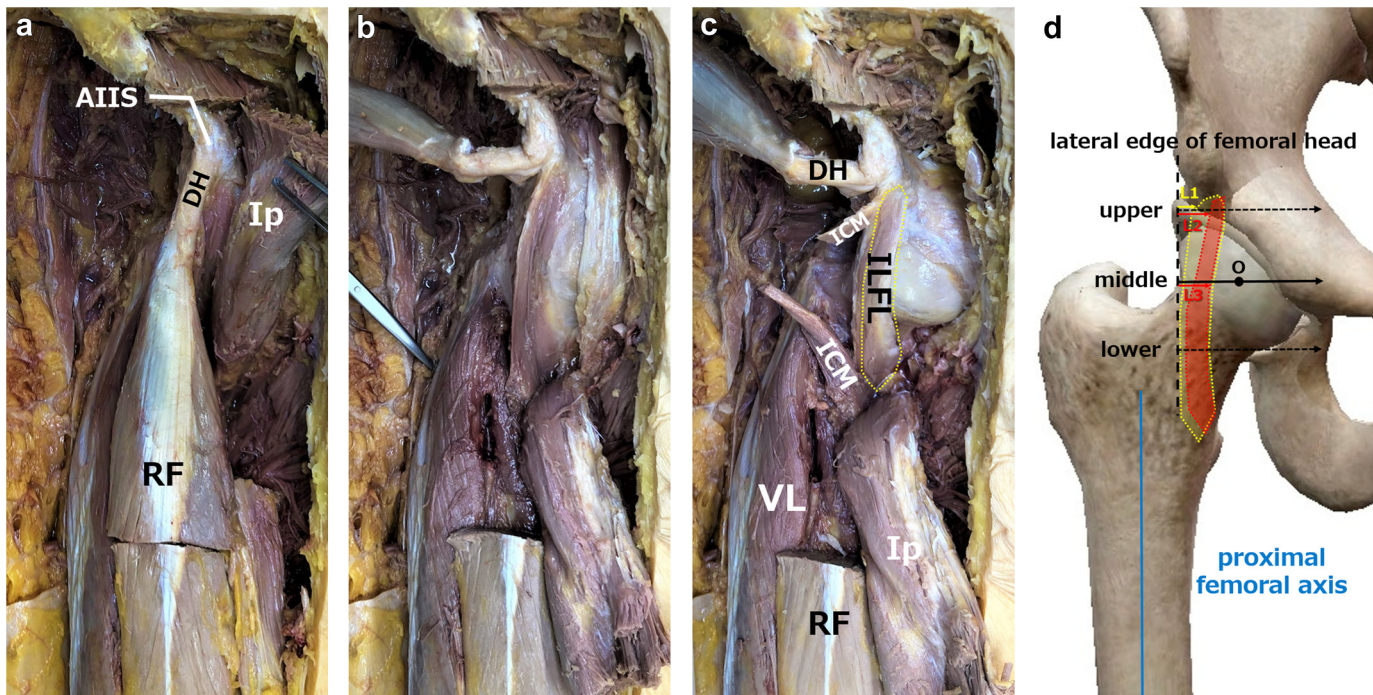
the ICM and ILFL were 21.1%–37.4% and 4.9%–36.5%, 9.5%–35.6% and 7.9%–38.7%, and 11.0%–38.7% and 9.5%–42.4% at the upper, middle, and lower levels, respectively. The ICM thickness was positively correlated with the femoral length ( $r = 0.52$ ,  $P < .001$ ). Moreover, there was a positive association between the ICM width and the femoral head diameter ( $r = 0.53$ ,  $P < .001$ ).

The ICCs were 0.83, 0.84, and 0.94 at the upper, middle, and lower levels, respectively, for the distance from the reference line and 0.89 for the ICM thickness.

