Surg Radiol Anat (2016) 38:349–352
DOI 10.1007/s00276-015-1585-6

ANATOMIC BASES OF MEDICAL, RADIOLOGICAL AND SURGICAL TECHNIQUES

Anatomical study of the morphological continuity between iliotibial tract and the fibularis longus fascia

Jan Wilke[1] · Tobias Engeroff[1] · Frank Nürnberger[2] · Lutz Vogt[1] · Winfried Banzer[1]

Received: 11 June 2015 / Accepted: 26 October 2015 / Published online: 2 November 2015

Abstract
Purpose Recent research indicates that the skeletal muscles of the human body do not function as independent actuators. Instead, they seem to be linked by connective tissue forming myofascial chains. While the existence of such meridians has been demonstrated for the ventral and the dorsal side of the body, no data are available for morphological fusion of lateral muscles. This study aimed to provide evidence for the inferior part of the lateral myofascial chain.
Methods Fourteen legs (7 embalmed cadavers, four ♂, 86 ± 7 years) were dissected to reveal a potential myofascial continuity between the fibularis longus muscle, more detailed, its fascia, and the iliotibial tract (ITT). Three investigators judged the general existence as well as the degree and characteristics of the continuity. If an anatomical continuity was evident, strain was applied to both structures in order to evaluate the tissues' ability for tensile transmission.
Results An indirect connection between the iliotibial tract and the fascia of the fibularis longus muscle was found: in all examined legs, the ITT fused strongly with the crural fascia. The latter was hardly separable from the fibularis longus fascia. Application of strain to the ITT caused local movement in the crural fascia and the underlying fascia of the fibularis muscle.
Conclusions The iliotibial tract fuses firmly with the crural fascia and the degree of continuity suggests that moderate amounts of strain might be transmitted. However, biomechanical studies precisely quantifying this tensile transmission are warranted in order to estimate the relevance of the linkage for the locomotor system.

Keywords Myofascial meridians · Fascia · Dissection · Connectivity

✉ Jan Wilke
wilke@sport.uni-frankfurt.de

[1] Department Sports Medicine, Institute of Sports Sciences, Goethe University Frankfurt, Ginnheimer Landstraße 39, 60487 Frankfurt am Main, Germany

[2] Department of Anatomy (II), Goethe University Frankfurt, Frankfurt am Main, Germany

Introduction

In the last decade, the anatomical construction and organization of fascia have aroused increasing interest of movement therapists and physicians. The rich hydration and vascularisation [3] as well as the discovery of free nerve endings [16, 18], contractile cells [4], and sensory receptors [4, 16] suggest that fascia is not merely a passive envelope of the skeletal muscle but a mechanically and sensorically active tissue.

Previous research also challenges another traditional view of the muscle-surrounding connective tissue. In contrast to separating the active components of the musculoskeletal system, it forms an extensive network of myofascial continuity. A previous systematic review [20] demonstrated that the connective tissue, as proposed by Myers [13], links the individual muscles of the body to myofascial chains. Both in vitro experiments with cadavers [2, 14] and in vivo trials [5, 11] yield indications for strain transmission along these meridians thereby providing an argument to incorporate them into training and exercise therapy.

In their review on the morphological presence of myofascial meridians, Wilke et al. [20] found good evidence for three chains: the superficial back line (consisting of the plantar fascia, the gastrocnemius, the hamstrings, and the erector spinae), the front functional line (adductor longus, rectus abdominis, contralateral pectoralis major) and the back functional line (vastus lateralis, gluteus maximus, contralateral latissimus dorsi). However, in particular, there is inconclusive evidence for a myofascial chain on the lateral side of the body.

The present anatomic study therefore aimed to examine whether a direct fusion exists between the fascia of the fibularis longus muscle and the iliotibial tract (ITT) which both form the inferior part of the lateral line [13].

Materials and methods

Sample

The study was conducted adhering to the scoring criteria of the QUACS scale, which is a valid 13-item tool for quality appraisal of cadaveric studies [21]. The individual items of the scale are listed in Table 1. To examine the morphological relationship between the fibularis longus and the ITT, 14 legs of 7 Caucasian cadavers (4 ♂, 86 ± 7 years, mean storage time 21 ± 6 month) were dissected. The cadavers were embalmed in formaldehyde (2 % aqueous solution, perfusion fixation via femoral and carotid arteries, storage in the same fixative until use) and did not exhibit indications for traumatic lesions or previous surgery. All dissections were carried out at the local university department of anatomy during an anatomy course for medical students. The dissecting investigators were not involved in the selection of the cadavers.

