

The anatomy and function of the gluteus minimus muscle

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In order to investigate the functional anatomy of gluteus minimus we dissected 16 hips in fresh cadavers. The muscle originates from the external aspect of the ilium, between the anterior and inferior gluteal lines, and also at the sciatic notch from the inside of the pelvis where it protects the superior gluteal nerve and artery. It inserts anterosuperiorly into the capsule of the hip and continues to its main insertion on the greater trochanter.

Based on these anatomical findings, a model was developed using plastic bones. A study of its mechanics showed that gluteus minimus acts as a flexor, an abductor and an internal or external rotator, depending on the position of the femur and which part of the muscle is active. It follows that one of its functions is to stabilise the head of the femur in the acetabulum by tightening the capsule and applying pressure on the head. Careful preservation or reattachment of the tendon of gluteus minimus during surgery on the hip is strongly recommended.

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Knowledge of the anatomical relationships and function of gluteus minimus is limited. It is described as a fan-shaped muscle arising from the external iliac fossa between the anterior and inferior gluteal lines and covered almost entirely by gluteus medius.¹⁻⁵ Reports of the exact site of the insertion of the tendon of gluteus minimus vary. Some describe it as at the anterior surface of the greater trochanter,^{2,3} and some to the external side of the anterior rim of the greater trochanter and the superior aspect of the capsule of the hip. More recently, it has been reported to be at the ventral triangular area of the greater trochanter.^{6,7} The French literature has it at the *tubercule prétrochantinien*.⁸

The function of gluteus minimus is also uncertain. Both minimus and medius have been described as having essentially the same function, primarily abduction, with internal rotation and flexion being possible, depending on the position of the femur.^{1-3,9}

Based on anatomical and electromyographic studies, Gottschalk, Kourosch and Leveau¹⁰ proposed a different model of the gluteus complex. They declared that the primary function of the entire gluteus minimus and the posterior part of gluteus medius is to stabilise the head of the femur in the acetabulum during the gait cycle.

Our interest in this muscle was raised by the observation of a lateral indentation in the head of the femur in patients with spastic diplegia of the hip (Fig. 1). In the course of periacetabular osteotomy with an intertrochanteric osteotomy, we found gluteus minimus in this indentation, separated by the capsule. We deduced that this appearance was due to pressure by gluteus minimus as it resisted superolateral migration of the head. Notching of the head has previously been described in patients with cerebral palsy and was attributed either to a taut ligamentum teres,¹¹ the overlying capsule, spastic abductor muscles,^{12,13} or to the rim of the acetabulum.¹⁴

Materials and Methods

We studied the anatomy of gluteus minimus in 16 hips from nine cadavers, of which eight were fresh and one embalmed. There were nine right and seven left hips. The age at death had varied between 45 and 80 years.

The dissection was carried out with the cadaver in the



Fig. 1a

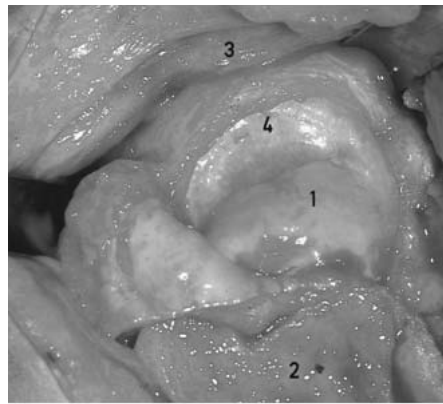


Fig. 1b

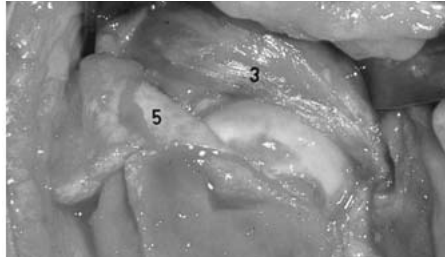


Fig. 1c

A 14-year-old-girl with spastic diplegia. Figure 1a – Preoperative radiograph with a superolateral indentation of the head of the femur. Figures 1b and 1c – Intraoperative view of the head (1) after osteotomy of the greater trochanter (2). Gluteus minimus (3) is retracted superiorly, with excellent visualisation of the groove (4) in the head. Gluteus minimus (3) is released and lies in the indentation. The joint capsule is seen (5).

