Gemelli and Obturator Internus Muscles:
Different Heads of One Muscle?

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ABSTRACT  Background: The superior gemellus, inferior gemellus, and obturator internus muscles were once regarded as a single muscle judging from their insertion and function. However, current textbooks of anatomy do not treat them as one muscle. In gross anatomy, the classification of muscles depends largely upon the nerve supply, so that the present author re-examined the nerve supply to the three muscles.

Methods: Fourteen nerve-muscle specimens were taken from 12 cadavers (five males and seven females) and examined with the unaided eye and under a dissecting microscope.

Results: (1) The modes of nerve supply to the superior gemellus, inferior gemellus, and obturator internus muscles differed; however, the nerves to the muscles shared the same spinal nerve components. (2) The gemelli formed a muscular pocket ("gemellus pocket") through which obturator internus muscle passed.

Conclusions: In light of this knowledge on nerve muscle relationships, the difference in the pattern of nerve supply to the superior gemellus, inferior gemellus, and obturator internus muscles cannot be the basis for stating that the muscle are independent. Rather, their fusion to form the gemellus pocket and their common insertion suggest that they are different heads of one muscle.  © 1995 Wiley-Liss, Inc.

Key words: Gemelli muscles, Nerve supply, Gross anatomy

The superior gemellus, inferior gemellus, and obturator internus muscles have been regarded as a single muscle unit and called the "rotator triceps muscle" (Kaneko, 1973), because the gemelli converge onto the tendon of insertion of the obturator internus muscle and because the three muscles terminate at the same common bony attachment, the medial aspect of the greater trochanter. Their functions are also common; they act synergistically to rotate the pelvis and/or femur. However, current textbooks of anatomy do not treat these three muscles as one single muscle (e.g., Williams et al., 1989; Agur and Lee, 1991).

When two or more muscles share the same insertion, the judgment as to whether each is an independent muscle or they are heads of a (multicipital) muscle may require some discussion. Other factors, such as positional and functional independence, nerve supply, and even historical background of the naming must be taken into consideration. The primary purpose of the present study was to clarify the nerve supply to the three muscles, since classification of muscles depends largely upon the nerve supply in classical gross anatomy (see Discussion). The author suspected that the reason for abandoning the name "rotator triceps muscle," in spite of its morphological and functional validity, might be related to the nerve supply. During the present study, the author found that the gemelli often form a small muscular pocket and realized the limitations of our understanding in the positions of the three muscles.

MATERIALS AND METHODS

Fourteen randomly selected sides, seven right and seven left, of 12 embalmed cadavers (five males and seven females) were examined. The ages ranged from 66 to 85 years.

The skin and subcutaneous tissue of the lower half of the trunk and femoral regions were removed. The gluteus maximus and gluteus medius muscles were removed, and the gemelli were clearly exposed. The musculature of the trunk, the intervertebral disk, and nerves of the lumbar plexus were cut horizontally at the level between the third and fourth lumbar vertebrae. The intrapelvic organs, such as the rectum, urinary bladder, and uterus, were displaced laterally, the lumbar vertebrae and sacrum were sawed sagittally, and the pelvic diaphragm and pubic symphysis were cut into equal halves. The sacrotuberous ligament and hamstring muscles were removed as necessity. The origin of the obturator internus muscle and its nerve were examined on the inside of the pelvis, and the or-

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igin was freed with inversion toward the muscle insertion. The origins of the superior gemellus muscle and inferior gemellus muscle and their nerves were also examined, and they were inverted toward the insertion. The obturator internus, gemelli, and additionally, quadratus femoris muscles were carefully isolated from their bony attachments. Nerves to these muscles were carefully preserved. The isolated nerve-muscle specimen was further examined under a dissecting microscope.

RESULTS

Origin, Course, and Insertion of Obturator Internus, Superior Gemellus, and Inferior Gemellus Muscles

The medial surface of the os coxae is covered with the iliacus and obturator internus muscles. The former muscle originated from the superior part of the ilium, covered most of the medial surface of the iliac ala, and was inserted onto the lesser trochanter of the femur. The latter muscle (Fig. 1) arose widely from the margin of the obturator foramen, obturator membrane, iliac bone, and base of the ischial spine. It covered most of the lesser pelvis, converging like a fan at the lesser sciatic notch. A saddle-shape cartilage, with superior, inferior, lateral and medial bows, was located on the lesser sciatic notch. The obturator internus muscle changed its course on the cartilage and was inserted into the medial aspect of the greater trochanter of the femur. The superficial (= dorsal) surface of the muscle consisted mostly of muscle bundles except for the tendinous portion for insertion (Fig. 2A). The deep (= ventral) surface could be roughly divided into the muscular proximal and tendinous distal halves (Fig. 2B). The tendinous half faced the cartilage with an interposed synovial bursa.