## Discussion

This study investigated the anatomical structures and sizes of ICM and ILFL. The anatomical measurements were reliable, and the medial edge of ILFL corresponded to that of ICM. ILFL and overlying ICM covered the lateral side of the anterior aspect of the femoral head. A correlation was found between ICM thickness with the femoral length and ICM width with the femoral head diameter.

Dislocation is a common complication of THA that occurs in approximately 0.3%–10% of all primary cases, leading to revision surgery [16]. Soft-tissue tension is a factor contributing to dislocation [17]. The preservation and repair of the capsular ligament can prevent dislocation in surgery using the conventional posterolateral approach [18,19]. Recently, DAA and the anterolateral approach have both gained more attention because they are associated with faster functional recovery and lower dislocation risk [3,20]. Although the ability of anterior capsule preservation to prevent dislocation remains controversial [5], one report demonstrated lower leg length discrepancy after preservation and repair of the capsule using the DAA [21]. Moreover, a previous study proposed the use of the stepwise approach for soft-tissue releases [4].



**Figure 2.** (a–c) Anterior view of the right hip in neutral position. Autopsy of the iliocapsularis muscle (area surrounded by the red line) and the inferior iliofemoral ligament (area surrounded by the yellow line). (a and b) The iliocapsularis muscle can be found in the medial and under the direct head of the rectus femoris muscle. (c) The inferior iliofemoral ligament is located under the iliocapsularis muscle. (d) The schematic diagram indicating the measurement of the lateral and medial edge of the iliocapsularis muscle and the inferior iliofemoral ligament. A reference line (black dashed line) parallel to the proximal femoral axis (blue line) was drawn at the lateral edge of the femoral head. These measurements were performed at the top (upper), center (middle), and bottom (lower) of the femoral head. Several examples are shown. L1 and L2 are the distance at the upper part between the reference line and the lateral edge of each iliocapsularis muscle and the inferior iliofemoral ligament. L3 is the distance at the middle part between the reference line and the medial edge of each iliocapsularis muscle. O, center of the femoral head.

The capsular ligament can help achieve hip joint stability during dynamic and static motions [6]. Biomechanical cadaveric studies of the capsular ligament have shown that ILFL can facilitate primary restraint while in extension and external rotation [9,22]. Although existing evidence on the preservation of the ILFL to prevent dislocation after THA is controversial [3,5], given that these positions are essential for dislocation and exposure of the femur during hip surgery using the DAA and anterolateral approach, the resection of entire ILFL can increase the risk of dislocation after THA. In addition, a radiographic study has reported that ICM is an important anterior stabilizer of the femoral head [23].

An anatomical study has reported that the iliofemoral ligament is composed of superior and inferior branches, which is inserted together into the inferior edge of AIIS via the fibrocartilage, thereby forming the inverted Y-shaped ligament [11]. ILFL ran across the anterior surface of the femoral head, and it was attached into the inferior portion of the intertrochanteric line [10]. ICM is the deepest

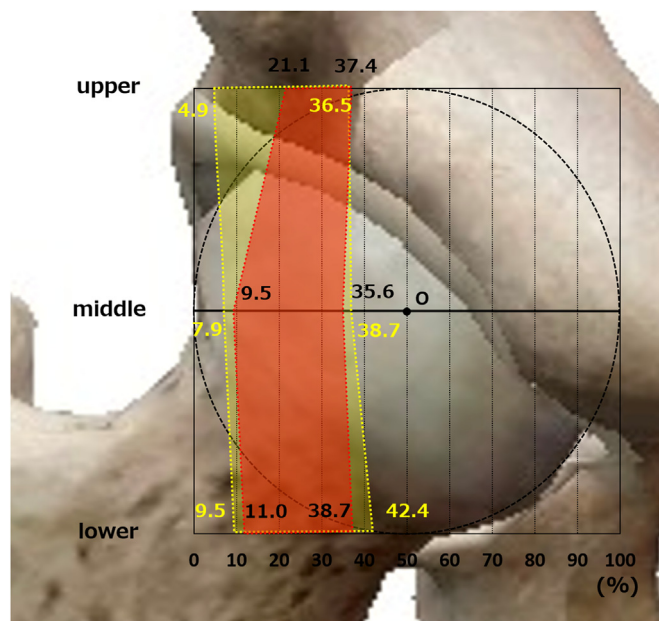
portion of the iliopsoas and is attached to ILFL via the deep aponeurosis [14]. The origin of ICM corresponded with the inferior

