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CONTRIBUTION TO THE ANATOMICAL STUDY OF THE OBLIQUE PORTION OF THE *Vastus lateralis* MUSCLE

Débora Bevilaqua-Grossi[1], Vanessa Monteiro-Pedro[2], Gilmar da Cunha Sousa[3], Zenon Silva[3] and Fausto Bérzin[4]

[1]Department of Biomechanics, Medicine and Reabilitation of the Locomotor Apparatus, Ribeirão Preto School of Medicine, São Paulo University (USP), [2]Department of Physiotherapy, Federal University of São Carlos (UFSCar), [3]Department of Anatomy, Federal University of Uberlândia (UFU), [4]Department of Morphology, School of Dentistry, State University of Campinas (UNICAMP), Piracicaba, SP, Brazil.

ABSTRACT

Thirty-two human thighs were dissected to determine the anatomical organization of the two portions of the *vastus lateralis* muscle, and their relationships with associated structures the lateral retinaculum and iliotibial tract. In all of the cases, the *vastus lateralis* muscle consisted of a long, proximal portion, (the *vastus lateralis longus* - VLL), and an oblique, distal portion (the *vastus lateralis obliquus* - VLO). The oblique portion (VLO) originated from the aspera line of the femur and from the lateral intermuscular septum. The tendon of the VLO ran below and laterally to the long portion (VLL), which it subsequently joined on the superolateral border of the patella. The VLO also interdigitated with the lateral retinaculum and iliotibial tract. The VLL showed an extensive aponeurosis in its proximal two thirds. The gross morphology of the VL muscle agreed whith previous descriptions for this muscle and suggested that the VLO could play an important role in patella stabilization. This muscle could therefore be of clinical importance in the treatment of disorders involving the patellofemoral joint.

Key words: Anatomy, lower limb, muscle, quadriceps femoris

INTRODUCTION

Despite recent advances in our understanding and treatment of many musculoskeletal conditions, patients with symptoms of anterior knee pain remain an orthopedic enigma [7]. About 50% of muscle skeletal injuries involve the knee joint [6], and disorders of the patellofemoral joint are the most common cause of these lesions [28]. The stability of the patellofemoral joint is more dynamic than static, and is mediated by the action of the *vastus lateralis* muscle which, together with the iliotibial tract, acts mainly as the knee extensor, and the *vastus medialis* muscle, which pulls the patella medially during extension [2,21,33]. A common feature in patients with patellofemoral pain is the malalignment of the extensor apparatus that results in an imbalance between the lateral and medial components of the quadriceps muscle. This situation leads to abnormal traction of the patella and may cause anterior knee pain [7].

Correspondence to: Dr. Débora Bevilaqua Grossi
Departamento de Biomecânica, Medicina e Reabilitação do Aparelho Locomotor, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo (USP), Av. Bandeirantes, 3900, CEP 14049-900, Ribeirão Preto, SP, Brasil. Tel: (16) (55) 602-2418, Fax: (16) (55) 633- 0336, E-mail: deborabg@fmrp.usp.br

There are few descriptions of morphological variations in the quadriceps muscle [11,16,20]. Although not specifically discussed in the manual of anatomical nomenclature published by the Brazilian Society of Anatomy [32] or in classic works on anatomy [34,35,39], the medial portions of the quadriceps muscle, the *vastus medialis,* has been studied by several authors [2,22,29,30,36,40]. Anatomically, the *vastus medialis* is divided into proximal (*the vastus medialis longus,* VML) and distal (the *vastus medial obliquus*, VMO) portions. These portions of the *vastus medialis* muscle differ from each other anatomically [22,30], in their pattern of inervation [36], histochemically [37] and functionally [2,17,21,28].

