# Elucidating intramuscular neural distribution of the quadratus lumborum muscle to propose an optimal trigger point injection for myofascial pain syndrome

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# Abstract

Postural habits and repetitive motion contribute towards the progress of myofascial pain by affecting overload on specific muscles, the quadratus lumborum muscle being the most frequently involved. The therapy of myofascial pain syndrome includes the release of myofascial pain syndrome using injective agents such as botulinum neurotoxin, lidocaine, steroids, and normal saline. However, an optimal injection point has not been established for the quadratus lumborum muscle. This study aimed to propose an optimal injection point for this muscle by studying its intramuscular neural distribution using the whole mount staining method. A modified Sihler's procedure was completed on 15 quadratus lumborum muscles to visualize the intramuscular arborization areas in terms of the inferior border of the 12th rib, the transverse processes of L1-L4, and the iliac crest. The intramuscular neural distribution of the quadratus lumborum had the densely arborized areas in the three lateral portions of L3-L4 and L4-L5 and the medial portion between L4 and L5.


# Introduction

The quadratus lumborum (QL) muscles are the fundamental muscles responsible for abnormal posture in patients with myofascial pain syndrome (MPS). MPS is known to result from hyperactivated muscle spasm [28, 31, 46]. The points with tenderness in the spasmatic portion of the muscle belly are known as the myofascial trigger points (MTrPs). The MTrPs usually occur in the anatomically thickest portion of the muscle belly with the most intramuscular neural arborization [15, 24, 25, 30, 43].

The treatment of MPS involves the release of MTrPs using injective agents such as botulinum neurotoxin (BoNT), lidocaine, steroids, and normal saline. BoNT hinders neural transmission by stalling the release of acetylcholine at the neural endplate and inhibits muscle contraction. [8]. Therefore, injecting BoNT is extensively used as a therapeutic option for the control of MPS and tension-type headaches.

BoNT injection has been stated to be effective for pain control in MPS involving the QL muscle [6, 11, 27, 33, 54]. In pain management, BoNT injection is recognized to be more efficient and effective than oral medications for pain control and functional improvement [12, 52, 55]. When injecting into the QL muscle, the intramuscular neural patterns should be carefully considered to avoid side effects such as the spread of the injective agent to nearby muscles.

Today, BoNT injection is recognized as the most effective and safest treatment for muscle inactivation [3, 4, 21, 41]. The effects of BoNT rely on application by the presynaptic membranes of the motor neurons at the motor end-plate. Consequently, injections should be administered into the neuromuscular junctional regions [8, 9, 38, 58–61]. The importance of utilizing BoNT injections targeted at the neuromuscular junction has been confirmed by clinical studies on the iliopsoas and biceps brachii muscles. Neuromuscular-junction-focused injections have been reported to effect a higher pain reduction than conventional injections [19, 51].

There are many studies indicating that MTrP pathophysiology appears to be associated with the intramuscular neural arborized areas, also known as identical with MTrPs [15, 24, 25, 30, 43]. Thereby, trigger point injections including lidocaine and steroids have to be injected in intramuscular neural arborized areas.

The aim of this research was to propose effective and safe injection points of the QL muscle by studying the intramuscular neural arborization and suggest injective methods for treating MPS involving the QL muscle.

# Methods

This study was conducted in compliance with the principles of the Declaration of Helsinki. Consent was received from the patients and families of the deceased cadaver prior the procedure and dissections.

A total of 15 QL muscles from Korean cadavers (5 men and 5 women with a mean age of 77.6 years; range, 63–95 years) have been subject to modified Sihler's procedure to reveal the intramuscular neural arborization.

The neural arborization of the muscles were discovered in accordance with the four landmarks: the inferior border of the 12th rib, the transverse processes of L1-L4, and the iliac crest (Fig. 1).

The QL muscles underwent Sihler staining, using the modified method developed by Liem and Douwe van Willingen [29]. This method involves multiple steps to obtain a visual representation of the intramuscular neural arborization pattern.

Following Sihler's staining procedure, the QL muscles were divided into five parts by transverse lines from the tips of the transverse processes (L1-L4) and two vertical lines (medial and lateral), separated by the width of one's index finger.