**Table 2**  
Measurement of the iliocapsularis muscle and inferior iliofemoral ligament (mm).

Parts	Level	Lateral edge	Medial edge	Width	Thickness
ICM	Upper	9.7 ± 2.4	17.3 ± 3.3	7.5 ± 2.0	1.3 ± 0.5
	Middle	4.4 ± 1.6	16.4 ± 3.1	12.0 ± 2.9	9.0 ± 2.1
	Lower	5.1 ± 1.9	17.8 ± 3.4	12.8 ± 3.1	9.1 ± 2.1
ILFL	Upper	2.9 ± 1.9 <sup>a</sup>	17.5 ± 4.1	14.6 ± 4.1 <sup>a</sup>	NA
	Middle	3.6 ± 2.1	17.9 ± 4.1	14.2 ± 3.7 <sup>a</sup>	NA
	Lower	4.4 ± 2.4	19.6 ± 4.6	15.2 ± 3.5 <sup>a</sup>	NA

Values are given as mean ± SD. ICM, iliocapsularis muscle; ILFL, inferior iliofemoral ligament; NA, not applicable; SD, standard deviation.

<sup>a</sup> P < .05.



**Figure 3.** A schematic diagram indicating the spatial distribution of the iliocapsularis muscle and the inferior iliofemoral ligament relative to the femoral head. The black and yellow values indicate the mean ratio of the iliocapsularis muscle and the inferior iliofemoral ligament, respectively, relative to the femoral head diameter, which represent 100%. The area surrounded by the red and yellow lines indicates the approximate range connecting these values.

edge of AIIS [24], which is consistent with the measurements of the present study.

The morphological measurements around the hip have been conventionally described using the clock-face method [24,25]. It might be reasonable to describe the anatomical structure referring to the acetabular rim. However, the clock-face reference point cannot be obtained using the anterior approach before osteotomy and dislocation of the femur. Thus, we applied a reference line and coordinate system, which could be identified from the surgical view. We believe that this coordinate system and measurement are reliable based on the interobserver ICC and are clinically applicable for hip exposure during surgery.

Our study showed that the overwrapping structure of ILFL and ICM corresponded to the medial edge. In addition, there was a correlation between the ICM width and femoral head diameter. Based on the lateral distribution of ILFL and ICM to the femoral head, it might be difficult to preserve the whole ligament for hip exposure, particularly in cases of contracture. However, based on our findings, surgeons can identify the extent of excision and release the lateral ILFL in the surgical view with consideration of the ICM and femoral head.

This study had several limitations. First, the average age of the cadavers was 84.0 years. Age-dependent factors including muscle atrophy could influence the ICM thickness and width. Second, all specimens were collected from cadavers with normal hips (without osteophytes and contracture). Therefore, our measurements may not be applicable to patients with osteoarthritis of the hip. Third, the dynamic change in hip motion after THA was not examined because our specimens were obtained from formalin-embalmed cadavers and did not contain any implant components. Thus, the clinical importance of ILFL preservation remains unclear.

This study evaluated the anatomical structure of ICM and ILFL. They were found at the anterolateral side of the femoral head, and the medial edge of ILFL corresponded to that of ICM. Thus, ICM could be a landmark for preserving ILFL in THA using the anterior approach. Nevertheless, further clinical studies must be performed to assess the utility of ICM as a landmark in THA for osteoarthritis.

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## Conflicts of interest

The authors declare there are no conflicts of interest.

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