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A novel approach to ultrasound-guided L3-4 thoracolumbar fascia injection for chronic pain after spine surgery: a prospective pilot study

Yingying Lv[1], Junzhen Wu[1], Yongming Xu[1], Shaofeng Pu[1], Chen Li[1] and Dongping Du[1*]

Abstract

Background Fascial tissues have been overlooked in the past, and there are only few studies on the thoracolumbar fascia and its treatment methods. The present study aimed to investigate the effectiveness and safety of ultrasound-guided bilateral L3-4 thoracolumbar fascia injection in treating postoperative low back pain.

Methods A prospective pilot study was conducted at a university hospital. Twenty-six patients with postoperative low back pain resistant to conservative therapies and US-guided bilateral L3-4 medial branch block (MBB) were included as participants. They were treated with US-guided L3-4 mid-thoracolumbar fascia injection. Using real-time fluoroscopy, we monitored the contrast medium's diffusion range and double-checked the needle tips' positions throughout the procedures. The pain numeric rating scales (NRS), lumbar anteflexion range of motion (ROM), and Oswestry disability index (ODI) were assessed through telephone interviews one, four, and twelve weeks after the procedures. All data were processed by SPSS software version 23.0 (IBM Corp., New York).

Results Compared with NRS at baseline, pain scores decreased throughout the observation period. Lumbar anteflexion range of motion of US-guided bilateral L3-4 mid-thoracolumbar fascia injection continuously improved during the first, fourth, and twelfth week. No intravascular injections or neurologic injuries were observed.

Conclusion The US-guided bilateral L3-4 mid-thoracolumbar fascia injection facilitated a uniform dispersion of the medication, akin to the gentle spread of a goose feather, between the erector spinalis and quadratus lumborum muscles across the affected lumbar vertebrae. This technique demonstrated substantial clinical effectiveness in patients who were unresponsive to standard US-guided MBB.

Keywords L3-4 thoracolumbar fascia injection, Postoperative low back pain

*Correspondence:
Dongping Du
dudp@sjtu.edu.cn
[1]Pain Management Center, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University School of Medicine, No. 600, Yishan Road, Shanghai, China

Background

Clinical observations indicate that lumbar surgery can effectively alleviate the radiation pain in lower limbs, but some patients continue to experience low back pain [1]. Post spinal surgery syndrome (PSSS) is a complex chronic neuropathic pain with complex mechanisms involving central and peripheral sensitization, which makes treatment challenging [2]. Due to multiple injuries of original diseases and surgical trauma, effective methods are limited. Nonsteroidal Antiinflammatory Drugs (NSAIDs) and opioids are mostly prescribed, but their effect is usually inadequate. In recent years, the in-depth study of the anatomy and function of the thoracolumbar fascia has revealed that, as the largest fascia of the human body, many nerves related to low back pain pass through the thoracolumbar fascia [3]. The most important division of the lumbar nerve's posterior branch enters the erector spinalis muscle through the bone fiber hole. From there, it travels through the posterior layer of the thoracolumbar fascia and is distributed throughout the subcutis. When these branches become congested or compressed, this is a common mechanical cause of low back pain [4–5]. The potential mechanism underlying thoracolumbar fascia (TLF) injections is grounded in the intricate neuroanatomy and sensory innervation of the fascial tissues in the lumbar region. For example, any effect resulting from blockade of sympathetic nerve endings in the thoracolumbar fascia would apply only to back pain emanating from the fascia itself [6]. The TLF is not merely a passive connective tissue structure; rather, it is richly innervated by free nerve endings, mechanoreceptors, and afferent nerve fibers that interface closely with the musculoskeletal components of the lower back. Fascial tissues have been overlooked in the past, and there are only few studies on the thoracolumbar fascia and its treatment methods.

