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# An Anatomic Study of the Impressions on the Greater Trochanter: Bony Geometry Indicates the Alignment of the Short External Rotator Muscles

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ABSTRACT

In this study, 44 hip regions from 25 embalmed cadavers were dissected to identify the bony landmarks on the greater trochanter, which indicate the individual short external rotator muscle insertions. Micro-computed tomography (micro-CT) images were obtained to identify the bony impressions on the greater trochanter. Then, the soft tissues were removed and their insertions were identified to assess correlation with micro-CT images. Bony landmarks indicating the insertions and the running course of the piriformis muscle, the obturator internus muscle, and the obturator externus muscle were identified on the greater trochanter in all specimens. These findings could be helpful for preserving muscles during capsular release in the anterior approach because the alignment of the short external rotator muscles can be estimated preoperatively using CT images.


Minimally invasive surgeries have become the trend in all aspects of orthopedic surgery, including total hip arthroplasty (THA). In THA, the importance of preserving the muscle has been widely recognized, and therefore, muscle sparing approaches are widely used. The advantages of muscle sparing approaches include quick recovery, less pain, decreased blood loss, shorter hospital stay, and reduced dislocation rate [1–3]. The direct anterior approach is one of the muscle sparing approaches which has become one of the standard approaches in THA [1–4]. When using the direct anterior approach, acetabular preparation and implantation of the acetabular component are easy tasks [5], whereas preparation of the femoral canal is more technically demanding [5]. To prepare the femur for prosthetic implantation, releasing the posterior capsule from the greater trochanter is generally necessary to achieve sufficient exposure [3–6]. Preservation of the short external rotator muscles is considered to be important because it contributes to joint stability and prevents postoperative dislocation [7]. However, despite careful capsular release and femoral rasping, damage to the short external rotator muscle may occur [8]. Ito et al [9] reported on the quantitative data of the anatomic insertions of the short external rotator muscles. However, since the shape of the greater trochanter is quite varied, it is difficult to define a standardized form of the greater trochanter, and to perform anatomic mapping of the tendon insertions on the greater trochanter. To date, few detailed anatomical studies regarding the relation between the bony landmarks and the insertions of the short external rotator muscles have been undertaken. We hypothesized that there are some consistent bony landmarks which indicate the insertion sites of muscles on the greater trochanter, and they can be identified using bone morphology. The purpose of this study was to investigate the bony geometry of the greater trochanter and identify the bony landmarks that indicate the insertion of each of the short external rotator muscles.

## Materials and Methods

Forty-four hip regions from 25 embalmed cadavers [8 males and 17 females; average age at the time of death, 86.7 (range, 71–104)] were dissected. The cadavers that we used were all donated to the department of anatomy. The consent documents of donations were completed and signed by the subject before death. All cadavers were fixed in 8% formalin and preserved in 30% ethanol. The proximal one-third of the femur with soft tissues was obtained by cutting the femur and detaching the soft tissues from the coxal bone. The skin, fat, and subcutaneous tissues were removed until only the muscles and the capsular structures around the greater trochanter remained. At first, the greater trochanter with surrounding soft tissue was examined using micro-computed tomography (micro-CT: inspeXio smx-100ct, SHIMADZU, Kyoto, Japan), and a three-dimensional model of the greater trochanter was reconstructed using data of micro-CT and an application

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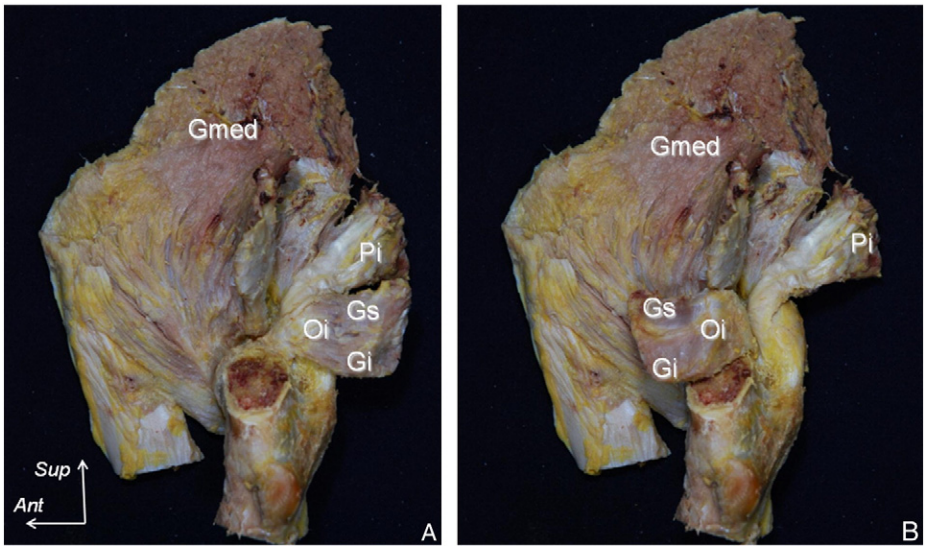


