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Thoracolumbar fascia in the lumbar region: anatomical description and topographical relationships to the cutaneous nerves: a preliminary study

Wojciech Przybycień[1], Krzysztof Balawender[2], Jerzy Walocha[1], Ewa Mizia[1], Michał Bonczar[1, 3], Patryk Ostrowski[1, 3], Michał Golberg[4], Anna Smędra[5], Edward Clarke[6], Andrzej Żytkowski[7, 8]

[1]Department of Anatomy, Jagiellonian University Medical College, Kraków, Poland
[2]Department of Normal and Clinical Anatomy, Institute of Medical Sciences, Medical College of Rzeszow University, Rzeszów, Poland
[3]Youthoria, Youth Research Organization, Kraków, Poland
[4]Department of Histology and Embryology, Chair of Anatomy and Histology, Medical University of Lodz, Łódź, Poland
[5]Chair and Department of Forensic Medicine, Medical Faculty, Medical University of Lodz, Łódź, Poland
[6]Department of Normal and Clinical Anatomy, Chair of Anatomy and Histology, Medical University of Lodz, Łódź, Poland
[7]Faculty of Philology, Department of Polish Dialectology and Logopedics, University of Lodz, Łódź, Poland
[8]Norbert Barlicki Memorial Teaching Hospital No. 1 of the Medical University of Lodz, Łódź, Poland

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Background: *The study aims to determine principal topographical relations between thoracolumbar fascia (TLF) and lateral branches derived from the dorsal (posterior) rami of lumbar spinal nerves and elucidate their potential link to lumbar region pain. The research protocol involves basic TLF morphological description, evaluating its relation to the nerves, and examining general histology.*

Materials and methods: *The research was conducted on four male cadavers fixed in 10% neutral buffered formalin.*

Results: *The dorsal rami of the spinal nerves branched into medial and lateral divisions. The lateral divisions were about 1 mm thick and mainly visible in the subcutaneous tissue during stratigraphic dissection. They pierced the TLF superficial layer. They descended sidewards and downwards within the superficial fascia (laterally to the erector spinae muscle) to provide sensory innervation to the skin.*

Conclusions: *Anatomical relationships between TLF, deep (intrinsic or true) back muscles, and dorsal rami of the spinal nerves are complex and may be clinically involved in low back pain etiopathogenesis.* (Folia Morphol 2024; 83, 2: 417–425)

Keywords: fascia, innervation, musculoskeletal system, spinal nerves, thoracolumbar fascia, topographical anatomy

Address for correspondence: Wojciech Przybycień, Department of Anatomy, Jagiellonian University Medical College, ul. Kopernika 12, 31–034 Kraków, Poland; e-mail: w.przybycien@uj.edu.pl

INTRODUCTION

According to the Medical Subject Headings (MeSH) thesaurus, fascia can be referred to as "Layers of connective tissue of variable thickness. The superficial fascia is found immediately below the skin; the deep fascia invests muscles, nerves, and other organs" [3]. Fascia is then a multidimensional soft tissue that surrounds muscles, bones, and organs, conditioning the internal architecture of the musculoskeletal system. Recent observations suggest that fascia is not just a passive "envelope" for muscles but an active tissue that contributes to several essential functions. It plays a vital role in constituting the structural integrity of the muscular system, in the transmission of mechanical forces between muscles, reduces the friction created during movement between the muscles it surrounds, mediates muscle metabolism, and enables the individual components of the musculoskeletal system to function in an integrated manner [12, 13, 21, 24]. As Kumka and Bonar [12] stress, "Fascia is virtually inseparable from all structures in the body and creates continuity amongst tissues to enhance function and support".