A variation in the macroscopic anatomy of the proximal portion of the *vastus lateralis* muscle and its fusion with the *vastus intermedius* muscle have been described [11,41]. Scharf *et al.* [29] were the first to describe the two distinct portions of the *vastus lateralis* muscle, denominating them the *vastus lateralis longus* (VLL) and *vastus lateralis obliquus* (VLO). We have found no earlier citation of these distict portions of this muscle in the anatomical and

clinical literature. In a study of the anatomy of the lateral compartment of the knee Hallisey *et al.* [13] also noted the presence of two portions in the *vastus lateralis* muscle. These authors stressed the clinical importance of surgically releasing of this muscle when there is a need to reduce the lateral tensions on the patella. In a subsequent study, Weinstabl *et al.* [40] confirmed the presence of the VLO. However, the clinical relevance of these portions remains to be more elucidated.

Considering that the VMO and VLL muscles are the most important dynamic stabilizers of the patella and that few studies have investigated the VLO and its relationship with the other structures of the lateral compartment of the knee, such as the lateral retinaculum and iliotibial tract, we investigated the occurrence and organization of the VLO muscle in a series of 32 lower limbs. The findings reported here should be useful in future functional studies aimed at understanding the clinical relevance of this muscle.

MATERIAL AND METHODS

Thirty-two human lower limbs (16 right and 16 left limbs from 30 males and 2 females), were used. The limbs were fixed and conserved in 10% formol solution, and further dissected using established techniques for exposing the VLO muscle. The limbs were dissected with the cadaver in supine position and the knee joint fully extended. Skin and subcutaneous tissue were removed with care being taken to preserve the lateral structures of the knee. The fat tissue was removed as described by Hallisey *et al.* [13] so as to reveal the separation between the two portions of the *vastus lateralis.* In order to determine the origin of the VLO, the structures of the lateral compartment of the knee, such as the iliotibial tract and lateral retinaculum, were preserved during dissection and subsequently carefully removed to study their relationships with the VLO.

Quantification of anatomical variation (av) was obtained by considering the total of specimens (n_{tot}) studied (n = 32) as 100%, as follows: $X = (av) \cdot 100/n_{tot}$.

RESULTS

In all of the specimens, the *vastus lateralis* muscle consisted of a long, proximal portion, the VLL, and an oblique, distal portion, the VLO, that were separated by a fascia in the distal portion. The VLO originated from the aspera line of the femur and the lateral intermuscular septum, where it was inserted by its own tendon and passed inferiorly and laterally to the VLL tendon. The VLO subsequently jointed in a common tendon with the VLL on the superolateral border of the patella (Fig. 1).

