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Ultrasound-Guided In-Plane Interlaminar Lumbar Endoscopic Approach with Smartphone and Portable Light Source: Description of a New Surgical Technique

Acesso Endoscópico Interlaminar lombar em plano guiado por ultrassom com smartphone e luz portátil: descrição de uma nova técnica cirúrgica

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Abstract

Introduction Endoscopic spine surgery enables the minimally invasive treatment of pathologies affecting the spinal cord and roots. Herein we describe an unprecedented technique of Ultrasound-Guided in-plane interlaminar lumbar endoscopic approach with a smartphone and portable light source.

Methods The interlaminar approach was performed in a cadaveric specimen at L4 to 5 and L5 to S1 bilaterally. A curvilinear 2 to 5 MHz ultrasound probe was employed, the puncture was performed with the needle, a guide wire was inserted until the flavum ligament, followed by the dilator and working cannula. A 30° spinal endoscope, with an optical adapter of the endoscope camera for smartphone and portable endoscope lighting was inserted, the flavum ligament was visualized, and an opening in this site was performed with the scissors. Open dissection of the specimen was subsequently performed by identifying the puncture site in the interlaminar window.

Results The four interlaminar punctures were successfully guided by ultrasound; the opening of the ligamentum flavum was performed in the most lateral part of the interlaminar space, near the junction of the superior and inferior articular processes of the corresponding vertebrae in all the punctures.

Discussion The ultrasound makes possible to identify facets, foramina, transverse processes, and the interlaminar space. It is possible to minimize the use of radioscopy and its associated risks, both for patients and health professionals.

Keywords
- spine
- endoscopy
- ultrasonography
- interventional

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Conclusions The ultrasound-guided, in-plane, interlaminar, lumbar endoscopic approach with smartphone-adapted endoscope and portable light source is feasible and practical, minimizing radiation risks and making it possible to perform endoscopic spinal surgery.

Resumo

Introdução A cirurgia endoscópica da coluna possibilita o tratamento minimamente invasivo de patologias que acometem a medula espinhal e raízes. Aqui descrevemos uma técnica inédita de acesso endoscópica, interlaminar, lombar, em plano guiado por ultrassom com um smartphone e fonte de luz portátil.

Métodos A abordagem interlaminar foi realizada em espécime cadavérico em L4 a 5 e L5 a S1 bilateralmente. Foi utilizado um transdutor de ultrassom curvilíneo de 2 a 5MHz, realizada a punção com a agulha, inserido um fio guia até o ligamento amarelo, seguido do dilatador e da cânula de trabalho. O endoscópio de coluna de 30° com adaptador óptico para smartphone e iluminação portátil foi inserido, visualizando o ligamento amarelo, que foi aberto com tesoura. A dissecção aberta do espécime foi realizada posteriormente, identificando o local da punção na janela interlaminar.

Resultados As quatro punções interlaminares foram guiadas com sucesso por ultrassom; a abertura do ligamento amarelo realizada foi na parte mais lateral do espaço interlaminar, próximo à junção dos processos articulares superior e inferior das vértebras correspondentes em todas as punções.

Discussão A ultrassonografia permite identificar facetas, forames, processos transversos e o espaço interlaminar. É possível minimizar o uso da radioscopia e seus riscos associados, tanto para pacientes quanto para profissionais de saúde.

Conclusões A abordagem endoscópica, interlaminar, lombar, em plano guiada por ultrassom, com endoscópio adaptado à smartphone e fonte de luz portátil, é viável e prática, minimizando os riscos de radiação e possibilitando a realização de cirurgia endoscópica da coluna vertebral.

Palavras-chave
- coluna
- endoscopia
- ultrassonografia intervencionista

Introduction

Degenerative diseases of the lumbar spine have a high prevalence, reaching 27.3% of the population and increasing with age and risk factors such as obesity.[1] Degenerative disc disease occurs in 12.2% of the patients, and is frequently associated with low back pain and lumbosciatalgia.[2]

Minimally invasive spine surgery includes procedures that have the common aim of avoiding biomechanical complications, preventing damage to crucial posterior stabilizers, and preserving the stability and structural integrity of the spine.[3] So it is possible to perform surgeries with less tissue aggression, faster postoperative recovery, and shorter hospital stays with viability and efficiency, increasing its accessibility in the last two decades.[2]

The percutaneous endoscopic, or full-endoscopic, discectomy technique has been scientifically proven to be a good alternative to open discectomy, especially for lumbar disc herniation, and the main surgical field has been shifted from the intradiscal space to the epidural space.[4] Percutaneous endoscopic lumbar discectomy becomes particularly attractive for sequestrectomies, with the advent of angled scopes allowing 360° visualization and enabling the removal of extruded lumbar disc fragments while preserving the disc.[5]

The two major approaches of endoscopic spine surgery are transforaminal and interlaminar, with different techniques and indications.[6] The interlaminar endoscopic technique is used for discectomies involving mostly central-lateral disc herniations, specially at the L4 to 5 and L5 to S1 levels, which correspond to the majority of lumbar disc hernias.[7] Classically, the approach is performed with the aid of fluoroscopy during the surgical procedure, which assists in the puncture of the interlaminar window and the positioning of the working cannula for the endoscope insertion.