Modified Sihler staining

The modified Sihler's staining method (Fig. 2) is presented.

Fixation: The QL muscles were kept in 10% non-neutralized formalin for 1 month. The formalin mixture has been substituted with fresh solution whenever it became cloudy.

Maceration and depigmentation: The fixed QL muscles were cleaned in flowing water for an hour. It was subsequently placed in 3% aqueous potassium hydroxide solution combined with the hydrogen peroxide mixture for 1 month.

Decalcification: The depigmented QL muscles were then bottled in Sihler's I solution (glycerin, aqueous chloral hydrate, and glacial acetic acid).

Staining: The decalcified QL muscles were subsequently stained with the Sihler's II solution (glycerin, aqueous chloral hydrate, and acetic acid). This staining process takes 1 month for neural branch visualization.

Destaining: The stained specimens were washed again with the Sihler's I solution. This step was performed to destain the muscle fibers for visualizing only the neural branches.

Neutralization: The destained QL muscles were neutralized in fresh water for half a minute. Subsequently, the specimens were bottled in a mixture of 0.05% lithium carbonate.

Clearing: The neutralized QL specimens were cleared with increasingly concentrated glycerin solutions (20–100%). The clearing stage took approximately 4 h.

## Results

# Locations of the neural entry points

In 13 of the 15 specimens, the iliohypogastric nerve entry point in the medial region was between the transverse processes of L1 (T-L1) and L2 (T-L2), and in 2, it was between the 12th rib and T-L1. In 14 of the 15 specimens, the ilioinguinal nerve entry point in the medial region was between the transverse processes of L4 (T-L4) and L5 (T-L5), and in 1 specimen, it was between the transverse process of L3 (T-L3) and T-L4. In all the specimens, the thoracic intercostal nerve entered the medial region between the 12th rib and T-L1.

# Intramuscular arborization patterns of the quadratus lumborum

Eleven of the 15 QL muscles had three regions in which the arborization pattern was the largest: the middle portion from T-L3 to T-L4 and from T-L4 to the iliac crest, and the lateral portion from T-L3 to T-L4. Three of the 15 QL muscles had two portions in which the neural arborization was the largest: the lateral portion from T-L3 to T-L4 and from T-L4 to the iliac crest and the middle portion from T-L3 to T-L4. The remaining specimen appeared to have one region in which the arborization pattern was the largest: the middle portion from T-L3 to the iliac crest. A Sihler-stained specimen of an intramuscular arborization is illustrated (Fig. 3).

## Discussion

The QL muscle includes three layers, each with muscle fibers having a different direction. The superficial layer is the thinnest layer, which comprises the iliocostal and the iliothoracic muscle fibers. The middle layer comprises the lumbocostal muscle fibers, which differ in thickness. The deep layer consists of the medial iliolumbar fibers and the lateral iliocostal fibers. The QL muscle is thicker in the lower portion than in the upper portion [35]. The muscle acts as a lumbar spine extensor, a lumbar stabilizer, and is involved

in lateral tilting. The innervation occurs through the ilioinguinal nerve, the iliohypogatric nerve, and twelfth thoracic intercostal nerve [20].

MPS is a commonly diagnosed disease that affects up to 95% of people around the world, and 9 million suffer from this disorder in the United States alone [1]. MPS is a chronic pain disorder mostly caused by MTrPs, that are located in the muscle belly. MPS is the main cause of pain in 85% of patients visiting pain clinics [17, 48]. The risk of MPS include various postural habits and occupational activities causing an excessive burden on a specific muscle [7, 53]. Postural habits and repetitive movements contribute to the progress of myofascial pain by causing overloading on specific muscles, the QL muscle being the most commonly involved [14].

Though the mechanism is not fully understood, one of the possible reasons for such movements having a negative effect is sarcomere shortening. Studies have revealed that shortening is due to an increase in the activation of the neuromuscular junction and its over-release of acetylcholine. Additionally, a large amount of calcium is released in the sarcoplasmic reticulum through a dysfunctional Ryanidine receptor, and sustained muscle contraction occurs along the calcium channel [32]. To release muscle contraction, BoNT is a commonly used injective agent for MPS [23, 32, 44].

