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Anatomical variation of quadratus plantae in relation to flexor hallucis longus and flexor digitorum longus: a rare case

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The quadratus plantae (QP) is considered as a part of the plantar intrinsic foot muscles. This muscle has two lateral and medial heads of origin, both of which arise from the plantar surface of calcaneus, and insert into the tendon of flexor digitorum longus (FDL). Various functions have been attributed to the QP muscle, which includes assisting the plantar flexion of the lateral four toes, straightening the oblique pull of FDL and etc. Several anatomical variations of the QP muscle have been reported in the literature. During a routine dissection in the Department of Anatomy at Kerman University of Medical Sciences, a variant plantar muscle was observed in a 40-year-old male cadaver. In the present case, we report a rare variation associated with the insertion pattern of this muscle, which is reported for the first time in Iran. The tendinous end of the QP muscle was divided into three tendons and were then inserted to the inferior surface of 2nd, 3rd and 4th tendons of FDL. Also, a slim tendinous interconnection was also observed between the QP and flexor hallucis longus (FHL). The lack of connection between the FDL and FHL tendons was the other rare variation of this case. Exact knowledge of the possible variations of the QP muscle is of utmost importance to foot surgeons, clinicians and also anatomists. (Folia Morphol 2023; 82, 2: 412–415)

Key words: quadratus plantae, flexor digitorum longus, flexor hallucis longus, foot, tendon

INTRODUCTION

The quadratus plantae (QP) muscle is located in the second layer of the plantar muscles of the foot [4]. "Massae carnae", "caro plantae pedis", "caro quadrata", "pronator pedis" and "flexor accessorius" are the names which have been attributed to this muscle so far [16].

The QP has no equivalent muscle in the hand. This muscle originates by two heads which are inserted to the plantar surface of calcaneus. They are separated at their origin by the long plantar ligament [4]. The lateral head is smaller and originates from lateral border of the plantar surface of the calcaneus and the long plantar ligament, while the larger medial head arises from the medial concave surface of the calcaneus [4]. The medial head is only found in man, but the lateral head is presented in the other mammals [16]. These heads attach to the posterolateral surface of flexor digitorum longus (FDL) tendons by a flattened end [8].

In terms of comparative anatomy, the equine, bovine, ovine and porcine species do not possess the QP

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muscle; however, this muscle is presented in the canine and feline species and also in some primates [13, 16].

The QP muscle has several functions, such as assisting the FDL in plantar flexion of the lateral four toes [6], pronation of the foot and supporting the medial and lateral longitudinal arches of the foot [7]. Another important action of this muscle is straightening the oblique pull of FDL [11]. Despite the wide number of proposed functions, the exact role of this muscle has been remained unexplained [15].

The QP muscle is subjected to great variations in human. These variations include the sites of origin, the type of insertion and also the number of heads of this muscle [1, 9, 18]. It may be also completely absent which is a rare exception [13].

Here, we present a rare variation in QP muscle associated with an unusual type of insertion which to our knowledge, is reported for the first time in Iran.

CASE REPORT

During a routine dissection in the Department of Anatomy at Kerman University of Medical Sciences, a variant plantar muscle was observed in a 40-year-old male cadaver. After dissecting and retracting the skin and subcutaneous tissues, the plantar aponeurosis and the flexor digitorum brevis tendons were cut from the first layer of the foot at the metatarsophalangeal joints to expose the second layer of the foot. During this step, the medial and lateral plantar nerves and vessels were revealed. Then, a relationship in the distal end of the QP with the flexor hallucis longus (FHL) and FDL tendons was observed in both foots (Fig. 1). For accurate assessment of this connection, the FHL and FDL tendons were followed and the flexor retinaculum was dissected. The tibial nerve was diagnosed, and the tendons were then cut at the ankle joint proximally and at the metatarsophalangeal joints distally. The abnormal insertion of QP was then studied carefully and photographed (Fig. 2).

In the current case, origin of the medial and lateral heads was the calcaneus (normal origin) and QP was innervated by lateral plantar nerve. At the insertion point, this muscle had a tendinous end which was divided into three tendons and were then inserted to the inferior surface of 2nd, 3rd and 4th tendons of FDL (with the same thickness as the FDL tendons). Also, the tendinous part was connected to the FHL tendon with a slim tendinous connection (about one-third of the thickness of FHL tendon, Fig. 2) [3, 6]. It should be noted that no connection was seen between the FHL and FDL tendons in this case.