Methods

This prospective pilot study was conducted under the principles of the Declaration of Helsinki. This procedure was reviewed and approved by the Ethics Committee of Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University(Approval No. 2021 – 117). All patients provided written informed consent to participate in the study, including consent for the publication of procedural images. This prospective pilot study included all patients resistant to conservative treatments and regular US-guided lumbar MBB at our institution. All patients who underwent lumbar surgery (including traditional and minimally invasive surgery) more than six months ago and had low back pain (NRS ≥ five points) for more than three months only experienced low back pain without radiating pain in lower limbs. There was no lumbar disc herniation or spinal canal stenosis in the lumbar MRI. Twenty-six patients underwent US-guided bilateral L3-4 thoracolumbar fascia injections from May 2021 to May 2023.

Procedure

US-guided bilateral L3-4 thoracolumbar fascia injection was performed by an experienced pain physician in our department. Before the treatment, the patient was placed in a prone position in the operating room and monitored noninvasively through a continuous electrocardiogram and blood pressure, and pulse oximetry. An intravenous infusion was established before the procedure. The physician stood on the patient's left or right side. As an illustration, we discuss the L4 mid-thoracolumbar fascia injection. All patients were in the prone position with a thin pillow on their abdomen, their arms extended straight on both sides of the body, and their lower limbs extended naturally. First, we scanned upward from the sacral vertebra to confirm the L4 spinous process. A high-frequency convex array US probe (2–15 MHz, EDGE-II; SonoSite, USA) was placed flat on the patient's low back and scanned in musculoskeletal mode. L4 spinous, articular, and transverse processes were located next. After sterile procedures, the needle tip was advanced between the erector spinae and the quadratus lumborum from exterior to interior using our US-guided in-plane approach (Fig. 1). After careful aspiration, 1 mL of 0.9% NaCl was injected to confirm the proper positioning of the needle tip. The needle tip was adjusted up or down if the blood was aspirated. After confirmation, 1 ml contrast medium with 1 ml 0.9% NaCl was injected, and an anteroposterior (AP) view of the fluoroscopic image was taken two minutes later. The needle tip placement was successful when contrast flowed across two lumbar segments. After that, 20 mL of 0.2% mixture of ropivacaine and compound betamethasone injection (3.5 mg, calculated by betamethasone) was injected under US guidance.

Date recording

All participants' baseline characteristics, including age, gender, body mass index (BMI), duration of symptoms, baseline NRS (0–10), ROM, and ODI, were collected from patient medical records before the operation. ROM and NRS were recorded after one, two, and twelve weeks injection to evaluate the procedure's efficacy. ODI was recorded after 12 weeks injection to assess the quality of life improvement. The adverse effects were also recorded during the procedure.

Statistical analysis

All data were processed by SPSS software version 23.0 (IBM Corp., New York). Normally distributed continuous data on patient demographics and pain characteristics were reported as the mean standard deviation (SD). A