For treating MPS, it is critical to locate the MTrPs, which form what is called a taut band. MTrPs are shortened muscle fibers due to overly activated muscle contraction. Needle electromyography studies have demonstrated the transmission of low-amplitude electrical activity by MTrPs, which is called spontaneous electrical activity [2, 43, 45, 50]. The study by Kuan et al. [42] demonstrated that BoNT injection in MTrPs blocks acetylcholine release into the synaptic cleft and diminishes spontaneous electrical activity in MTrPs.

Several studies have shown that MTrP pathophysiology appears to be associated with intramuscular neural arborized areas [15, 24, 25, 30, 43]. The study by Xie et al. [54] showed that not only BoNT injection but also lidocaine-injection therapy in the intramuscular arborized area significantly reduces the degree and frequency of pain in patients at 6 months after treatment.

Injective treatment targeting the QL muscles is becoming commonly practiced for its effectiveness in relieving MPS [10, 22, 26, 36]. MPS involving the QL muscle frequently occurs when sitting cross-legged, which causes the hemipelvis to rise, approximating from the iliac crest to the 12th rib, and the shortening of the ipsilateral QL muscle. A common sleeping position, lying on one's side with the adducted upmost lower, will likewise a reason for the shortened QL muscle. This can lead to MPS with patients usually complaining that their suffering is even worse at night [16].

Additionally, anatomical factors include leg length discrepancy, which causes excessive lumbar lordosis and excessive stress on the QL muscle. The compensatory scoliosis produced by the QL muscle is a necessary lumbar curvature needed to maintain balance. This leads to the overloading of the QL muscle, which leads to an excessive burden on it [14].

The intramuscular neural arborized area are injection target point for MPS, and commonly injected agents are BoNT, lidocaine, steroid, and normal saline [5, 13, 18]. In particular, injective BoNT treatment in MPS is known to remain effective up to 4 months, in contrast to the short-term effects of oral medication and lidocaine injections [5, 13]. When using BoNT injection to treat MPS, studies have suggested that treatment sessions should be conducted every 3 months to maintain pain reduction from MPS [22, 52].

The main, known, therapeutic consequences of BoNT are caused by releasing muscle contractions and easing the vicious pain cycle [34, 47, 49]. It is also assumed that the relief from muscle tightness and BoNT itself suppress the diffusion of neurotransmitters within the peripheral nerve, suppressing peripheral sensitization [37, 40]. Since BoNT acts on the neuromuscular junction, the broad and precise anatomical knowledge of the neuromuscular arborization patterns of the muscles is essential for attaining maximum relief with the lowest possible amount of BoNT.

Even though BoNT procedures are minimally invasive compared with surgical procedures, there is still a risk of damaging the nerve trunks, not the neural arborized area. Therefore, the precise knowledge of the anatomical features of the muscle should be understood. Several studies have conducted Sihler staining, which is a whole-mount staining method that dyes myelin sheaths, providing an effective visualization of nerve endings without damaging the nerves [39, 55–57, 62]. Using Sihler staining on the QL muscle will facilitate an accurate and comprehensive understanding of the neural distribution.

Presently, there is absolutely no standardized injection site or optimal dose for BoNT of the QL muscle. The volume of BoNT must be adequate to present a sufficient level of the toxin in the arborized area of neural distribution. Reports on complications suggest that BoNT should be delivered in the arborized area of the target muscle with small doses and fewer injections.

Overall, we suggest that injective treatment using BoNT, lidocaine, normal saline, steroids, and EMG need to be directed in the three regions: the middle portion from L3 to L4 and from L4 to the iliac crest and the lateral portion from L3 to L4 (Fig. 4).

