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Anatomical variation of co-existing bilaminar tensor of the vastus intermedius muscle and new type of sixth head of the quadriceps femoris

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Abstract

Background: We present a case report of Quadriceps Femoris (QF) with co-existing bilaminar Tensor of the vastus intermedius muscle (TVI) and new type of sixth head.

Materials and methods: Cadaveric dissection of left thigh of a 72 years old was performed for research and teaching purposes at the Department of Anatomical Dissection and Donation,

Medical University of Lodz. The left lower limb were dissected using standard techniques according to a strictly specified protocol. Each head of the muscle was photographed and subjected to further measurement.

Results: During dissection, an unusual type of TVI muscle was observed. It consisted of two surfaces, superficial and deep. In addition sixth head of QF muscle grew out from the VM muscle.

Conclusions: The knowledge of the existence and possible variations of additional heads of QF muscle is necessary during diagnostic process of muscle strains. Moreover, according to course of tendons that heads may take part in patella stabilization.

Key words: quadriceps femoris, tensor vastus intermedius, anatomical variations, knee joint

INTRODUCTION

The anatomy of the thigh area and knee joint is highly variable in respect of the ligaments, muscles and vessels around the knee. Interestingly, recent anatomical studies have shed light on the variability of muscles that have long seemed to have constant anatomical structures. [1, 18–20, 22]

The Quadriceps Femoris (QF) and Patellar Ligament (PL) are parts of the knee extensor mechanism; the QF is also a patella and knee joint stabilizer. [6, 27] It is the largest muscle in the body by muscle mass and is traditionally described as consisting of four heads: Rectus femoris (RF); Vastus Medialis (VM); Vastus Lateralis (VL), and Vastus Intermedius (VI). [6, 7] They all form a common tendon attaching to the base of the patella. [11] Most studies of the anatomical variability of the QF concern duplication of the VM or VL muscle. [17] Golland et al. and Holyoke were among the first to report an additional head of the QF. [8, 13] Current anatomical research labels the fifth head of the QF as the “Tensor of the vastus intermedius” (TVI). [10] The incidence of the TVI ranges from 29% to 100%. [3, 10, 28].

Grob et al. described the TVI muscle with constant origin between the intertrochanteric line and greater trochanter and based their classification on the ability to separate the TVI tendon from the VM and VI muscles. Similar classification was proposed by Veeramani et al. in South Indian population. [26] Olewnik et al. proposed a classification

determined by the variability within the proximal attachment and listed three types: TVI independent; TVI grows out from other muscles; and multiple supplementary heads. Both groups also reported the possibility of more additional heads; however, there is no description of the bilaminar variability of the TVI muscle.

This paper describes an extremely rare variant of the TVI, which consists of two layers, superficial and deep. The rare case described can be used to supplement the currently prevailing classification by Olewnik et al.

CASE REPORT

A 72-year-old male cadaver was subjected to routine anatomical dissection at the Department of Anatomical Dissection and Donation, Medical University of Lodz, Poland. The purpose of the dissection was research and the education of medical students. The left lower limb (hip joint, thigh and knee joint) was dissected using standard techniques according to a specifed protocol The lower limb was positioned in supine position on the dissection table. Dissection began with hip joint capsule resection. Following this, all femoral nerve branches and quadriceps femoris vessels were dissected. The next step was to remove the quadriceps femoris with additional heads, which was the objective of our study. Each head of the vasti, rectus femoris, tensor of vastus intermedius and sixth muscle belly was separately vascularized from transverse branches of the lateral circumflex femoral artery and innervated with branches originating from the femoral nerve. Finally, the tendons were dissected to identify potential additional tendon bands.

Each head of the muscle was photographed and subjected to further measurement using an electronic caliper (Mitutoyo Corporation, Kawasaki-shi, Kanagawa, Japan), each measurement being performed twice by two researchers with accuracy up to 0.1 mm.

During dissection, an unusual type of TVI muscle was observed. It consisted of two surfaces, superficial and deep. An additional sixth head was visualized, which has no equivalent in either of the classifications of additional QF muscle bellies. This additional head grew out from the VM muscle. (Figs. 1,2) This type of insertion constitutes an extension of type 2 in the Olewnik et al. classification. Measurements of the muscles are given in Table 1.

DISCUSSION

The muscles of the lower limb derive embryologically from the condensed mesenchyme of the pre-muscle sheath. By the end of fourth week of embryo development there are three regions: thigh, leg, and foot. The QF nucleus expands as a single mass overlying the anterolateral aspect of the middle of the femur's shaft. [16] Afterwards, the mass is apportioned into RF, VL, VM and VI. Division is completed when the embryo is 20 mm long. The additional head of the QF presumably forms as an extra division of the mesenchyme when the embryo is 11-19 mm long. However, an embryological study is needed to confirm this. [2]

The QF was long considered to have a constant four-headed architecture. [6] The only variations reported concerned duplication of the VM or VL muscle. [17] Some authors have proposed segmental classification of the VM and VL architecture. The VL muscle has three components, superficial, intermediate, and deep, while the VM muscle consists of longus and obliquus partitions. [4, 25]