The thoracolumbar fascia (TLF) is a multifunctional membrane. Both two-layer and multi-layer TLF models appear in the literature [1, 12, 20, 23]. In this study, the classical two-layer model was adopted for simplicity. Our study mainly concerns lateral branches derived from the dorsal (posterior) rami of lumbar spinal nerves; thus, the classical model is sufficient to describe the topographic anatomy of those nerves within the erector spinae compartment. However, the reader must remember that recent studies on TLF present its more complex spatial arrangement and biomechanics [23]. The TLF integrates, among others, the activity of the back and abdominal muscles with the spine and pelvic bone biomechanics. It transmits muscle tension between the spine, abdomen, pelvic girdle, and lower limbs and is the basis for muscle attachments, blood vessels, and nerves. Damage or overloading of the TLF can cause pain in the lower part of the spine. The TLF is undoubtedly one of the critical elements stabilizing the lumbar spine [1, 12, 13, 20, 21, 23, 24]. Frequently performed imaging diagnostics of a patient's spine whose clinical presentation may indicate sciatica or an intervertebral disc issue often do not explain the patient's condition. We can then discuss pseudo-sciatica symptoms that do not require surgical but rather conservative treatment. The critical issue in those conditions can be related to symptoms derived from fascial structures. The pain may be projected in a manner divergent from the typical segmental innervation of a given spinal nerve territory (may be projected beyond the specific dermatome). Therefore, one of the first elements we can suspect of generating such symptoms and pain is the TLF, whose innervation is not fully known and defined [2, 4, 16, 22]. It is supposed to come from the dorsal rami of the spinal nerves, but the topographical relations between TLF and nerves require further research. Thus, the study aims to determine principal topographical relations and elucidate their potential link to lumbar region pain. The research protocol involves basic TLF morphological description, evaluating its relation to the nerves, and examining general histology.

MATERIALS AND METHODS

The research was conducted on four male cadavers (aged from 47 to 96 years). The study protocol involved classical anatomical dissection techniques. Sharp dissection was applied to remove the skin from the surface of the back. After identifying lateral branches of the dorsal (posterior) rami, the superficial fascia was gradually removed, and TLF superficial layer was exposed. The dissection aimed mainly to specify the topographical relationships between the TLF and the branches derived from the dorsal rami of spinal nerves, which could give a clearer picture of the clinical procedure related to the pain syndrome of the lumbar spine. The general arrangement of the TLF was also assessed. After the topographical relations were recorded, the deep dissection was subsequently conducted.

The TLF samples were also harvested from one cadaver freshly fixed in 10% neutral buffered formalin (the body of a male donor 47 years old at death) and subjected to histochemical and immunohistochemical examination. Tissue samples were harvested at the L2 level. The classical paraffine method was used for tissue sample processing. Mallory's trichrome staining was applied to trace collagenous structures distribution. Tissue immunostaining was additionally applied to visualize the nerves in the histological samples. Based on the previously described protocol, an automated immunohistochemistry (anti-S100 antibody, Dako) was used [4].