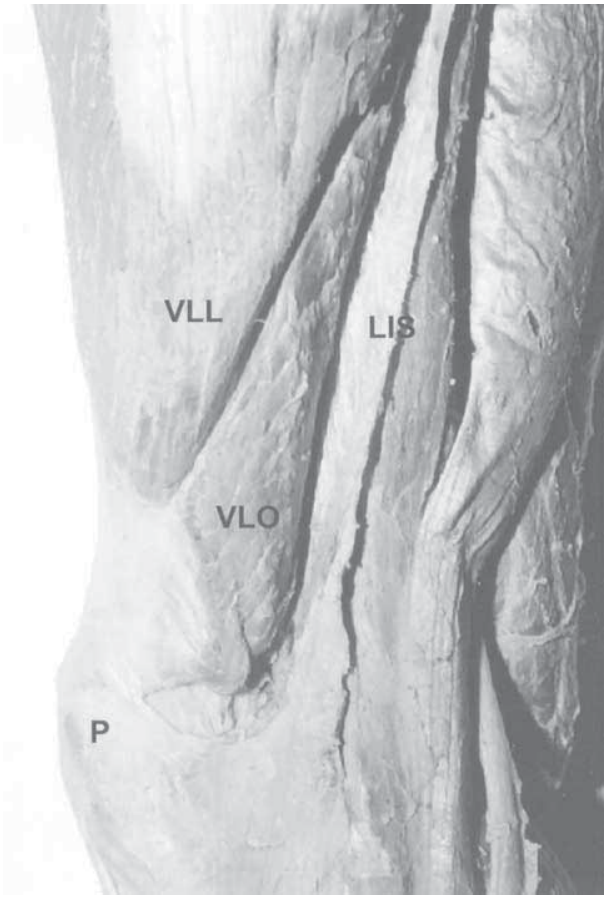

Figure 1. Lateral view of the right thigh showing the origin of the obliquus portion of the v*astus lateralis* muscle *(vastus lateralis obliquus* —**VLO***)* in the lateral intermuscular septum (**LIS**) and its insertion in the superolateral border of the patella (**P**). **VLL** - *vastus lateralis longus.*

In all specimens, the VLL showed an extensive superficial aponeurosis (SA) that covered more than two thirds of the surface proximal (Fig. 2A). In 26 (81.3%) of the specimens, an anatomical variation referred to as deep aponeurosis (DA) was seen in the fascia separating the portions. The DA ocurred in the distal third of the VLL and separated this muscle from the VLO (Fig. 2B). This aponeurosis was absent in six (18.7%) of the specimens.

The distal fibers of the VLO were interdigitated with the lateral retinaculum and the iliotibial tract in all specimens, and a careful dissection was necessary in order to separate these structures. The iliotibial tract was also interdigitated and appeared recovered the surface of the VLO in all cases (Fig. 3)

DISCUSSION

The results of this study agree with previous reports [13,29,40] that indicated the presence of an