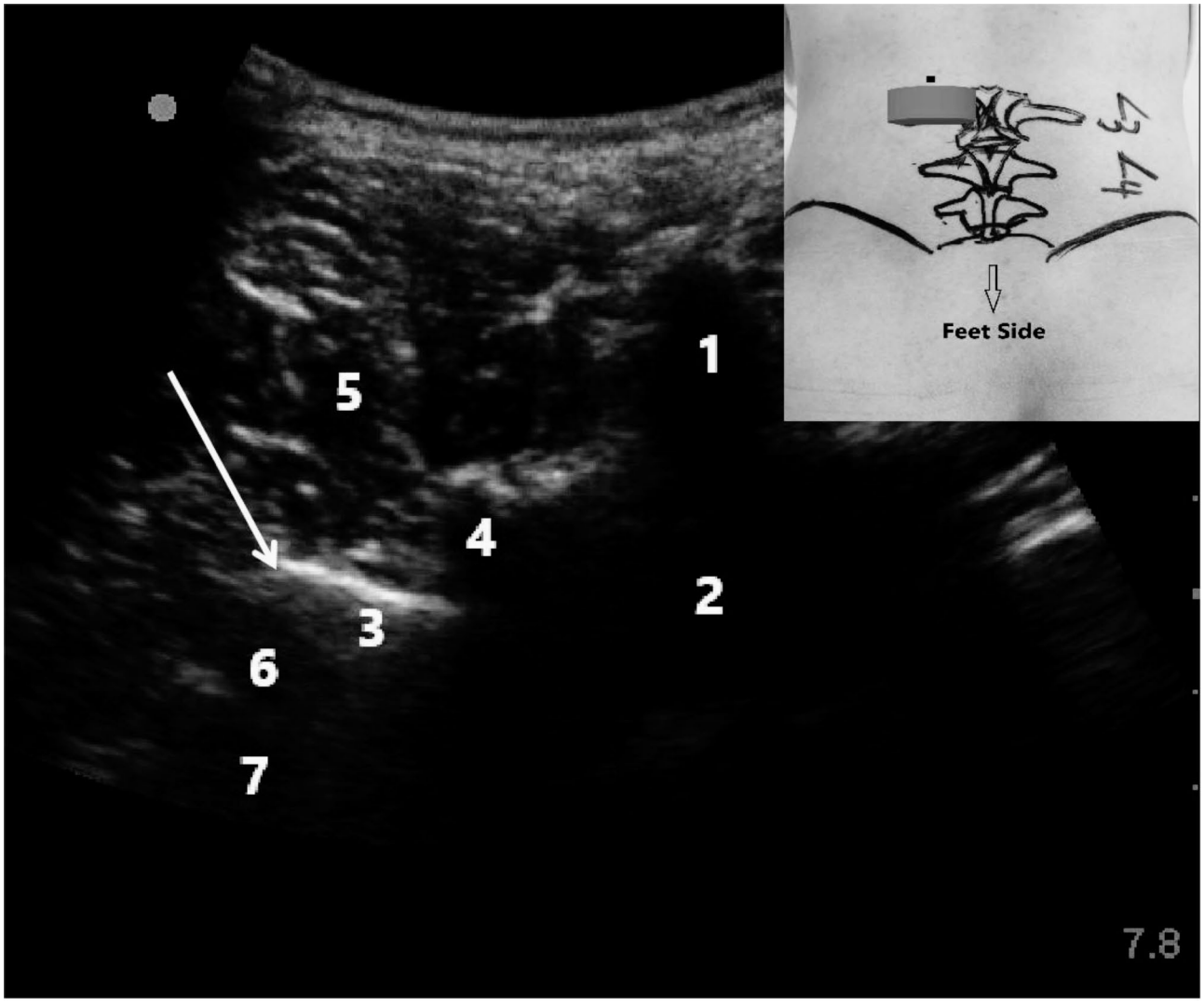

Fig. 1 An example of US-guided L4 thoracolumbar fascia injection. The upper right corner showed the patient's posture diagram, the placement direction of the ultrasound probe was shown by the blue icon. The needle tip was advanced to the apical part of transverse process using the in-plane approach. The anatomical structures are shown in the figures in the figure: 1. L4 spinous process; 2. L4 vertebral body; 3. L4 transverse process; 4. L4 superior articular process; 5. erector spinae muscle; 6. quadratus lumborum muscle; 7. psoas major muscle

Table 1 Patient characteristics

Characteristics	Patients ($N=26$)
Age (mean ± SD, years)	65.85 ± 4.32
Gender (men/women)	14/12
BMI (mean ± SD, kg/m^2)	26.79 ± 1.78
Duration of symptoms (mean ± SD, years)	2.24 ± 0.86
NRS at baseline (mean ± SD)	5.27 ± 0.45
Range of motion (ROM)(mean ± SD, degree)	20.92 ± 3.03
Oswestry Disable Index(ODI)(mean ± SD)	71.12 ± 2.50

generalized linear mixed model (GLMM) was performed to evaluate pain NRS score changes over repeated measurements. Statistical significance was defined as $P<0.05$. Their preoperative characteristics were recorded, and prospective data were collected for the ODI and ROM.