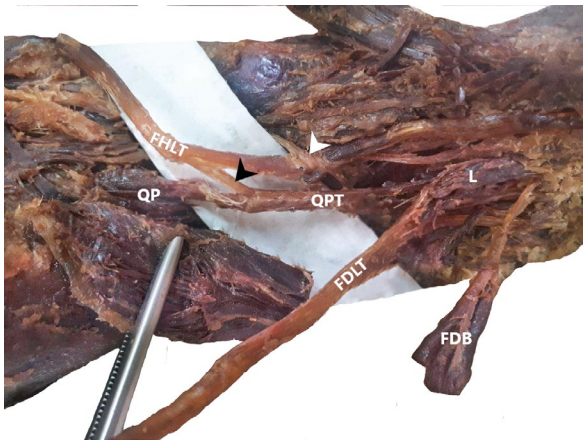

Figure 1. Photograph of foot dissection, the quadratus plantae tendons beneath the flexor digitorum longus and the tendinous interconnection between quadratus plantae and flexor hallucis longus are shown; FDLT — flexor digitorum longus tendon; FHLT — flexor hallucis longus tendon; FDB — flexor digitorum brevis; QP — quadratus plantae; QPT — quadratus plantae tendons; L — lumbrical; black arrowhead — tendinous interconnection; white arrowhead — medial plantar nerve.

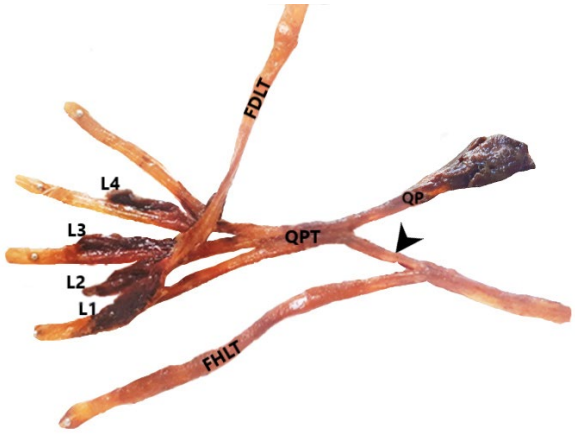

Figure 2. The arrangement pattern of tendons; FDLT — flexor digitorum longus tendon; FHLT — flexor hallucis longus tendon; QP — quadratus plantae; QPT — quadratus plantae tendons; L1 — first lumbrical; L2 — second lumbrical; L3 — third lumbrical; L4 — fourth lumbrical.

DISCUSSION

Understanding the high variability of QP muscle is of great importance to surgeons who perform foot reconstructive surgery. This is due to the fact that this muscle might get injured in hindfoot traumas such as fractures of calcaneus or it may cross the operation field used for the treatment of various deformities

and diseases such as congenital clubfoot, diabetic foot, etc. [13, 17].

Several variations of QP including its insertion pattern and also the tendinous interconnection between the QP and FHL have been reported in the literature [9, 10, 13, 14, 17, 18]. According to the type of insertion, the QP muscles can be categorised into three groups: muscular, tendinous and aponeurotic [13]. In the present case, the QP had only the tendinous insertion pattern, and also its tendon was divided into three slips which were then inserted into the flexor tendons of the second, third and fourth toes. The QP acts as the medial stabilizer of FDL tendons but since it has not been attached to the posterolateral side of FDL in this case, it seems that it lacks the function of medial stabilization of FDL tendons [11].

In the present case, a tendinous interconnection was observed between the QP and FHL. Nasir has shown that this type of interconnection may be responsible for straightening the line of pull of FHL and therefore facilitates the role of first toe during take-off. However, such variation does not lead to any clinical disorders since it does not cause the entrapment of any vessels and nerves [10].

The interconnections between the FDL and FHL can be classified into four types: type I (a connecting slip from the FHL to FDL tendons), type II (a slip from FDL tendons to FHL), type III (crossed slips between FDL and FHL) and type IV (no attachment between FDL and FHL) [12]. Pretterklieber [14] reported a summary of previous studies on connections between the FHL and the FDL in which the percentages of different types of interconnections were 75%, > 1%, 23% and 2% for types I, II, III and IV, respectively. Based on the previous studies, it has been stated that a connection between the FHL and the FDL is regarded as the regular case [6, 9, 18]. For instance, Le Double [9] has shown that the slip from the FHL to the 2nd and 3rd tendon of FDL is the regular condition. However, in the current case, no connection was observed between the FDL and FHL tendons which is considered as a rare variation compared to the other studies. Treatment of posterior tibial tendon dysfunction and also Achilles tendon rupture, requires tendon transfer of either FDL or FHL. In order to perform this surgical procedure in the best possible way, exact knowledge of the variations of FDL, FHL and the QP, and also their connections are essential to foot surgeons [2, 5].

CONCLUSIONS

The rare variation in the QP insertion which was reported in the present case give us more understanding of the possible variations of the QP muscle which is important for anatomists, and useful for various surgical procedures in the foot region and also the imaging and biomechanical studies.

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