lateral position. After removal of the skin and subcutaneous tissue, the fascia over gluteus maximus and medius was incised in the interval between the two muscles. Gluteus maximus was then detached from the ilium and reflected posteriorly. Next, gluteus medius was dissected off gluteus minimus in a distal-to-proximal and posterior-to-anterior direction. Based on our anatomical findings, a model of gluteus minimus was developed, attached to plastic bones of a hemipelvis and proximal femur (Fig. 2). A prosthetic hip was implanted to provide a normal range of movement. The joint capsule was simulated using a broad rubber sheet, glued to the anterosuperior circumference of the acetabulum and to the intertrochanteric line on the proximal femur. The muscle was divided into four identical sectors, sector I being the most anterior and sector IV, the most posterior. Each sector was represented by a cord 2 mm thick, which was firmly fixed at its insertion on the greater trochanter and directed through pulleys on the capsule of the hip and at its origin. The excursion of each cord was measured independently. Schanz screws were inserted at right angles into the greater trochanter to control and measure the degrees of rotation and flexion. Three measurements were made for each directional movement, starting with the hip in the neutral position and the mean value was calculated. The measurements were taken for flexion, external and internal rotation in both the extended and flexed position, and for abduction.

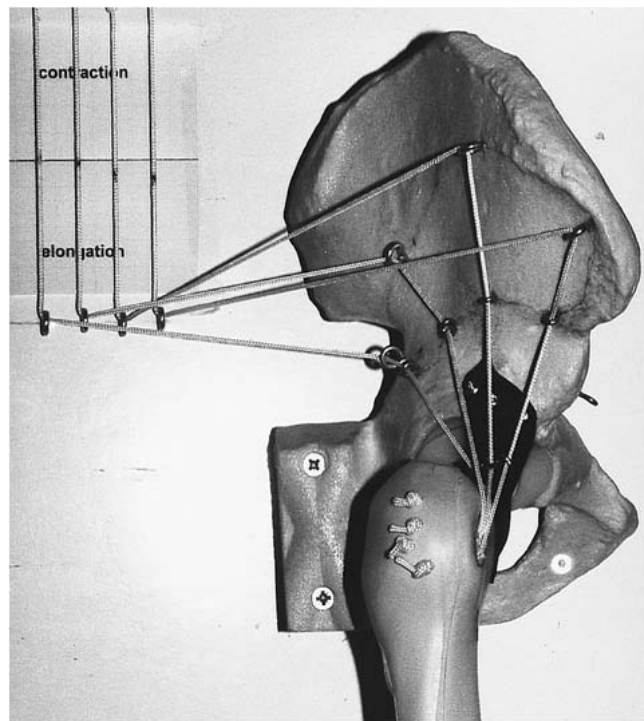


Fig. 2

A model of gluteus minimus. Four different sectors of the muscle are represented by cords, guided through pulleys, which represent the attachment to the capsule and the origin of the muscle. The excursion is measured on the scale (left).

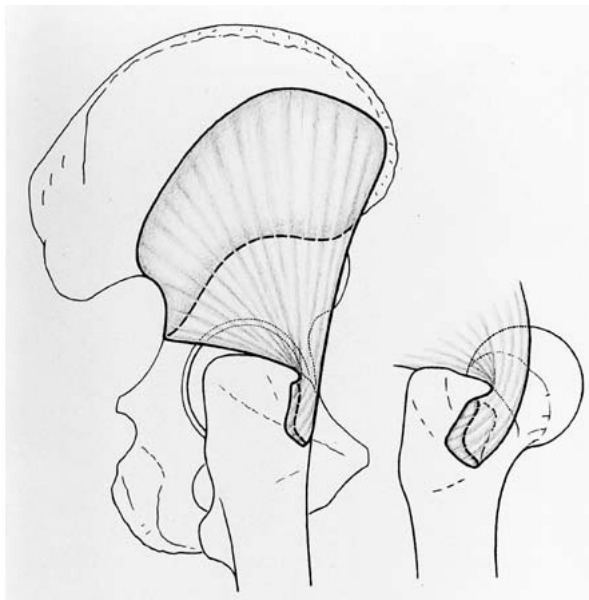


Fig. 3

Diagram of gluteus minimus showing the area of origin, excluding the anteroinferior iliac spine and the reflected head of the rectus from inside the pelvis at the greater sciatic notch.