Table 2 Comparison of NRS scores, ROM and ODI at baseline and after US-guied L3-4 thoracolumbar fascia mid-level injection

	Baseline	1 week after injection	2 weeks after injection	12 weeks after injection
NRS	5.27 ± 0.45	2.42 ± 0.50	1.85 ± 0.37	2.31 ± 0.37
ROM	20.92 ± 3.03	46.04 ± 4.00	45.19 ± 3.97	44.31 ± 4.02
ODI	71.12 ± 2.50	/	/	34.81 ± 4.92

Results

Patients' characteristics are presented in Table 1. The average age of patients was (65.85 ± 4.32) years. Compared with NRS scores at baseline (5.27 ± 0.45), pain scores decreased throughout the observation period (one week, 2.42 ± 0.50, $P<0.01$; two weeks, 1.85 ± 0.73, $P<0.01$; twelve weeks, 2.31 ± 0.47, $P<0.01$; Table 2). Compared

with ROM at baseline (20.92 ± 3.03), it was significant improved during the observation period (one week, 46.04 ± 4.00, $P < 0.01$; two weeks, 45.19 ± 3.97, $P < 0.01$; twelve weeks, 44.31 ± 4.02, $P < 0.01$; Table 2). Compared with ODI at baseline (71.12 ± 2.50), it was visibly changed after twelve weeks (34.81 ± 4.92, $P < 0.01$; Table 2). Fluoroscopic images of all the patients showed the contrast medium diffusing evenly over two lumbar segments, as smoothly as the goose feather between the erector spinalis and the quadratus psoas muscles. Whether or not an internal fixation was performed, drug diffusion was optimal (Fig. 2). No cases of inadvertent vascular injection or neurological injury were identified among the patients. Additionally, temporary complications including hypotension, motor impairment, or injection-site reactions were not detected.

Discussion

We evaluated the effect of L3–4 thoracolumbar fascia mid-level injection on low back pain in patients who had undergone lumbar surgery and were resistant to conservative treatments and regular US-guided MBB. The results showed that the procedure significantly decreased NRS scores throughout the follow-up period compared to baseline ones. After treatment, the symptoms of all patients were significantly improved, the quality of life notably improved, and the effect lasted for at least three months. Previous studies have rarely used thoracolumbar fascia as the treatment target for patients with low back pain after lumbar surgery. It is believed that lumbar facet osteoarthritis caused by local internal environment abnormalities may be a major cause of residual low back pain in patients after lumbar disc nucleus pulposus