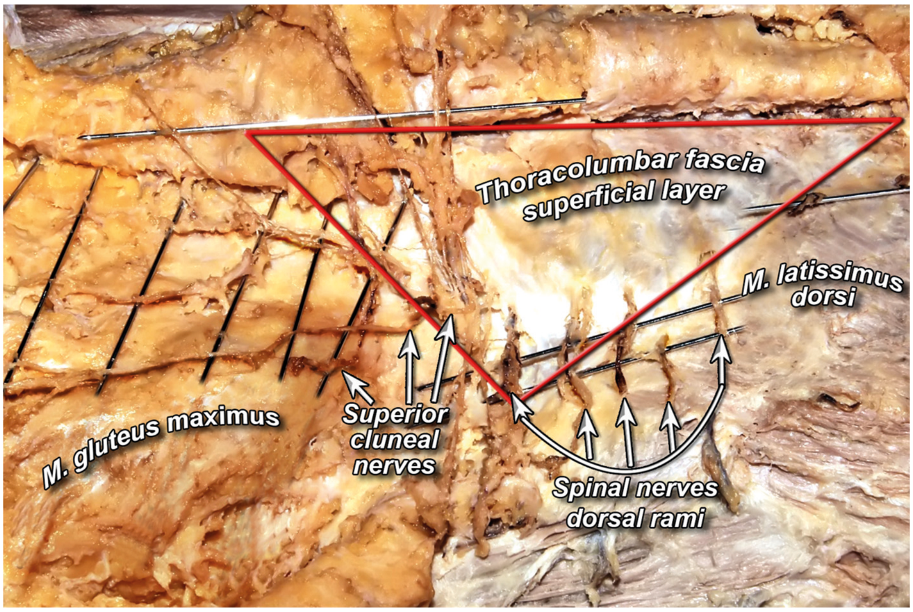

Figure 1. Stratigraphic dissection showing remnants of the superficial fascia, thoracolumbar fascia (TLF), and lateral branches of the spinal nerves dorsal rami. Posterior view of the lumbar and gluteal regions. A red triangle marks the superficial layer of the TLF located in the lumbar region. The TLF is continuous with the gluteal fascia inferiorly. The superior cluneal nerves ran oblique and downward to reach the gluteal region. They emerge from the superficial layer (posterior lamina) of the TLF, just superior to the iliac crest.

RESULTS

General arrangements of the TLF

The TLF attached to the spinous processes of the thoracic and lumbar vertebrae, the sacrum, and the iliac crest, forming a bone-fibrous canal for the deep muscles of the back, especially the compartment for the erector spinae muscle. The posterior lamina (TLF superficial layer) was a thick fibrous membrane located posterior to the erector spinae muscle, also known as the sacrospinalis group of muscles (Figs. 1, 2, and 4). The serratus posterior inferior and latissimus dorsi muscles began from this TLF superficial layer. It was attached to the spinous processes of the thoracic and lumbar vertebrae, to the median sacral crest (reaching the coccyx), and to the iliac crest. The anterior lamina (deep TLF layer) was thinner than the posterior lamina. It was located anterior to the erector spinae muscle and posterior to the quadratus lumborum and psoas major muscles. It was spanned between the twelfth rib and the iliac crest. Both TLF laminae connected laterally to the erector spinae muscle, forming a fascial compartment to the muscle. Anatomical relationships within this compartment define the proximal course of the lateral branches derived from the dorsal rami of lumbar spinal nerves (Fig. 2). In the lumbar region, on the lateral border of the erector spinae muscle, TLF was formed by a common tendon of the transversus abdominis muscle, which reached the costal processes of the lumbar vertebrae.

Topographical relations between the TLF and lateral branches of spinal nerves' posterior rami

The dorsal rami of the spinal nerves branched into medial and lateral divisions. The lateral divisions were about 1 mm thick and mainly visible in the subcutaneous tissue during stratigraphic dissection (Fig. 1). They pierced the TLF superficial layer. They descended sidewards and downwards within the superficial fascia (laterally to the erector spinae muscle) to provide sensory innervation to the skin (Fig. 1). During the dissection, the branches run obliquely in the deeper layer (within the erector spinae muscle). After the TLF superficial layer was cut and reflected, the lateral divisions of the spinal nerves' dorsal rami were easily visualized as they pierced the iliocostalis lumborum muscle (Figs. 2 and 4). Some of those rami descended obliquely downward and reached the gluteus maximus muscle's external surface. Those rami are referred to as superior cluneal nerves (Figs. 1, 3, and 4). Superior cluneal nerves emerged from the superficial layer (posterior lamina) of the TLF, just superior to the iliac crest (Fig. 1). The subsequent removal of the erector spinae muscle allowed tracing of the spinal nerves' dorsal rami as far as their origin between the costal