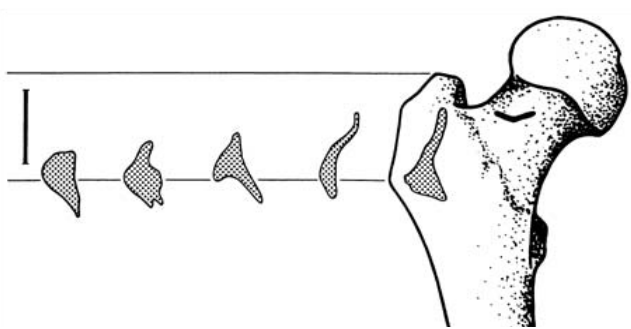


Fig. 4

Diagram showing the differing areas of insertion of the tendon of gluteus minimus on the greater trochanter.

Results

The gluteus minimus muscle arises from the external iliac fossa. From there the fibres converge, crossing the hip anterolaterally to their insertion on the front of the greater trochanter. The line of origin begins anteriorly 3 to 5 mm below the anterior superior iliac spine and runs posteriorly, parallel to the iliac crest to the iliac tubercle. From there it follows the anterior gluteal line to the greater sciatic notch from where the caudal portion of the muscle takes its origin inside the pelvis (Fig. 3). The posteroinferior border of the muscle covers the posterosuperior acetabulum and follows the inferior gluteal line to the anteroinferior iliac spine. Anteriorly, gluteus minimus arises from the ridge between the anterosuperior and anteroinferior iliac spines.

The muscle fibres converge from the area of origin to a

tendinous insertion into the capsule of the joint. They measure about 4 cm in length and blend with a fascia on the surface of gluteus minimus. This fascia increases in thickness and finally becomes the tendon of gluteus minimus at its insertion into the capsule. The tendon then continues to its insertion on a ridge lateral to the anterior triangular area of the greater trochanter. The capsular insertion is irregular and measures 10 to 15 mm mediolaterally and 20 to 25 mm craniocaudally. The insertion on the greater trochanter shows great variation between an irregular L-shape and a triangular area on the greater trochanter (Fig. 4). The area anterior and medial to the insertion may be covered with a thin layer of fibrocartilage forming the bottom of a bursa under the tendon of gluteus minimus.

The posterior fibres run in a dorsoventral direction to the capsule and the anterior fibres in a craniocaudal direction. They make an angle of approximately 75° with each other. The anterior craniocaudal fibres follow an almost straight course while the posterior fibres wind around the greater trochanter. The relationship between the capsular and trochanteric insertions changes during the arc of hip flexion. In the neutral position, the posterior fibres alter their direction between 60° and 80° at the capsular insertion, whereas the anterior fibres run straight. At 90° of flexion, all fibres of muscle and tendon run straight from their origin to their insertion on the trochanter.

There was a fan-shaped appearance to the musculature in nine hips. In two, an accessory muscle was identified arising directly from the lateral edge of the iliac crest between the anterosuperior iliac spine and the iliac tubercle and from the fascia covering gluteus minimus. Distally, it joined the tendon of gluteus minimus. The branch of the superior gluteal nerve to the tensor fasciae latae passed behind this muscle. Five specimens could not be classified into either group; in these the muscle between the anterosuperior iliac spine and the iliac tubercle originated directly from the lateral edge of the iliac crest, but was covered by the fascia of gluteus minimus. As in the cases with the accessory muscle, the nerve to tensor fasciae latae passed behind these muscle fibres. In a subsequent dissection of two specimens we found a sequential innervation of gluteus minimus with four distinct branches coming from the superior gluteal nerve.

Muscle function. The model of gluteus minimus (Fig. 2) allowed us to measure the excursion of the muscle in standardised directions. On moving the hip from extension to 100° of flexion in neutral rotation, sectors I and II shortened, sector III remained unchanged and sector IV elongated slightly (Fig. 5). With external rotation of the extended hip, sector I elongated, sector II showed no change in length of the muscle fibre and sectors III and IV shortened. With internal rotation the entire muscle elongated increasingly from anterior to posterior (Fig. 6). With internal rotation of the flexed hip, sectors I to III shortened and sector IV showed no change in length. With external rotation all the muscle fibres elongated (Fig. 7). Abduction

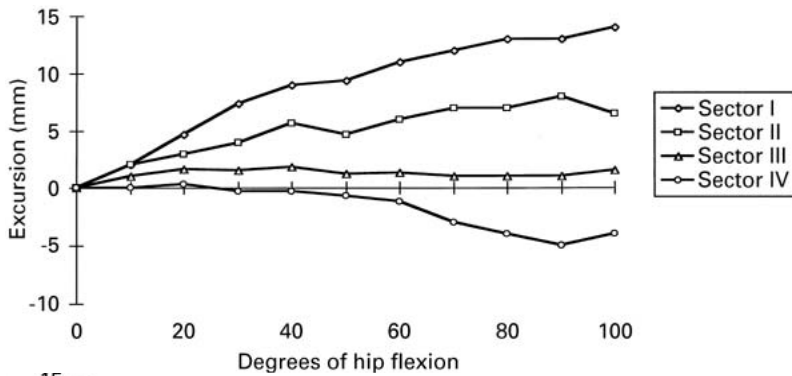


Fig. 5

Excursion of the muscle fibres during hip flexion from 0° to 100°.