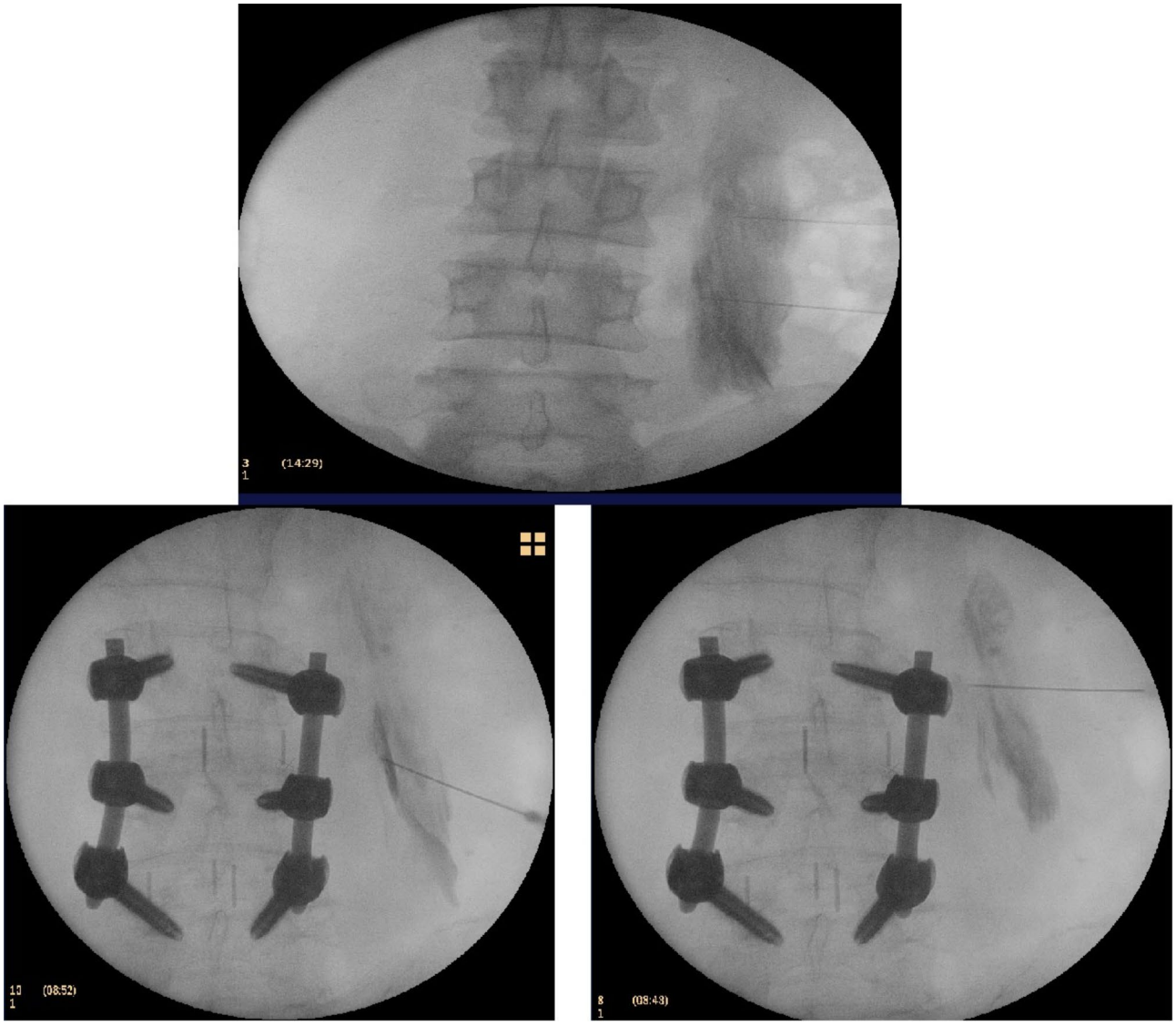

Fig. 2 Fluoroscopic images of the patients. Whether or not an internal fixation was performed, the contrast medium(1 ml contrast medium with 1 ml 0.9% NaCl) diffusing evenly over two lumbar segments