# Declarations

**Conflicts of interest:** The author(s) declare no competing interests.

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# Figures

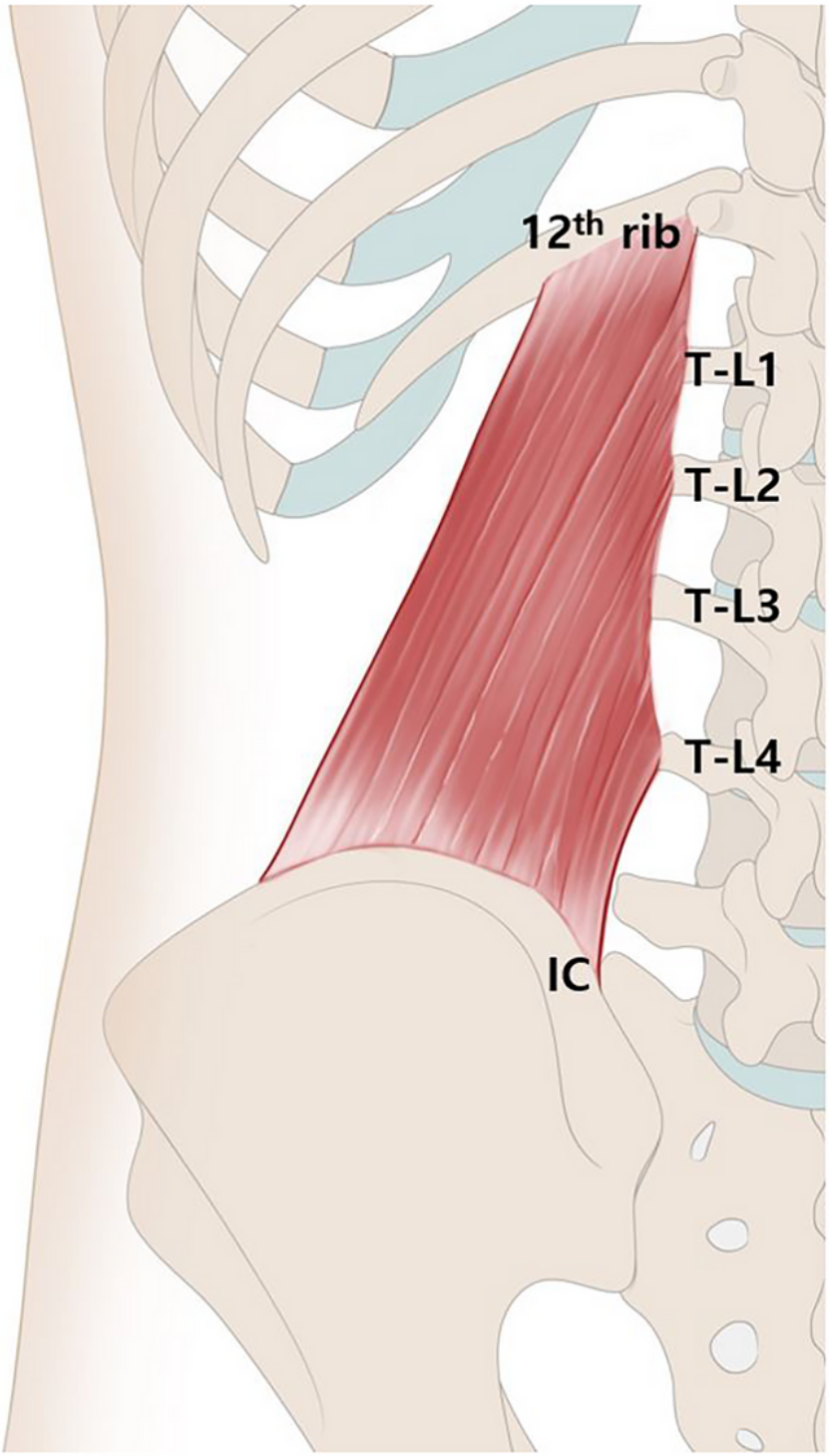



**Figure 1**

The specimens were harvested according to four landmarks: the inferior border of the 12th rib, the transverse processes of L1-L4, and the iliac crest.