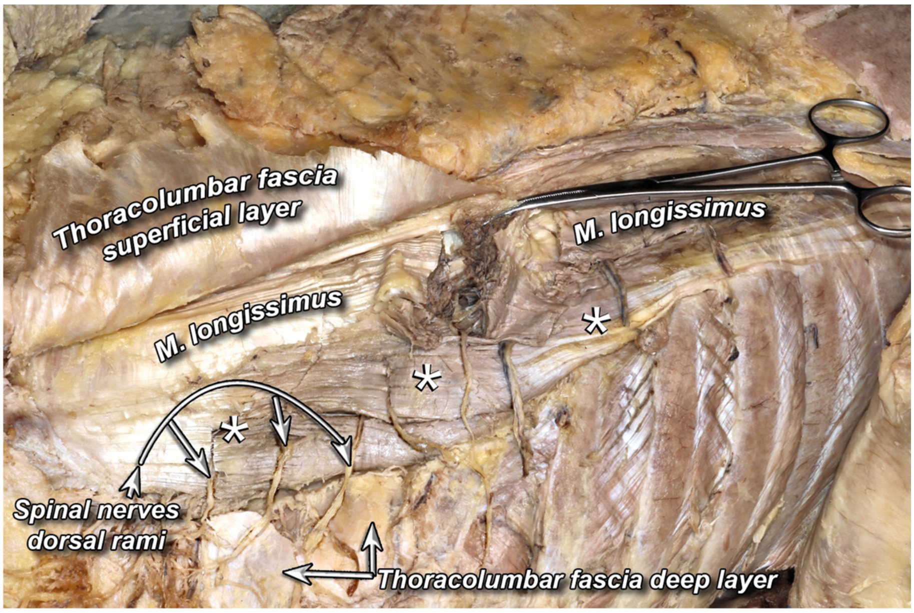

Figure 2. Stratigraphic dissection showing the deep layer of the thoracolumbar fascia (TLF) and spinal nerves dorsal rami. The posterior view of the back of the specimen presented in Fig. 1. The TLF superficial layer (posterior lamina) is cut and reflected. The Longissimus muscle was exposed. Lateral branches of the spinal nerves dorsal rami pierce the iliocostalis lumborum muscle (marked by asterisks).

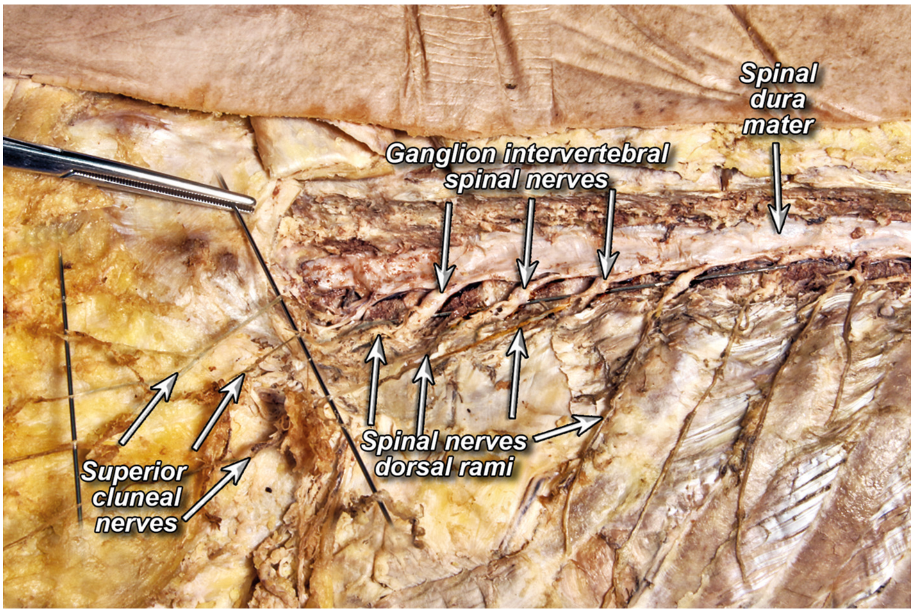

Figure 3. The deep dissection of the region shown in Figures 1 and 2. The spinal canal was opened, exposing the spinal dura covering the spinal cord and spinal nerves' origins. The spinal nerves' dorsal rami arise from the respective spinal nerves' trunks at almost right angles. They cross the costal processes of the lumbar vertebrae diagonally (specifically, of the lumbar vertebra located below the specific spinal nerve). Lateral branches of the spinal nerves dorsal rami continue their course within the iliocostalis lumborum muscle (which is removed in this specimen).

processes of the lumbar vertebrae (in the so-called "intertransverse space"; see Figs. 3 and 5). The spinal nerves' dorsal rami arose at almost right angles from the respective spinal nerves' trunks, crossed the costal processes of the lumbar vertebrae diagonally (specifically, of the lumbar vertebra located below the specific spinal nerve; see Fig. 3), and continued their course within the iliocostalis lumborum muscle.