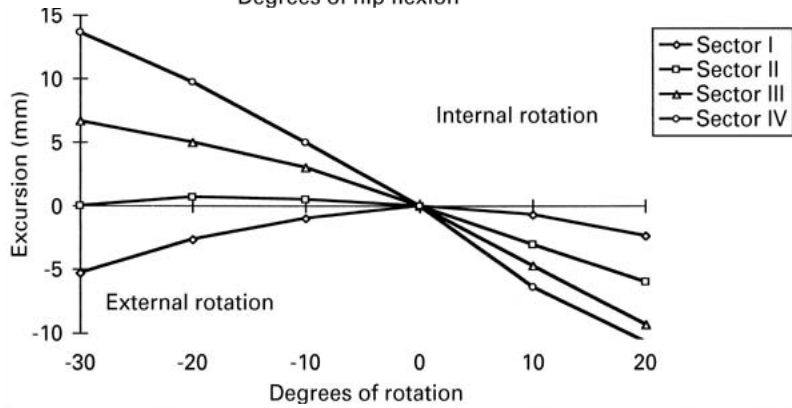


Fig. 6

Excursion of the muscle fibres in extension of the hip in internal and external rotation.

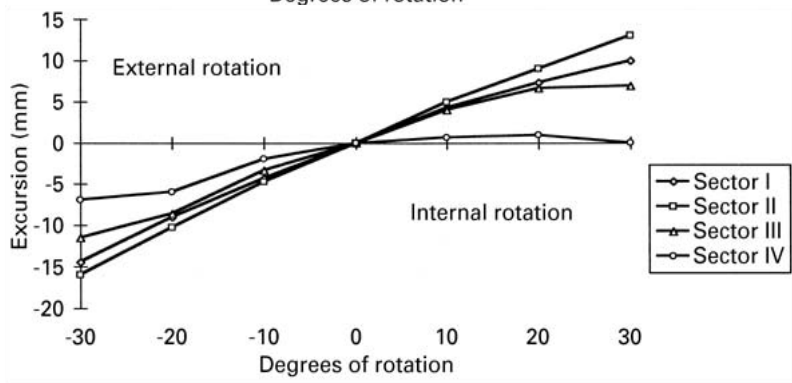


Fig. 7

Excursion of the muscle fibres in 90° flexion of the hip in internal and external rotation.

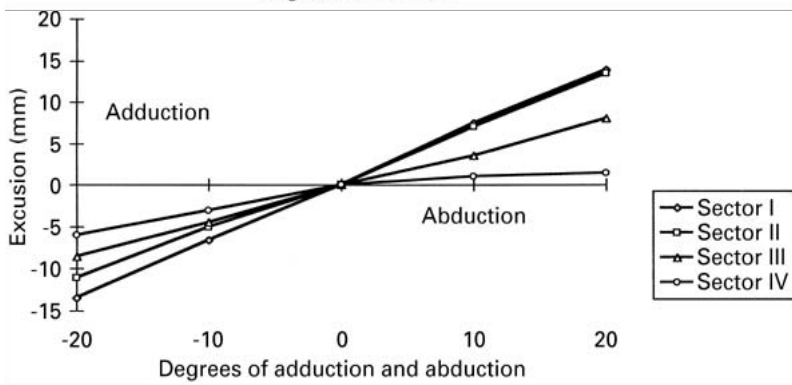


Fig. 8

Excursion of the muscle fibres at abduction.

caused increased shortening from sector IV to sector I, with sector IV showing little change in length (Fig. 8).

Discussion

Generally, the origin of gluteus minimus has been defined as from the external iliac fossa between the anterior and

inferior gluteal lines.^{1-3,5} Platzer, in *Pernkopf's textbook of anatomy*,⁴ describes an origin from inside the pelvis. At the greater sciatic notch the caudal muscle fibres cover the bone as they come round, protecting the superior gluteal artery and nerve from damage.