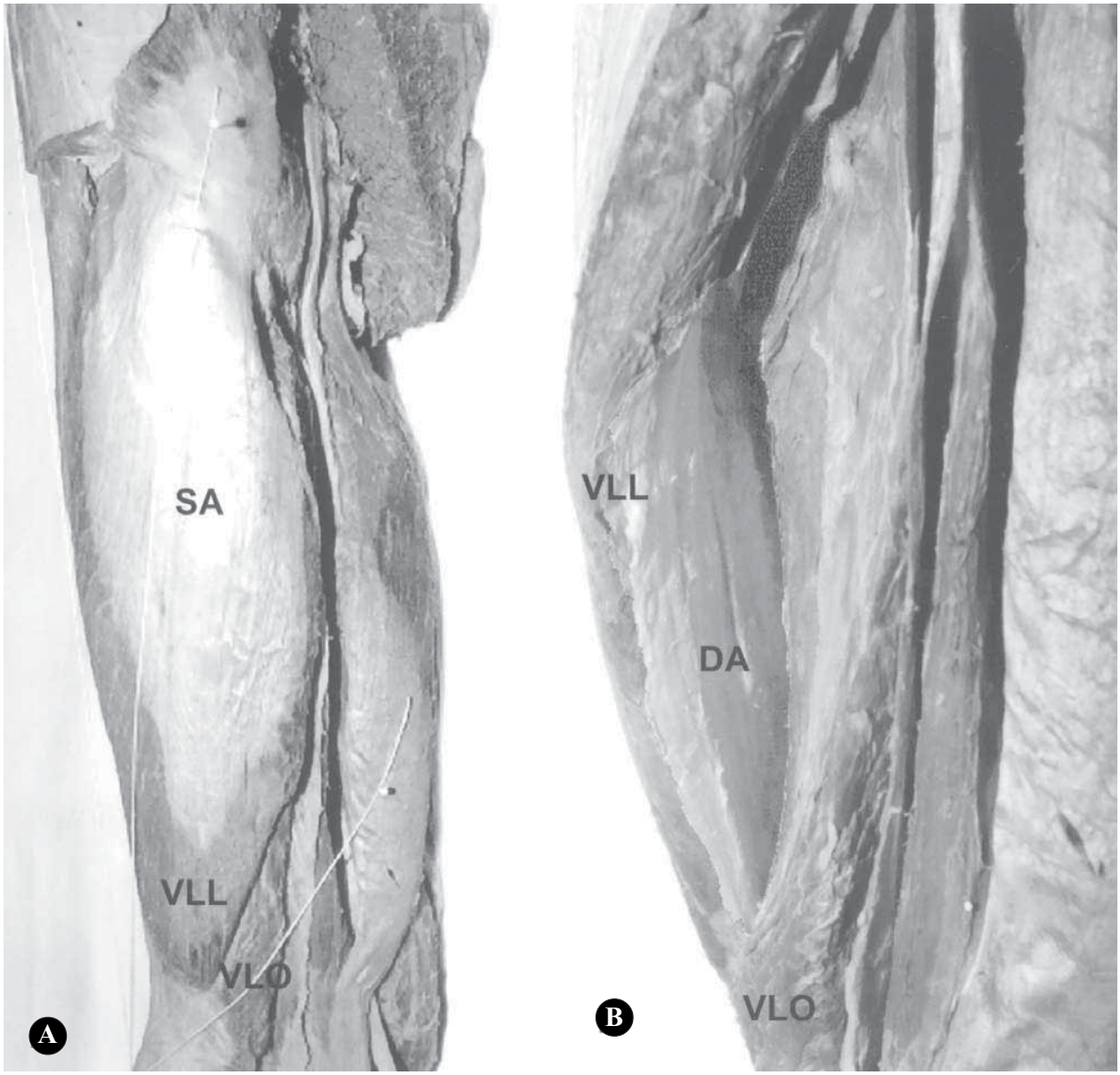

Figure 2. Lateral view of the right thigh showing the superficial aponeurosis (**SA** in panel **A**) and deep aponeurosis (**DA** in panel **B**) of the *vastus lateralis longus* (**VLL**). **VLO -** *vastus lateralis obliquus*.

oblique lateral portion in all of the limbs dissected. However Carneiro-Filho *et al.* [4] and Willan *et al.* [41] made no reference to the oblique portion of the *vastus lateralis* muscle in their study of this muscle anatomy. Similarly, no direct reference to the VLO muscle is made in classic anatomy textbooks.

Numerous studies have reported that part of the *vastus lateralis* muscle originates from the lateral intermuscular septum [1,3,10,12,14,15,23,27, 31,34,35,39], although Last [19] stated that a considerable bulk of the inferior portion of this muscle originated directly from the lateral intermuscular septum. In the limbs studied here, the VLO originated from the lateral intermuscular septum and was attached to the aspera line of the femur. These results agree with other reports indicating a similar origin [5,13,14,29,40].

As shown here the VLO muscle has its own tendon that ran inferiorly and laterally to the VLL muscle and joined the tendon of the VLL muscle to form a common tendon that inserted on the superolateral border of the patella. Testut and Jacob [34] and Testut and Latarjet [35] reported that the most lateral fibers of the *vastus lateralis* muscle, i.e.,