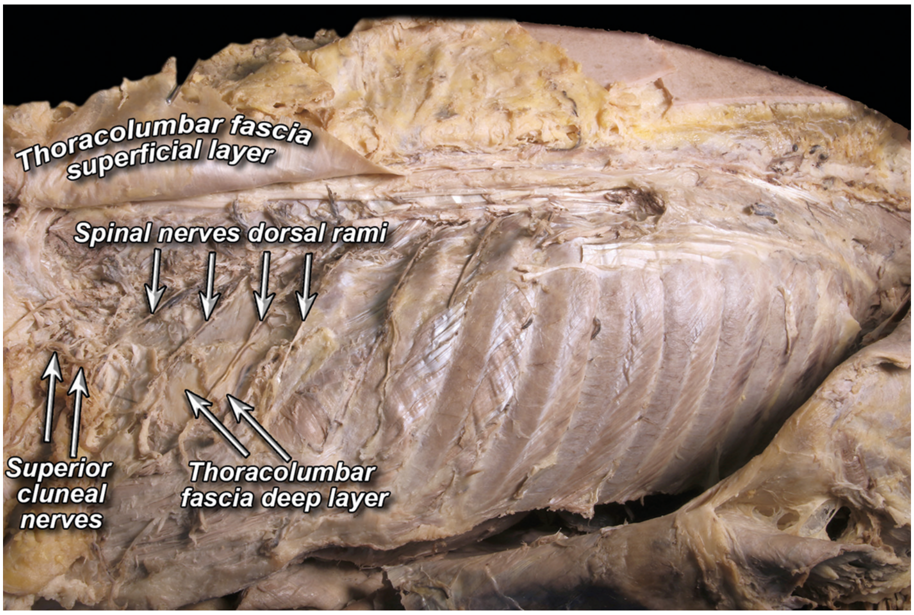

Figure 4. Stratigraphic dissection showing the deep layer of the thoracolumbar fascia (TLF) and spinal nerves dorsal rami. General posterior view of the back. The TLF superficial layer (posterior lamina) is cut and reflected, exposing the longissimus muscle and iliocostalis lumborum muscle (the latest muscle is pierced by lateral branches of the spinal nerves dorsal rami).