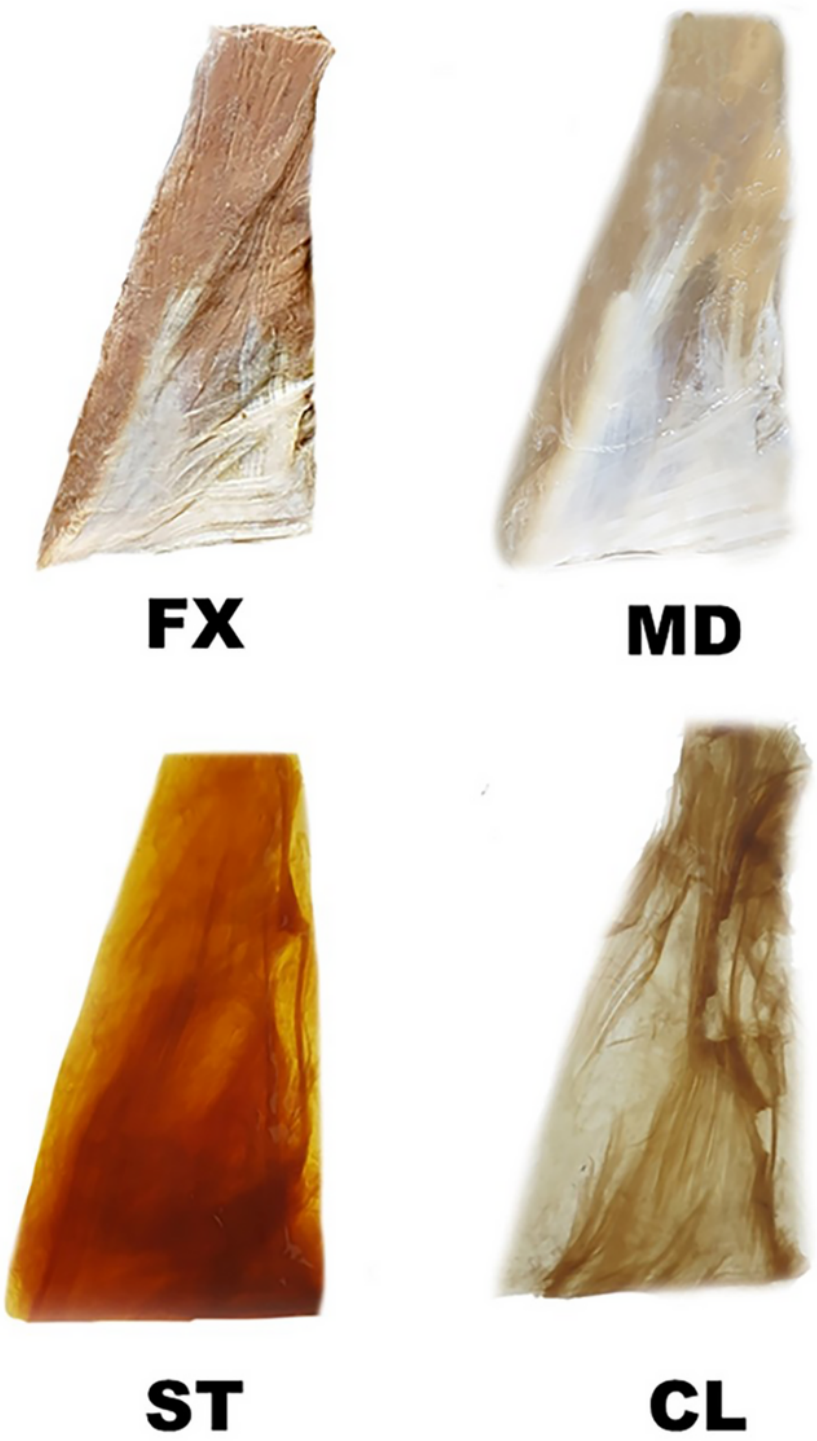