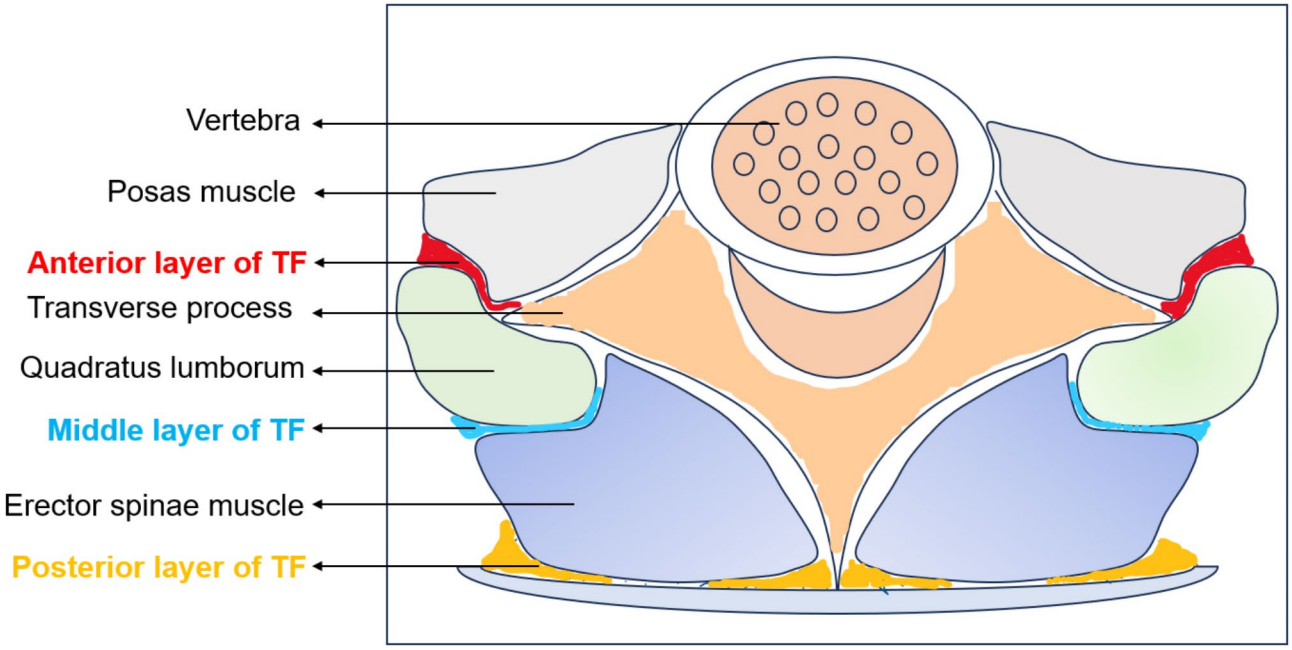

Fig. 3 A schematic illustration of thoracolumbar fascia. The dorsal rami of the spinal nerves traverse the medial aspect of the middle thoracolumbar fascia posterior to the quadratus lumborum muscle and then enter the erector spinae muscles

resection [7–8]. Therefore, lumbar medial branch block is frequently employed.

The thoracolumbar fascia being the largest fascia of the human body, surrounds the deep fascia of the back of paravertebral muscles in the thoracic and lumbar spines. Between the 12th rib and the iliac crest, it can be divided into three layers: anterior, middle, and posterior. The posterior and the middle layers converge at the lateral edge of the erector spinalis muscle to form the erector spinalis sheath, while the middle and the anterior layers converge at the lateral edge of the psoas quadratus muscle to form the psoas quadratus sheath [4, 9] (Fig. 3). The middle layer of the thoracolumbar fascia, spinous process, and transverse process of the lumbar spine form the lumbosacral osteofascial compartment. The thoracolumbar fascia is a part of the myofascial band that surrounds the lower torso. It plays an important role in maintaining normal curvature, stability, and load transfer of the lumbar spine [10]. Its poor elasticity may be one of the anatomical causes of low back pain [11]. Moreover, the aponeurosis of transverse abdominal muscle contributes to the thoracolumbar fascia's composition. Even if the target of fascial blockade is the motor nerve, it may still alleviate pain by relieving muscle spasms and preventing ischemic inflammatory reactions [6]. Hence, this layer is essential for posture control of the spine and normal stress maintenance. Compared with erector spinae plane block, these two injection methods are completely different. The erector spinae plane block involves injecting local anesthetic deep to the erector spinae muscles, generally at the level of the transverse processes of the thoracic vertebrae. The injection is placed in the fascial plane superficial to the transverse process and deep to the erector spinae muscle group [12].