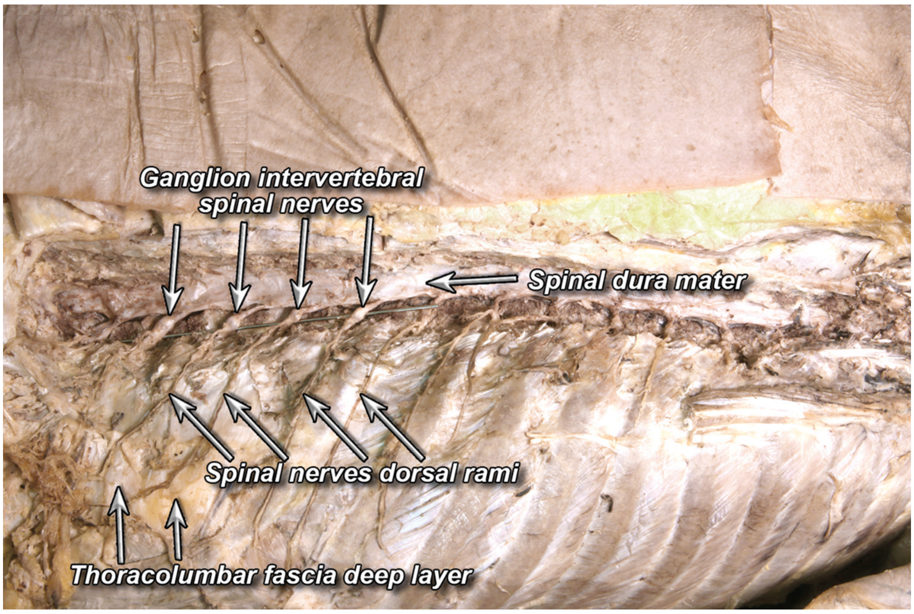

Figure 5. Stratigraphic dissection shows the thoracolumbar fascia's (TLF) deep layer and lateral branches derived from the dorsal rami of the lumbar spinal nerves. The vertebral canal was exposed, showing the spinal dura mater, spinal nerves, and spinal nerves' dorsal roots with the spinal ganglia in the thoracic and lumbar spine segments. The dorsal rami of the spinal nerves provide medial and lateral branches (the latest seen running oblique and downward).

Histological observations

In the histological study, TLF superficial layer harvested at the L4 level was composed of the thinner layer derived from the serratus posterior inferior muscle and the thicker internal layer bordering the erector spinae muscle (Fig. 6). Anti-S-100 immunostain revealed small nerves on both the borderline between the muscle and the inner surface of the TLF superficial layer (Fig. 7), as well as on the medial side of the TLF superficial layer (i.e., tiny nerves were observed 2–3 cm

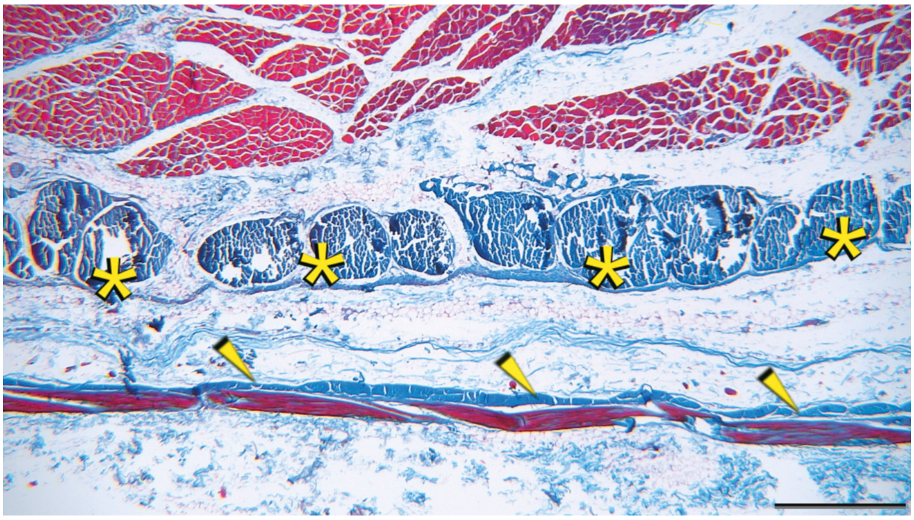

Figure 6. Horizontal section of the thoracolumbar fascia (TLF). Histological sample harvested at the L2 level. Mallory trichrome stain. Two layers of the TLF superficial (posterior) lamina are stained blue; the latissimus dorsi muscle forms a deep layer (marked by asterisks), and a superficial layer (marked by arrowheads) is formed by the serratus posterior inferior muscle. The scale bar shows 1 mm.