Golland et al. were the first to report an additional head of the QF between the VL and VI muscles. [8] Holyoke described that structure as deviating from normal anatomy. [13] Willan et al. were the next researchers to study an extra muscle belly. [28] However, this additional QF belly long remained without proper nomenclature and classification. Grob et al. named the QF head the Tensor of the Vastus Intermedius (TVI) and created the first fivefold classification based on the course of the tendon. They also reported another additional head that formed a common tendon with the TVI muscle. [11] Veeramani et al. proposed classification based on origin, middle, and distal course of TVI muscle on South Indian population. [26] Olewnik et al. suggested a different anatomical classification based on one hundred and six lower limbs. They proposed three types of TVI muscle with subtypes distinguished by the origin of the additional head. [21] Ruzik et al. were the first to observe additional heads that formed two independent tendons with insertion into the base of the patella. [24] However, it is still unclear whether the TVI muscle is an anatomical variant or a constant component of the QF muscle. In cadaveric studies, the frequency of the additional head ranges from 29% to 100%. [3, 10, 28]

The TVI muscle and additional heads as parts of the QF cause extension of the knee joint. The whole muscle has a key role in human locomotion. [6, 27] The QF also assists in patella stabilization. Patella instability is common problem, especially among young active patients; it results from failure of the medial stabilizers of the patellofemoral joint. [15] The medial patella stabilization complex is composed of the medial patellofemoral ligament (MPFL), medial patellotibial ligament (MPTL) and medial patellomeniscal ligament

(MPML). [12] Although the QF is a secondary stabilizer, the MPFL is connected to the aponeurosis of the vastus medialis obliquus fibres, creating a dynamic system that stabilizes the patella in the trochlear groove during active flexion. The TVI tendon and the tendon of the additional head insert into the medial part of the patellar base. Owing to the course of that tendon, the additional heads could possibly prevent patella dislocation. [11] It is highly feasible that the bilaminar structure and connection of the sixth head to the VM muscle affects the medialization of the patella more than other types previously described. [10, 21] Proper knowledge of the anterolateral thigh anatomy is also nessesery in reconstruction surgery. Anterolateral thigh flaps are widely used for reconstruction skin, fascia and muscle of the neck head and after breast mastectomy. [7]

Restoring the strength and function of the QF is a key point of rehabilitation after many surgical procedures such as ACL reconstruction. It should be performed before surgery because it improves the chances of returning to sport. The presence of a TVI or additional head improves the strength of knee extension, especially when it comprises two layers. In addition, the oblique course of the tendon and the connection between the sixth head and the VM muscle decreases the difference of strength between the medial and lateral components of the QF muscle, which can be useful during a rehabilitation protocol.

The RF muscle is the most frequently injured part of the QF. [5] Injury is usually connected to eccentric contraction of the QF muscle. Interestingly, there can be an eccentric contraction in the TVI muscle or other additional head. Owing to the similarity of the courses of the RF and TVI, awareness of the TVI or other additional heads could lead to missdiagnosis. A patient suffering from TVI or additional tendon rupture can present with indefinite knee pain. Nevertheless, there is only one case report of isolated TVI rupture identified by MRI. [9] Ultrasonography and MRI of the lower part of the thigh can reveal a tendon rupture. According to Rajasekaran et al., the transverse plane in a sonographic evaluation can feasibly lead to identifying a TVI rupture. [23]

CONCLUSIONS

We have reported another anatomical variability of the QF muscle, which should be included in classification. Knowledge of the true anatomy of a QF is essential during diagnosis and treatment of patients with symptoms in this region of the lower limb.

Declarations

The Bioethics Committee of the Medical University of Lodz (resolution RNN/114/19/KE) accepted the study protocol. The cadavers were the property of the Department of Anatomical Dissection and Donation, Medical University of Lodz, Poland.

The cadavers belong to the Department of Normal and Clinical Anatomy of the Medical University of Lodz.

Ethical approval

This article describes no studies involving human participants or animals performed by any of the authors.

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Conflict of interest: None declared

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Table 1. Measurements of the TVI muscle and Sixth head of QF

	Superficial portion of TVI muscle	**Deep portion of TVI muscle**	**Sixth head of QF**
Length of the muscle belly	105.57 mm	84.52 mm	129.38 mm
Width at the orgin	22.92 mm x	13.42 mm	26.17 mm
Thickness at the orgin	3.04 mm	2.02 mm	1.27 mm
Width upon passing the muscle belly	14.07 mm	12.20 mm	5.68 mm
Thickness upon passing the muscle belly	1.75 mm	1.70 mm	1.78 mm
Length of the tendon	8.55 mm, then formed a common tendon with deep portion	212.02 mm common tendon	147.15 mm
Width at the insertion	8.18 mm		9.07 mm
Thickness at the insertion	0.77 mm		0.82 mm

Figure 1. Dissected Quadriceps Femoris with additional heads. Black arrow - superficial portion of TVI muscle, white arrow- deep portion of TVI muscle, yellow arrow - sixth head of QF.

Figure 2. Additional heads of Quadriceps Femoris muscle. Black arrow - Superficial portion of TVI muscle, white arrow - deep portion of TVI muscle, yellow arrow - sixth head of QF.


1 mm