Table 1 Items of the QUACS scale to which the present study adhered

Item
Clear objective stated
Basic information (age, gender) about sample included
Applied methods described comprehensibly
Condition of the examined specimens reported
Education of dissecting researchers stated
Findings observed by more than one researcher
Results presented thoroughly and precise
Where applicable: statistical methods appropriate
Details about consistency of findings
Photographs of the observations included
Study discussed within the context of current evidence
Clinical implications of the results discussed
Limitations of the study addressed

Dissection

All dissections were collectively made by an anatomist (FN), a physician (TE) and a sports scientist (JW). After removing the skin and the subcutaneous adipose tissue, the superficial nerves as well as blood and lymph vessels were dissected. Subsequently, the superficial fasciae and the remaining adipose tissues were carefully stripped off layer by layer. Special care was given to prevent damage of the respective underlying tissue layers (below knee level: epimysium and overlying fibularis longus fascia; above knee level: ITT).

While bluntly separating the iliotibial tract from adjacent muscles and the fascia lata, particular attention was devoted to preserve the course of fiber direction. It was precisely traced to detect insertion points and connectivities to adjacent myofascial structures. Analogously, the fibularis muscles were dissected without removing or damaging the neighbouring tissues. The fibers of both the fascia of the fibularis longus and the overlying crural fascia (enveloping all muscles of the thigh) were followed to the insertion at the head of the fibula and the lateral condyle of the tibia.

Observations

After dissection, visual inspections were carried out by three observers (FN, TE, JW) who independently judged whether a continuity was present. In case of disagreement, the investigators met to discuss their individual assessment. The criteria for the detection of a morphological continuity were as follows: (1) visual inspection indicates fusion of structures, (2) carefully lifting the tissue at and surrounding the location of the supposed continuity (Fig. 1) confirms the initial observation, (3) application of strain to both the distal part of the ITT (in cranial direction) and the fibularis longus fascia (caudal direction) by means of a surgical forceps. During strain testing, possible movements of the

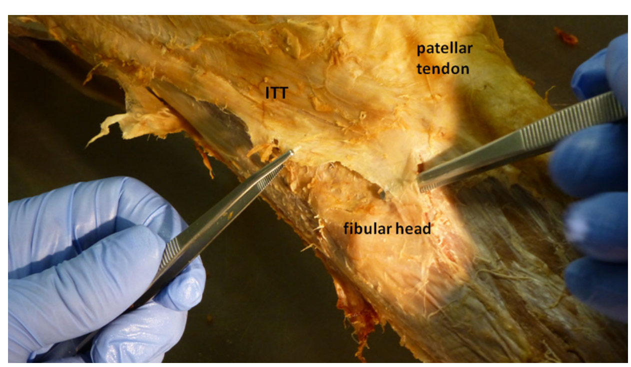

Fig. 1 Anatomical continuity between the ITT and the crural fascia just medial to the fibular head

adjacent, not affected structures were visually observed in order to allow assumptions about the degree of tensile transmission.

Results

While the fibularis longus fascia could easily be exposed distally, it adhered firmly to the crural fascia below knee level and both structures were not separable from each other. Thus, no structural continuity between the ITT and the actual fascia of the fibularis was observed. However, in all examined limbs, the distal part of the ITT fused with the overlying crural fascia just anteromedial to the head of the fibula (Figs. 1, 2).

The degree of dissectable continuity between ITT and crural fascia varied between the cadavers and was small to moderate. While in six legs (three of them male) only few fibers formed the bridge from the ITT to the crural fascia, the remaining cadavers exhibited a broad connection composed of numerous fibers (>10 mm).

The direction of fibers was similar in both neighboring structures: though running in several directions, a part of the collagenous fibers could clearly be traced from the ITT to the crural fascia showing a linear course (Fig. 3). Applying tension to the ITT led to movement of the crural fascia. However, vice versa, there was little to no motion of the ITT when the crural fascia was pulled caudally.

Discussion

The thigh and the lower leg are interconnected by means of collagenous connective tissue and may be seen as a functional unit. From a biomechanical point of view, the ITT is tightened by the tensor fasciae latae and the gluteus maximus muscle in order to counteract shear forces of the femur [15]. It is plausible that the aponeurotic band also receives small amounts of stabilizing tension from its caudal continuation, the crural fascia. This assumption is supported by two observations of the present study. First, the linear course of fibers running in the same direction in the ITT and the crural fascia suggests that the connection between both structures might serve as a transmitter of strain. Second, applying tension to the crural fascia stretched the ITT without creating notable motion while pulling the ITT cranially produced motion of the crural fascia.

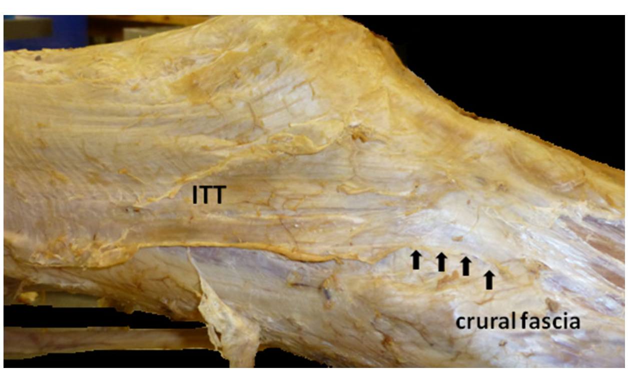

Fig. 2 Anatomical continuity (*arrows*) between ITT and crural fascia in another specimen. Note the linear course of the collagenous fibers