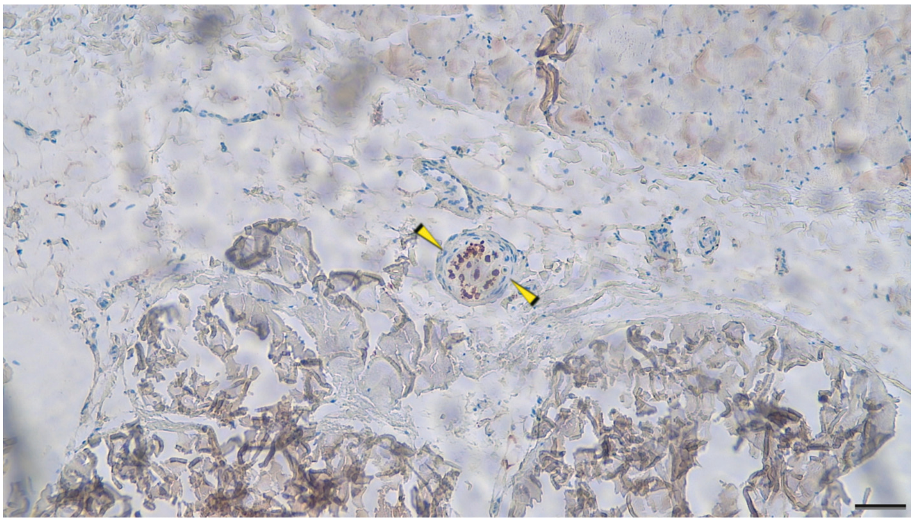

Figure 7. Small nerve (dark brown reaction) in the borderline between the muscle and the inner surface of the TLF superficial layer. Histological sample harvested at the L2 level. The scale bar shows 0.1 mm.

to the TLF superficial layer's attachment to spinous processes of the lumbar vertebrae; see Fig. 8).

DISCUSSION

As Willard et al. [23] summarize, TLF forms "a blending of aponeurotic and fascial planes that forms the retinaculum around the paraspinal muscles of the low back and sacral region". In addition to its role in movement, stability, and myofascial force transmission, this complex biomechanical system also provides proprioceptive communication throughout the body, including proprioceptive feedback for movement control [12].

There are two main approaches to the fascia in the literature. Classical anatomical dissection involves the removal of fascial elements to expose individual muscles [12, 20, 23]. In this approach, the emphasis is placed on the biomechanical role of muscles, ignoring the role of fascia in the transmission of forces and ensuring the integrated operation of individual muscle groups. On the other hand, the biomechanical approach reasonably assumes the functional role of the fascia. This approach examines detailed regional connections between fascial structures and bands, muscles, ligaments, and the skeleton [1, 12, 21–23,

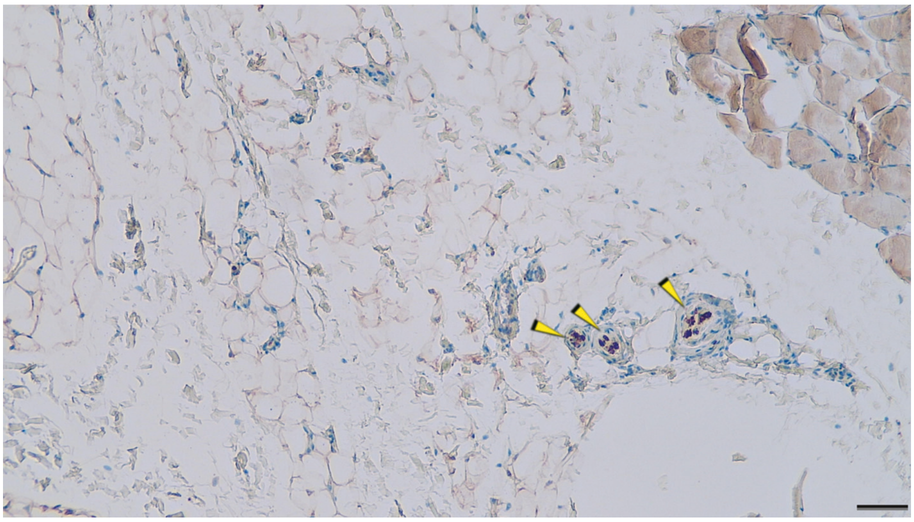

Figure 8. Small nerves in the medial part of the TLF superficial layer near its origin (marked by arrowheads and showing a dark brown reaction). Histological sample harvested at the L2 level. The scale bar shows 0.1 mm.