The presence of an accessory muscle anterior to gluteus minimus has been described^{3,5} and variously termed 'glu-

teus quartus' or 'gluteus scansorius'. This specific pattern was present in two out of our 16 dissections. The function of this accessory muscle remains unclear. A strong variant is found in monkeys and is thought to rotate the hip internally enabling them to climb trees (scansorius from scandere (Lat), to climb).³ Correspondingly, we observed that with increasing hip flexion the anterior part of gluteus minimus has a stronger action for internal rotation.

The function of gluteus minimus and gluteus medius was thought to be the same, that is primary abduction of the hip.^{1,3,5} We found that gluteus minimus acts as a flexor and an abductor of the hip and also as either an internal or external rotator, depending on which part of the muscle is active and on the position of the femur relative to the pelvis (Fig 5). This can be explained by the orientation of the muscle fibres and the change of direction of the tendon fibres at the joint capsule. The muscle fibres of sector I elongate during external rotation and are therefore able to resist this movement, which may help to prevent anterior dislocation of the natural or prosthetic hip. During passive internal rotation all muscle fibres elongate increasingly from anterior to posterior and are therefore able to resist internal rotation. This may help to prevent impingement of the femoral neck against the superomedial acetabular rim and posterior dislocation of a prosthetic hip. When the entire muscle is activated simultaneously, which theoretically is possible because of its sequential innervation, the forces for internal and external rotation are counterbalanced. In such a situation the femoral head is pulled into the acetabulum and stabilised.

In the flexed hip, the musculotendinous fibres run straight from their origin to the femoral insertion. The muscle fibres of sectors I to III rotate the hip internally, whereas the posterior fibres are inactive. During passive external rotation the entire muscle is stretched and is therefore able to resist external rotation.

We conclude that one of the primary functions of gluteus minimus is to stabilise the head of the femur in its socket. This has already been suggested from electromyographic and anatomical studies,¹⁰ and more recently by an MRI investigation of the abductors.¹⁵ The stabilising action seems to be more important in the extended hip, because of the stronger counterbalancing activity of the muscle. Tightening the joint capsule, a function which does not depend on the position of the hip, also adds stability. Furthermore, the tendon serves as a physical barrier against superolateral migration of the head since it passes over it (Fig. 9). This plays an important role in a hip which lacks geometrical stability, for example a dysplastic joint in which the head may sublux anterolaterally. A lateral flattening, or even indentation, of the head can be observed in such cases, especially in spastic hips.

The limitation of the model of gluteus minimus is that only passive excursions of the muscle fibres are measured. We attribute shortening to contraction and elongation to the ability to resist movement. Our study cannot, however,

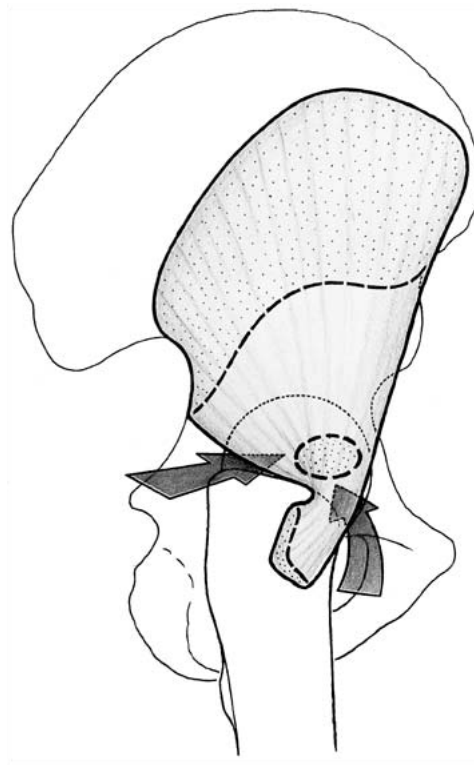


Fig. 9

Diagram of the forces exerted by gluteus minimus on the head of the femur, with one stabilising the counterbalanced action of the anterior and posterior parts of gluteus minimus, pulling the head into the acetabulum, and the other exerting direct pressure of the lateral tendon on the head.

imitate the activation and co-ordination of the different parts of the muscle in real life.

Recurrent dislocation after total hip arthroplasty has been attributed to inadequate myofascial tension.¹⁶⁻¹⁸ To enhance stability, anterior and distal advancement of the greater trochanter has been recommended to increase the tension in gluteus medius and minimus.^{16,17} The capacity of a trochanteric osteotomy to prevent dislocation of the hip by restoring the correct tension to the soft-tissue sleeve¹⁷ may be improved by including the insertion of minimus to the trochanter. Care should be taken to identify the insertion of gluteus minimus during the approach to the hip and to restore its anatomy at closure.

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