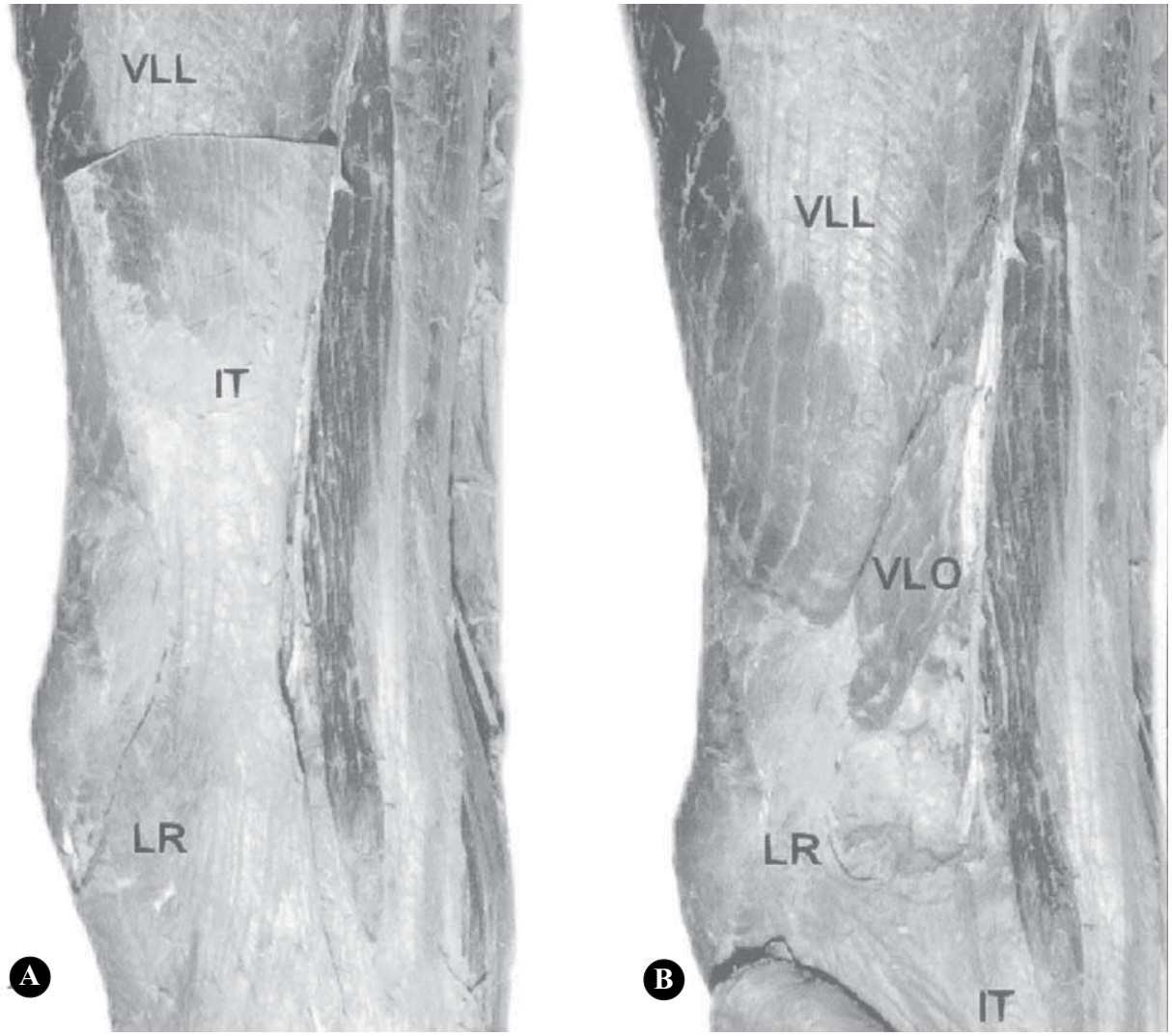

Figure 3. Lateral view of the right thigh. Note in panel **A** the iliotibial tract (**IT**) that covers the obliquus portion of the *vastus lateralis* muscle (*vastus lateralis obliquus* —**VLO**), and in panel **B** the **VLO** exposed after removal of the iliotibial tract and lateral retinaculum. **VLL** - *vastus lateralis longus*.

those of the VLO muscle, inserted into the superolateral border of the patella. However, other authors agree that the *vastus lateralis* muscle inserts not only at the base of the patella, as reported by Moore [25], but also on the superolateral border of the patella [1,3,5,10,12,15,23,27,31,39].