24]. This approach also focuses on advanced histological studies to determine the structure of the fascia at the tissue level, including the determination of specific types of receptors providing sensory information from the fascia. Our concise anatomical research proposed a topographic approach focusing on spatial relationships between TLF and selected neural structures. This approach can have a direct impact on clinical aspects [6–11, 14, 15, 19]. The relationship between fascia and nerves can be crucial in understanding the source of selected clinical symptoms, especially pain, which is especially true of TLF.

Diagnosing pain syndromes of the low back is challenging for doctors and physiotherapists. One of the causes of ailments can be nerve entrapment [16]. As shown in our study, lateral branches derived from the dorsal rami of the spinal nerves are characterized by a complex course with some angulations within their origin and course; those cutaneous branches also pierce the iliocostalis muscle and TLF. In a topographical context, fascia crossing points can be strong fixation points and potential sides of nerve entrapment. Superior cluneal nerves are a prime example of the issue. Those nerves are derived from the dorsal rami of the L1, L2, and L3 spinal nerves [7, 8, 16, 20]. Bogduk et al. [2] provided detailed description of the comparative anatomy of the lumbar dorsal rami is discussed and the applied anatomy with respect to "rhizolysis" also known as RF (radiofrequency), "facet denervation" and diagnostic paraspinal electromyography.

At the level of the iliac crest, some of the fibres pass through the osteofibrous canal formed by the iliac crest and the TLF. This area is a common site of nerve entrapment, which can lead to neuropathic pain [9, 16]. However, it should be remembered that low back pain symptoms may be related to TLF itself. Thus, knowledge of cutaneous nerve topography is part of clinically relevant anatomy. Surgical exposure of the superior cluneal nerves can be performed in invasive procedures, and the nerves can be dissected back to where they penetrate the TLF. When the nerve is entrapped, it can be sharply divided and released along its long axis in a distal to proximal direction [16]. The importance of topography of cutaneous nerves in the lumbar region can also be valid for surgical procedures involving the spine [2, 5]. Moreover, superior cluneal nerves can be injured during the posterior iliac crest harvesting [5]. Knowledge of cutaneous nerve topography can also be helpful in the application of non-invasive physiotherapy treatments in the case of low back pain. For instance, transcutaneous electrical nerve stimulation was proved effective for pain modulation [17]. Knowledge of lumbar dorsal rami may also be crucial for lumbar erector spinae plane block [6, 8, 9, 11, 14, 18].

Limitations of the study

The presented study was conducted on a small sample and should be continued on a larger sample, including individuals of both sexes. Studying a larger sample may provide insight into the anatomical variability of the nerves in the examined area, thus contributing to a more realistic view of the anatomical relationships and patient-specific anatomy [25], especially between TLF and cutaneous nerves. This issue is critical as both the ventral and dorsal rami of the spinal nerves can show unexpected deviations from the typical course [5, 10, 15]. The anatomy of the dorsal (posterior) arm is complicated, and therefore, detailed studies on all spinal nerves' dorsal rami subdivisions are scarce [2, 7, 10, 11, 18, 19, 22]. Our study focused mainly on the lateral branches of the spinal nerves' dorsal rami. However, we completed the work with a histological approach. As Willard et al. [22] stress, the presence of visible nerves does not necessarily imply that these nerves are innervating the fascia, and some nerves may transit through the fascia on their way to the muscle or skin. Thus, the innervation of all layers of the thoracolumbar fascia should be examined. Also determining the type of nerve fibres (proprioceptive, nociceptive, sympathetic) within the branches innervating TLF can be another research issue. However, although preliminary, our study attempts to gain insight into the relationship between TLF and cutaneous nerves from a comprehensive, topographical perspective.

CONCLUSIONS

Anatomical relationships between TLF, deep (intrinsic or true) back muscles, and lateral branches of the dorsal rami of the spinal nerves are complex. Considering their anatomy, the lateral branches of spinal nerves dorsal rami can potentially be clinically involved in low back pain etiopathogenesis.

ARTICLE INFORMATION AND DECLARATIONS

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Conflict of interest: None declared.

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