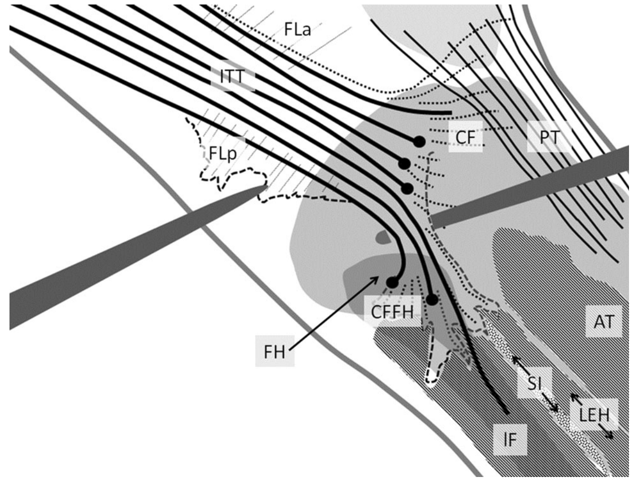

Fig. 3 Schematic draw illustrating the course of fiber direction. Note the linear course of fibers from the ITT connecting with the crural fascia. Projections of bones (femur, tibia, fibula, and patella, not visible in photograph) are marked in grey. *CF* crural fascia, *PT* patellar tendon, *AT* anterior tibialis muscle, *LEH* long extensor hallucis muscle, *SI* intermuscular septum, *lF* long fibularis muscle covered by fibular fascia, *CFFH* crural fascia above fibular head, *FH* fibular head, *FLp* fascia lata, posterior fiber bundles, *FLa* fascia lata, anterior fiber bundles

No direct continuity of the ITT to the fibularis longus fascia could be detected. Technically, the hypothesis that the ITT merges with the fibularis fascia, as suggested by Myers [13], cannot be verified based on our results. However, because the crural fascia adhered firmly to the fibularis longus fascia on the proximal level and both were virtually inseparable from each other, the link between ITT and crural fascia might fulfill the same function. Consequently, except for this limitation, we deem the concept of myofascial meridians to be generally valid with reference to the lateral leg.

To our knowledge, no other study investigated the anatomy of the ITT with special focus on the morphological continuity to the connective tissue overlying the fibularis muscles. However, in vivo Vieira et al. [7] examined the distal part of the ITT in ten fresh cadavers describing an aponeurotic fusion with the leg fascia. Our results are in line with their work.

The existence of a myofascial continuity between ITT and the crural connective tissue might be considered in exercise therapy. In patients with runner's knee, a chronic friction syndrome, stretches are typically performed for the hip muscles and the ITT itself in order to release tension and to lengthen the iliotibial tract [8]. Possibly, integrating the lateral crural muscles into treatment increases its efficiency. Similarly, as patients with patellofemoral pain syndrome display a tightened iliotibial tract [10], treating the fibularis group might be an appropriate addition for therapy. Besides offering new treatment approaches for such pathologies, the myofascial continuity between ITT and crural fascia could also explain referred pain. According to Travel and Simons [19], pain arising from trigger points located in the vastus lateralis muscle tends to radiate to the lateral lower leg. As the vastus lateralis fuses with the iliotibial tract [7], the continuity of ITT and crural fascia might represent the morphological substrate.

Verifying these theoretical thoughts should be the subject of further research. Therefore, biomechanical trials quantifying the amount of strain transferred between the two structures are warranted. Information from such studies would be particularly valuable if fresh specimens are used. In the present study, subjects were embalmed, which is a limitation as the preservation process causes hardening and shrinking. Formalin fixation has been shown to alter cross-linking [1, 6] and to reduce hyaluronan content [12]. As cross-links determine a tissue's stability and flexibility and as hyaluronan, being highly concentrated in fascia, permits effective sliding of the different tissue layers [17], these changes are crucial for applied biomechanics. Besides more precise measurement of strain, also the sole observation of continuity might be easier in fresh specimen as the individual layers of the connective tissue can be separated more accurately. Another area of future study is conducting in vivo trials. Such research helps to estimate the practical relevance of observational and biomechanical in vitro studies. Preliminary available evidence points towards a significant role of myofascial strain transmission in influencing movement behavior [5, 9, 11].

Conclusions

In the present study, the lower part of the lateral line could not be evidenced as proposed by Myers [13]. We failed to demonstrate a direct connection of the ITT and the fibularis longus fascia. However, the ITT is fused to the crural fascia, which has a close relationship with the underlying muscle fasciae. As a strain transfer between the ITT and the lateral lower leg fascia seems to be possible based on manual traction, additional studies elucidating the functional relevance of the detected continuity are necessary.

Compliance with ethical standards

Conflict of interest No conflicts of interest declared.

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