The superior gemellus muscle originated from the ischium along the superior bow and part of the lateral bow, and the inferior gemellus muscle originated from the ischium along the inferior bow and part of the lateral bow. In 5 of 14 (= 36%) specimens, the muscle fibers of the superior gemellus muscle terminated on the superior margin of the obturator internus tendon, and the muscle fibers of the inferior gemellus muscle terminated on the inferior margin (Fig. 2A, arrowheads). In such specimens, the gemelli appeared to sandwich the obturator internus tendon between each other: the three muscles were arranged on the same plane and were readily distinguishable. In the remaining nine (= 64%) specimens, superior (or inferior) gemellus muscle bundles, to a greater or lesser extent, covered the superficial surface of the obturator internus tendon. Only two muscles, the gemelli, were found in these specimens.

In some extreme cases, the inferior (or superior) gemellus muscle ran superolaterally (or inferolaterally) over the obturator internus tendon, gradually turned into an aponeurotic sheet, and terminated at the superior (or inferior) margin of the tendon (Fig. 3A). A small space, or “gemellus pocket,” was formed between the muscle-aponeurotic sheet and the obturator internus tendon. The margin that formed the entrance to the gemellus pocket was continuous with the fascia of the obturator internus muscle via loose connective tissue. The bottom of the pocket was formed by muscle bundles of the gemelli that were inserted into the obturator internus tendon. The depth of the pocket varied from several to > 20 mm, depending on the way in which distal bundles of the gemelli participated in the formation of the bottom of the pocket.

The gemelli that originated along the lateral bow of the cartilage were deeply situated in respect to the obturator internus tendon, and they offered a muscular bed over which the tendon of the obturator internus muscle could slide. The gemelli were usually separated from each other (Fig. 2B, arrowheads), but their origins were occasionally (in 4 out of 14 specimens) continuous (Fig. 3B, black asterisks). When the origins were continuous, their muscle bundles intermingled with one another so that the two muscles were inseparable.

Nerve Supply to Obturator Internus, Superior Gemellus, Inferior Gemellus, and Quadratus Femoris Muscles

Two nerves supplied these muscles: the nerve to the obturator internus muscle and the nerve to the quadra-
Fig. 2. A. Superficial surface of the four muscles (right side). The gemelli attach to the tendon of insertion of the obturator internus muscle (arrowheads), as in Figure 1. This type of muscular arrangement was noted in only 36% of specimens. Note that the superior gemellus muscle receives a twig (arrows) of the obturator internus nerve (white asterisk) on its superficial surface. The dotted line indicates the fold of the obturator internus muscle on the saddle-shape cartilage situated over the lesser sciatic notch. B. Deep surface of the same specimen. The quadratus femoris nerve sends off twigs to the deep surface of the superior gemellus muscle and inferior gemellus muscle (arrows). The small asterisks indicate the origin of the superior gemellus muscle and the large asterisks that of the inferior gemellus muscle. The gemelli are separated from each other (arrowheads) but formed a muscular bed over which the obturator internus tendon can slide. Dotted line, fold of the obturator internus; white asterisk, obturator internus nerve. Bars = 1 cm.
Fig. 3. A. Superficial surface of the four muscles (left side). Note that the obturator internus tendon is hidden by the inferior gemellus muscle, and only the gemelli are visible. The inferior gemellus muscle forms the gemellus pocket (open arrow). The most proximal bundle of muscle fibers and its aponeurotic extension form the orifice of the pocket (arrowheads). Small arrows, a twig of the obturator internus nerve that penetrates the superficial surface of superior gemellus muscle. Dotted line, fold of the obturator internus muscle. B. Deep surface of the same specimen. Note that the origins of the superior gemellus muscle (small asterisks) and the inferior gemellus muscle (large asterisks) are continuous along the lateral bow of the saddle-shape cartilage. The gemelli exchange their muscle bundles and are not separable. In this specimen, the obturator internus tendon is surrounded by a sheath made of the gemelli. The quadratus femoris nerve sends off several twigs to the gemelli (arrowheads) and the quadratus femoris muscle. The obturator internus nerve (white asterisk) and quadratus femoris nerve originate very close to each other (open arrow) and exchange their fibers at their origins. Dotted line, fold of the obturator internus muscle. Bars = 1 cm.
Nerve supply to the Gemelli

tus femoris muscle. They originated from the sciatic nerve at the level of pyriformis muscle (Fig. 3A). The obturator internus nerve turned around the ischial spine, radiated over the obturator internus muscle, and entered the muscle from its superficial surface (Figs. 2A, 3A). The nerve often (in 12 out of 14 specimens) sent off a twig to the superior margin or superficial surface of the superior gemellus muscle. The quadratus femoris nerve originated just a few millimeters lateral to the former nerve. It passed down behind the superior gemellus muscle and inferior gemellus muscle and reached the quadratus femoris muscle. This nerve sent off several twigs to the deep surface of the gemelli (Figs. 2B, 3B). It was noteworthy that the superficial gemellus muscle received a dual supply. It received twigs of the obturator internus nerve on its superficial surface and the quadratus femoris nerve on its deep surface.