PSSS is internationally recognized as a persistent or recurrent low back pain syndrome with or without sciatica, which is usually localized and unclear in nature. It can be classified into mechanical pain and neuropathy [13]. These patients often suffered from severe pain and their quality of life is seriously affected. Postoperative chronic pain is associated with multiple factors, including patient factors, operational factors, and postoperative factors. The treatment methods mainly include drug treatment, repeated surgery, and neuromodulation Spinal Cord Stimulation (SCS) [14]. Previously, low back pain caused by spinal factors (vertebral body, intervertebral disc, spinal ligament, etc.) was given special consideration [15]. Nonetheless, the relationship between thoracolumbar fascia injury and postoperative back pain is rarely discussed, and the effect of fascia injury on the therapeutic efficacy of the operation is unclear. Yan observed that thoracolumbar fascia injury is the main cause of lower back pain after percutaneous vertebroplasty [16]. Kyra [5] found the structural disorder of the thoracolumbar fascia complex in patients with low back pain by using ultrasonic scanning. Pain often arises from injury and inflammation of deeper musculoskeletal tissues. The potential mechanisms of analgesic action of fascial plane blocks (FPBs) can be broadly divided into a local effect on nerves in the vicinity of injection, and

a systemic effect resulting from vascular dispersion [6]. Thoracolumbar fascia injury is not rare and must be considered a significant concomitant injury in postoperative low back pain [17]. Specifically, the low back pain of patients with no obvious abnormality on postoperative lumbar spine imaging is likely due to long-term uneven force on the associated low back muscles, improper force, etc. In our study, both groups' symptoms were alleviated after the two treatments. The effect and experience of patients within the thoracolumbar fascia group were better than those within the posterior medial spinal nerve branch group. Being familiar with the anatomy and ultrasonic anatomy of the thoracolumbar fascia system is not only helpful in diagnosing and identifying the musculoskeletal system diseases that cause low back pain but also plays an extremely positive role in symptomatic treatment.

Several limitations should be acknowledged regarding the present investigation. First, the absence of a control group and the relatively limited sample size potentially restrict the external validity of the findings. Future large-scale randomized controlled studies are warranted to further evaluate the safety and clinical feasibility of this novel blocking method. Second, outcome assessment was confined to a 12-weeks post-treatment period, with no subsequent long-term evaluations conducted. Consequently, comprehensive understanding of the sustained efficacy of this innovative analgesic approach remains limited. Third, inter-observer variability among researchers conducting pain assessments could introduce measurement bias, potentially affecting the reliability of our results. Fourth, a uniform local anesthetic dose of 20 mL ropivacaine at a concentration of 0.2% was administered in this investigation. The dose was not adjusted according to individual patient characteristics or needs. Despite being standard clinical practice at our institution, this approach could increase the risk for local anesthetic systemic toxicity.

In summary, the analgesic effect of thoracolumbar fascia injections likely arises from interrupting the complex web of sensory fibers and free nerve endings embedded in the fascial and muscular layers. By temporarily inhibiting these neural pathways, TLF injections can mitigate persistent nociceptive input, reduce sensitization, and thereby improve pain control in patients with chronic lumbar spine–related discomfort.

Conclusion

The US-guided bilateral L3-4 mid-thoracolumbar fascia injection facilitated a uniform dispersion of the medication, akin to the gentle spread of a goose feather, between the erector spinalis and quadratus lumborum muscles across the affected lumbar vertebrae. This technique demonstrated substantial clinical effectiveness in patients who were unresponsive to standard US-guided MBB.

Abbreviations

FPB	Fascial Plane Blocks
MBB	Medial Branch Block
NRS	Numeric Rating Scales
NSAIDs	Nonsteroidal Antiinflammatory Drugs
ODI	Oswestry Disability Index
PSSS	Post Spinal Surgery Syndrome
ROM	Range of Motion
SCS	Spinal Cord Stimulation

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Author contributions

YingYing Lv and Dongping Du contributed to the study conception and design. YingYing Lv, Junzhen Wu and Chen Li performed the data analysis. YingYing Lv, Yongming Xu and Shaofeng Pu contributed to collect cases. The first draft of the manuscript was written by YingYing Lv and all authors commented on previous versions of the manuscript. All authors reviewed the manuscript.

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Data availability

Data is provided within the manuscript. The data that support the findings of this study are available on request from the corresponding author.