The division of the *vastus lateralis* muscle into two portions is more marked than of the *vastus medialis* muscle, which is divided into *vastus medialis longus* and *vastus medialis obliquus* portions separated by the alignment of its fibers and the presence of an areole fascial plane between them [22,29,30,40]. In fixed specimens, this fascia is not as easily identified as the fascia separating the long and oblique portions of the *vastus lateralis* muscle. In all of the specimens examined, a fat tissue was found between the two portions of the *vastus lateralis* muscle and recovered the fascia separating the VLL and VLO muscles, as also described elsewhere [13,29,40].

Another finding of this investigation was the presence of an extensive aponeurosis in the proximal two thirds of the muscle, as described by Goss [12] and Warwick and William [39]. This aponeurosis covered three quarters of the muscle surface. This aponeurosis also extended to deep within the muscle in 26 of the 32 specimens, where it occurred as an expansion of the fascia that covered the entire distal third of the VLL muscle, in a manner similar to a true tendon. Last [19] is the only author to mention that

the deep surface of the *vastus lateralis* muscle has a distal portion covered by a fascia thicker and stronger than its own fascia lata. This aponeurosis is an unmistakable marker of the separation of the two portions of the *vastus lateralis* muscle and suggests that the fleshly mass that originates from the intermuscular septum described by Last [19] could be the VLO muscle. The presence of a deep aponeurosis not only distinguishes the two portions but also confers specific characteristics to the *vastus lateralis* muscle that differentiate it from the other portions of the quadriceps muscle, especially the *vastus medialis* component. Because of these anatomical characteristics, the *vastus lateralis* muscle has a strong capacity to exert traction on the patella, in contrast to the *vastus medialis* muscle, which is exclusively fleshy.

The distal fibers of the VLO muscle were interdigitated with the iliotibial tract and lateral retinaculum in all of the specimens. Hamilton [14], Hollinshead and Rosse [15] and Warwick and William [39] reported that the *vastus lateralis* muscle supplied the capsule of the knee with an extension directed towards the lateral condyle of the tibia and eventually joined the iliotibial tract, to become continuous with the fascia of the leg. Distally, the lateral region of the patella was reinforced by the fibers of the iliotibial tract [34] which, according to Merchant and Mercer [24], becomes thicker distally.

The lateral intermuscular septum is the most fibrous expansion of the iliotibial tract [1,34] and, as shown here, is also the origin of the VLO muscle. According to Hughston *et al.* [17], this relationship between these two structures leads to excessive traction in the iliotibial tract that is transmitted to the tibia and to the lateral border of the patella, acting more as stabilizer than an extensor. These authors concluded that in normal conditions, the iliotibial tract is a dynamic stabilizer. In agreement with this, Ruffin and Kinningham [28] described the *vastus lateralis* muscle and part of the iliotibial tract as being responsible for the lateral dynamic force.

Fulkerson and Gossling [8] described the lateral retinaculum in detail and reported that it originated from the iliotibial tract and interdigitated with the fibers of the *vastus lateralis* muscle, in agreement with our results. The VLO fibers muscle represent one of the traction vectors acting on the patella [13]. These fibers are closely related to the lateral retinaculum and iliotibial tract and exert an important role in the stabilization of the patella.

This association can be verified clinically, after the surgical lateral release to free the fibers of the lateral retinaculum in order to decrease the lateral tension and recover the patellofemoral balance. The release of the distal fibers of the *vastus lateralis* muscle, (VLO) can improve the prognostic of recovery [9,13,18,24]. Thus, the iliotibial tract and lateral retinaculum are not exclusively static structures since they receive the tendinous insertions of the VLO muscle that could be an important dynamic stabilizer of the patella. When tense, the VLO muscle could contribute to the tension of the iliotibial tract and lateral retinaculum, and could be an important factor in the etiology of patellofemoral pain.

In conclusion, we have shown that the VLO muscle is a valid anatomical entity, in agreement with previous [13,29,40], recents works [9,38] and with orthopaedic textbook [26]. A correct understanding of the structures that contribute to the patellofemoral joint could lead to the development of procedures to treat pathologies that affect this joint.

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