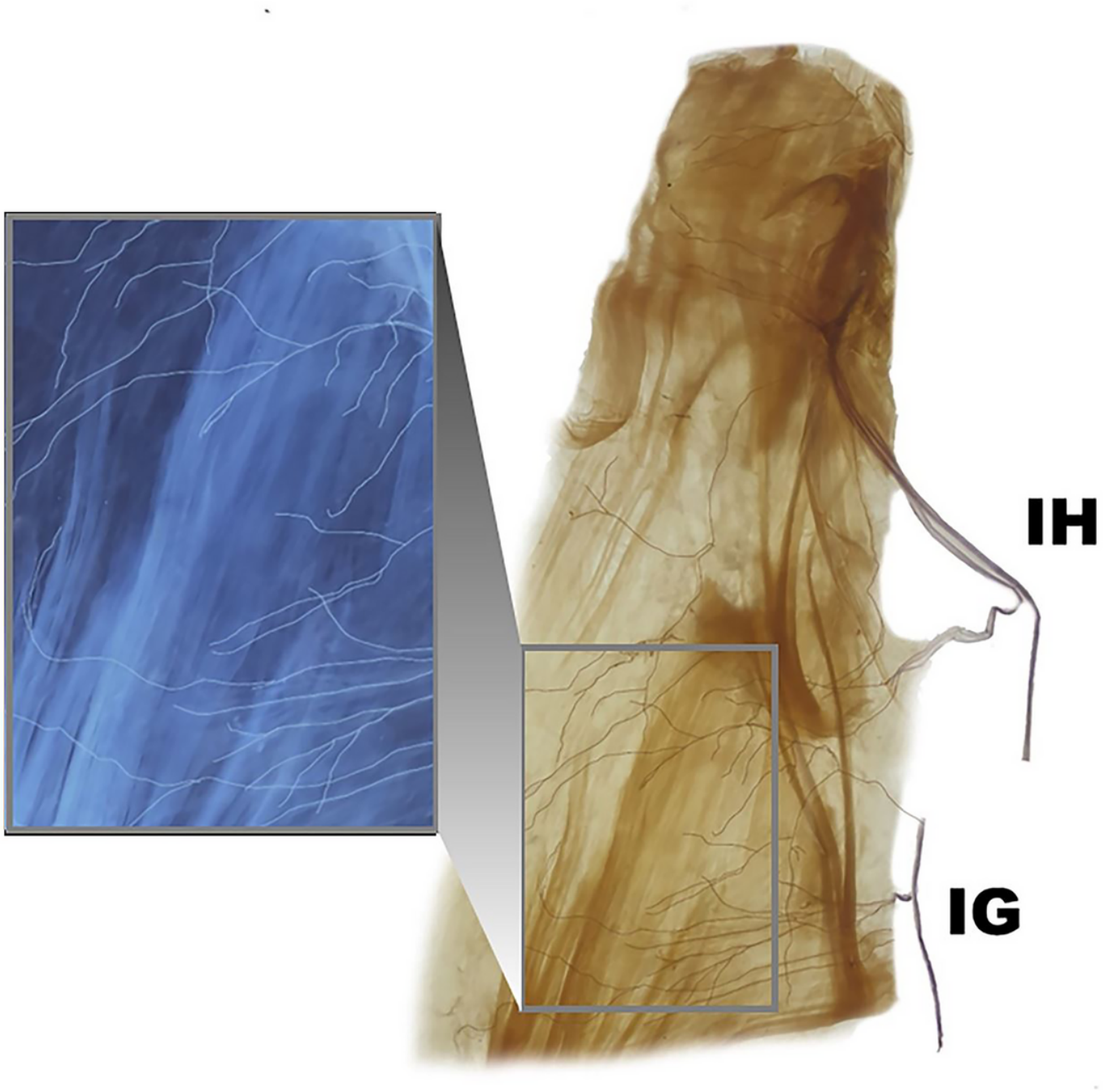