Declarations

Ethics approval and consent to participate

The experimental protocol was established, according to the ethical guidelines of the Helsinki Declaration and was approved by the Human Ethics Committee of Shanghai Sixth People's Hospital(Approval No.2021 – 117). Written informed consent was obtained from individual.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Taiji et al. Improving effect of microendoscopic decompression surgery on low back pain in patients with lumbar spinal stenosis and predictive factors of postoperative residual low back pain: a single-center retrospective study. BMC Musculoskeletal Disorders. 2021;22:954.
2. Ramnarayan R, Chaurasia B. The post spinal surgery syndrome: a review. J Craniovertebr Junction Spine. 2023;14(1):4–10.
3. Li Y, Yue J, Huang M, Lin J, Huang C, Chen J, et al. Risk factors for postoperative residual back pain after percutaneous kyphoplasty for osteoporotic vertebral compression fractures. Eur Spine J. 2020;29(10):2568–75.
4. Blasi M, Blasi J, Domingo T, et al. Anatomical and histological study of human deep fasciae development. Surg Radiol Anat. 2015;37(6):571–8.
5. Kyra DC, Karen H, Dickinson JW, et al. Measuring the morphological characteristics of thoracolumbar fascia in ultrasound images: an inter-rater reliability study[J]. BMC Musculoskelet Disord. 2018;19(1):1.
6. Chin KJ, Lirk P, Hollmann MW, Schwarz SKW. Mechanisms of action of fascial plane blocks: a narrative review. Reg Anesth Pain Med. 2021;46(7):618–28.

7. Tromme A, Charles YP, Schuller S, Walter A, Schaeffer M, Steib JP. Osteoarthritis and spontaneous fusion of facet joints after percutaneous instrumentation in thoracolumbar fractures. Eur Spine J. 2019;28(5):1121–9.
8. Chen Z, He L, Di J, Huang L, Feng F, Yang B, Xie P, Rong L. Lumbar facet joint osteoarthritis as the underlying reason for persistent low back pain after minimally invasive discectomy. Arch Orthop Trauma Surg. 2023;143(7):3811–21.
9. Chin KJ, Perlas A. Ultrasonography of the lumbar spine for neuraxial and lumbar plexus blocks. Curr Opin Anaesthesiol. 2011;24(5):567–72.
10. Elsharkawy H, El-Boghdadly K, Barrington M. Quadratus lumborum block: anatomical concepts, mechanisms, and techniques. Anesthesiology. 2019;130(2):322–35.
11. Blain M, Bedretdinova D, Bellin M, et al. Inflfluence of thoracolumbar fascia stretching on lumbar back muscle stiffness: a supersonic shear wave elastography approach. Clin Anat. 2019;32(1):73–80.
12. Saadawi M, Layera S, Aliste J, Bravo D, Leurcharusmee P, Tran Q. Erector spinae plane block: a narrative review with systematic analysis of the evidence pertaining to clinical indications and alternative truncal blocks. J Clin Anesth. 2021;68:110063.
13. Yang YL, Yan X, Li WH, et al. Long-term clinical outcomes and pain assessment after posterior lumbar interbody fusion for recurrent lumbar disc herniation. Orthop Surg. 2020;12(3):907–16.
14. James R, Daniell OL. OstiFailed back surgery syndrome: a review article. Asian Spine J. 2018;12(2):372–9.
15. DePalma MJ, Ketchum JM, Saullo T. What is the source of chronic low back pain and does age play a role? Pain Med. 2011;12:224–33.
16. Yan Y, Xu R, Zou T. Is thoracolumbar fascia injury the cause of residual back pain after percutaneous vertebroplasty? A prospective cohort study[J]. Osteoporos Int. 2015;26(3):1119–24.
17. Deng Z, Feng T, Wu X, Xie H, Song D, Wang J, Yang H, Niu J. Thoracolumbar fascia injury in osteoporotic vertebral fracture: the important concomitant damage[J]. BMC Musculoskelet Disord. 2023;24(1):166.

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