**Fig. 1.** Photographs of the anteromedial aspect of a right hip, after the femoral head was removed, showing the muscular and tendinous structures of the short external rotator muscles near their insertions into the greater trochanter. (A) The obturator internus runs anteriorly to the piriformis, and inserts into the medial aspect of the greater trochanter. (B) The obturator internus tendon was reflected. The piriformis runs posterosuperiorly to the obturator internus, and inserts into the tip of the greater trochanter. Gmed = gluteus medius, Pi = piriformis, Oi = obturator internus, Gs = gemellus superior, Gi = gemellus inferior, *Ant* = anterior, and *Sup* = superior.

software (VG Studio Max 2.0, Heidelberg, Germany), and configuration of the bone surface from the model was evaluated. Although several high-resolution CT technologies were available to evaluate the bone structure, micro-CT can achieve the highest resolution [10]. The micro-CT we used in this study allows resolution of 5 μm. After observation of the macroscopic characteristics of the muscles around the greater trochanter, the soft tissues around the greater trochanter were chemically removed. Then, the correlations of these tendon insertions and the images of micro-CT were assessed. The maximum length (parallel to the tendon running course) and maximum width (perpendicular to the tendon running course) of the footprints of the piriformis, the obturator internus, and the obturator externus, and the distance between the centers of the footprints were measured in all specimens.

## Results

### *Muscles Around the Greater Trochanter*

The muscular and tendinous structures around the greater trochanter are shown in Figs. 1 and 2. The obturator internus, gemellus superior, and gemellus inferior, formed a conjoint tendon.

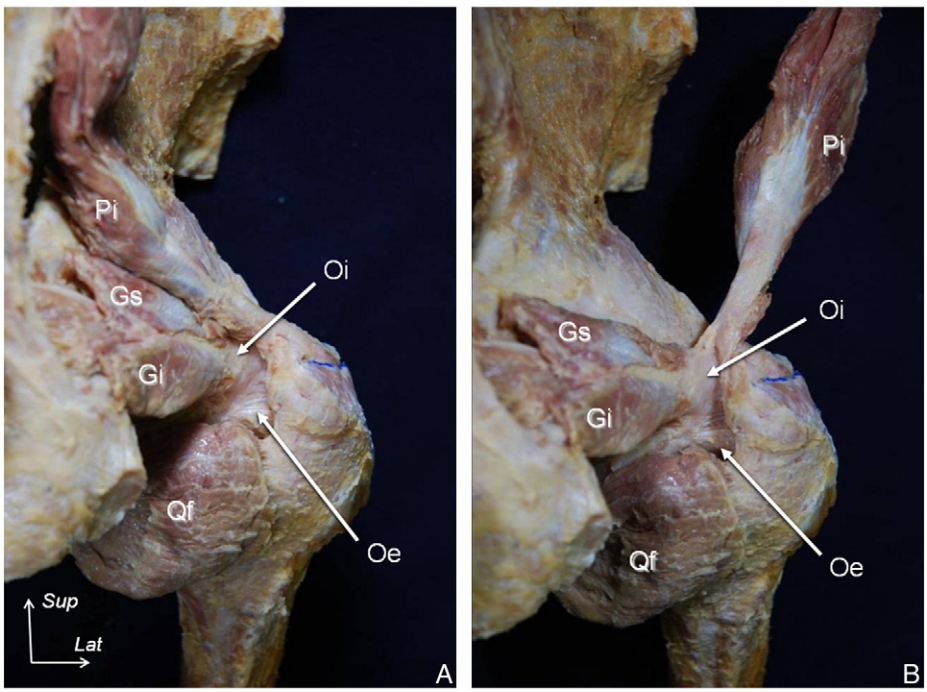


**Fig. 2.** Photographs of the posterosuperior aspect of a right hip. (A) The piriformis inserts into the tip of the greater trochanter. The obturator externus inserts into the medial aspect of the greater trochanter posteroinferiorly adjacent to the insertion of the obturator internus. (B) The piriformis tendon was reflected. The insertion area of the obturator internus is clearly observed. Pi = piriformis, Oi = obturator internus, Oe = obturator externus, Gs = gemellus superior, Gi = gemellus inferior, Qf = quadratus femoris, *Lat* = lateral, and *Sup* = superior.