Teasing of nerves under a dissecting microscope revealed that the obturator internus nerve and quadratus femoris nerve shared numerous fibers at their sciatic origins. Thus they appeared to consist of the same nerve components.

The twigs from the obturator internus nerve and quadratus femoris nerve did not communicate in the superior gemellus muscle. The former twig was usually thin and was mainly distributed in the superficial region, whereas the latter twig was thick and was distributed in the deep region of the muscle.

Discussion

Anatomists are inclined to think that the superior gemellus muscle, inferior gemellus muscle, and obturator internus muscle are arranged on the same plane, since current textbooks of anatomy (e.g., Williams et al., 1989; Agur and Lee, 1991) provide representations of these muscles similar to those in Figures 1 and 2A. The present study revealed, however, that this arrangement was, in fact, observed in only 36% of specimens. For the most part, a portion of the gemelli was located on a superficial plane to the obturator internus muscle and formed the gemellus pocket, whereas other parts of the gemelli were located more deeply than the obturator internus muscle and provided a muscular bed over which the obturator internus tendon slides. The gemelli are arranged not only "superiorly" and "inferiorly" to the obturator internus muscle but also superficially and more deeply. In other words, the gemelli often form a sheath, through which the obturator internus muscle passes. The sheath may function to maintain and/or modify the direction of contractions of the obturator internus muscle.

Teachers of gross anatomy often may be asked whether there are only two muscles in this region, and students are unable to identify which is the superior gemellus muscle, inferior gemellus muscle, or obturator internus muscle. Based upon our experience, we have customarily told students to separate the two muscles. If one finds a white tendon, it is the tendon of insertion of the obturator internus muscle. This finding eloquently reflects the three-dimensional positions of the muscles, although we must confess our lack of a clear understanding of them.

Williams et al. (1989) described that the gemelli were supplied by the nerve to the quadratus femoris muscle and that the obturator internus muscle was supplied by its own nerve. The present study confirmed this description with the exception that the superior gemellus muscle receives a dual supply in 86% of the cases (12 of 14 specimens). The muscle usually receives twigs both from the quadratus femoris nerve and from the obturator internus nerve. According to the classical concepts of gross anatomy, a muscle and its nerve are specifically associated from the earliest stages of development and this specific relationship does not change throughout life (Fürbringer, 1888, in Straus, 1946).

Some gross anatomists (Akita et al., 1993, 1994; Tomo et al., 1994) still indicate that the stable nerve-muscle relationship in the adult is confirmation of the specific nerve-muscle development. These authors believe that the nerve is the only reliable clue to speculate the origin and developmental process of the corresponding muscle. The dual nerve supply to the superior gemellus muscle may suggest, from the perspective of classical gross anatomy, that this muscle is derived from two premuscle masses, which are destined to form the obturator internus and quadratus femoris muscles. In this regard, the superior gemellus muscle differs decisively from the inferior gemellus muscle, because the latter muscle is only supplied by the quadratus femoris nerve. Thus the latter is derived from the same premuscle mass as that of the quadratus femoris muscle. However, this author questions whether the dual nerve supply to the superior gemellus muscle has such developmental significance. Recent studies suggesting that the peripheral nerve reaches the target muscle usually late in gestation (Ontell and KozeKa, 1984; Ross and Harris, 1987) obviously do not support the classical tenets of nerve-muscle specificity. The stable nerve-muscle relationship of the adult reflects the stability of developmental cues that guide the nerve to its appropriate destinations (Summerbell and Stirling, 1981; Ho and Goodman, 1982; Lance-Jones and Dias, 1991), but not the developmental process of formation of the muscle. The muscle develops to a considerable extent without the influence of the nerve (Schramm and Solursh, 1990) and, inversely, the axonal outgrowth from the spinal cord and nerve plexus formation do not always require the presence of the corresponding myotomes or target muscles (Lewis et al., 1981; Tosney and Landmesser, 1984). The final stage of muscle development has almost been reached when the muscle and its nerve develop a certain relationship. The muscle delivers important cues for extension (Pollack and Liebig, 1977) and guidance (Swanson and Lewis, 1982; Tosney and Landmesser, 1985) of the nerve.

In the light of these observations, the dual nerve supply to the superior gemellus muscle simply implies that the muscle has guided twigs both from the obturator internus nerve and from the quadratus femoris nerve. Similarly, the inferior gemellus muscle might have guided twigs only from the quadratus femoris nerve. The differences in position and other unknown conditions between the gemelli might be responsible for this difference in guidance of nerves. This author emphasizes that such a subtle difference in the nerve supply to the gemelli cannot be used as a basis for speculations about their developmental origins nor can it prove that they are different muscles. In fact, as the
present study showed, the gemelli are not always clearly separable. At least the two gemelli muscles and possibly also the obturator internus muscle may be derived from one premuscle mass judging from their close positions and muscular continuities.

LITERATURE CITED