**Figure 2**

The quadratus lumborum muscle underwent the modified Sihler method. The method consists of the stages of fixation (FX), maceration and depigmentation (MD), decalcification, staining (ST), and clearing (CL).




## Figure 3

Sihler-stained quadratus lumborum muscle. An enlarged view of the intramuscular neural distribution of the quadratus lumborum muscle is observed. The iliohypogastric (IH) nerve and the ilioinguinal nerve (IG) is observed to be entering at the medial portion of the quadratus lumborum muscle.

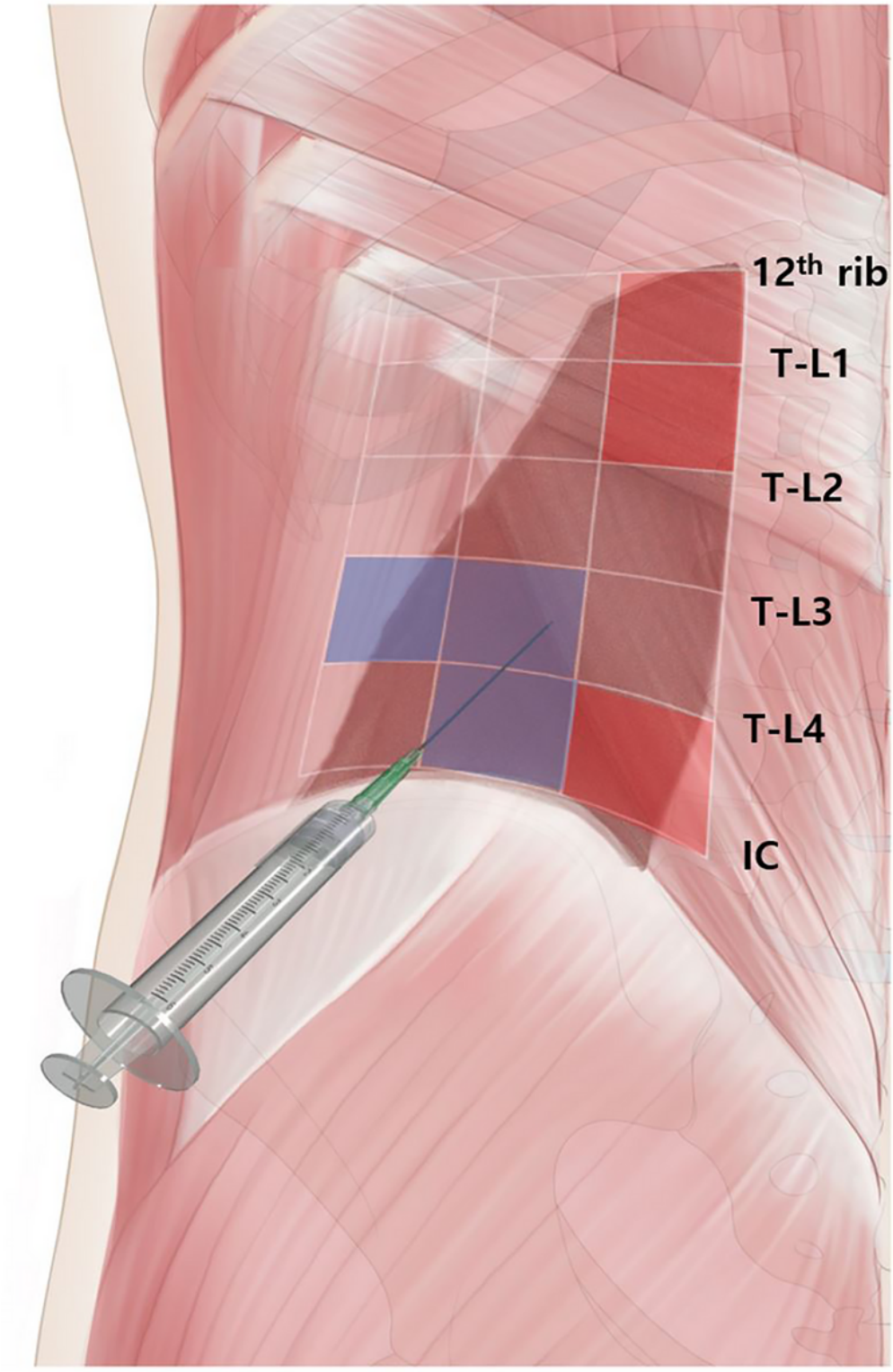



**Figure 4**

The largest regions of the intramuscular arborization patterns: the middle portions from the transverse process of L3 (T-L3) to L4 (T-L4) and from T-L4 to the iliac crest (IC) and the lateral portion from T-L3 to T-L4 (blue shaded). The thoracic intercostal nerve entry point was in the medial region between the 12th rib and the transverse process of L1 (T-L1) (red shaded). The iliohypogastric nerve entry point was in the

medial region between T-L1 and L2 (T-L2) (red shaded). The ilioinguinal nerve entry point was in the medial region between T-L1 and iliac crest (red shaded).