Ultrasonography can visualize spine anatomy, including the ligaments, erector spinae muscles, facet joints, transverse processes, foramina, and interlaminar spaces; it can also guide injections and interventional procedures.[8]

The use of radioscopy can pose risks to patients and healthcare professionals related to radiation. To minimize the use of intraoperative radioscopy and its risks, we describe in this paper an unprecedented technique, consisting of the ultrasound-guided, in-plane, interlaminar, lumbar endoscopic approach, with a smartphone-adapted endoscope and portable light source.

Materials and Methods

The technique was demonstrated in a cadaveric specimen using the Sonosite M-Turbo Ultrassound (FujiFilm SonoSite, Bothell, WA, USA) to perform the interlaminar in plane lumbar L4–5 and L5-S1 approach bilaterally with the

Fig. 1 Optical smartphone camera adapter attached to the endoscope in addition to a portable LED lamp.

Fig. 2 Sacrum is identified by seeing an hyperechogenic ramp on ultrasound.

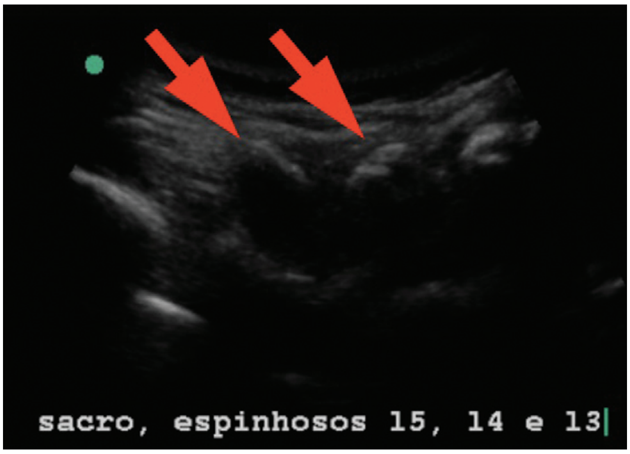

Fig. 3 Spinous processes of L5 and L4, which appear as more superficial hyperechoic structures with a deeply acoustic shadow.

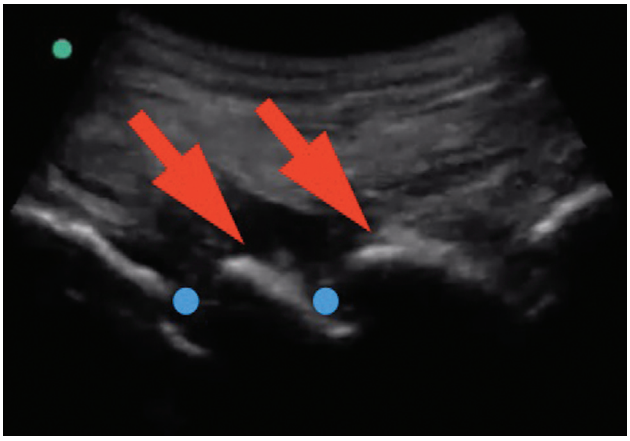

Fig. 4 Laminas are visualized as non-continuous hyperechoic structures that resemble the image of a "horses race" (arrow); between then it becomes possible to identify the flavum ligament as part of the posterior complex (circle).

puncture of the interlaminar window guided by ultrasound using a 2–5MHz curvilinear probe. An optical smartphone camera adapter MedEasy (MedEasy, São Paulo, SP, Brazil) was attached to the endoscope in addition to a portable LED lamp PhlatLight (Luminus Devices Inc., Woburn, MA, USA) (►**Fig. 1**).

The punctures were then performed in the L4 to 5 and L5 to S1 interlaminar windows bilaterally, guided by ultrasound and directed to the V point, which corresponds to the intersection of the inferior articular process of the superior vertebra with the superior articular process of the inferior vertebra and ligamentum flavum.

The step-by-step technique was didactically elaborated in 10 steps, which are presented in the results.

Subsequently, an open dissection of the specimen was performed with identification of the opening sites of the flavum ligament.

Results

Technical Note

1. With the specimen in the prone position and using a low frequency (2–5 MHz) curvilinear ultrasound probe oriented longitudinally in the midline, the sacrum is identified by seeing an hyperechogenic ramp on ultrasound (►**Fig. 2**).
2. In the midline, the transducer is directed cranially, allowing the identification of the spinous processes of L5 and L4, which appear as more superficial hyperechoic structures with a deeply acoustic shadow (►**Fig. 3**).
3. From the midline, the transducer is moved laterally by 1 cm, making it possible to visualize the non-continuous, hyperechoic structures that resemble the image of a "horses' race", constituting the sonographic image of the laminas. Between the laminas, it becomes possible

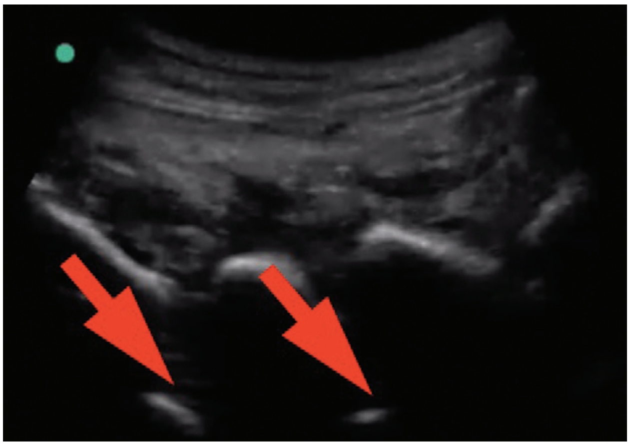

Fig. 5 Anterior complex formed by the posterior longitudinal ligament, disc and ventral dura mater.

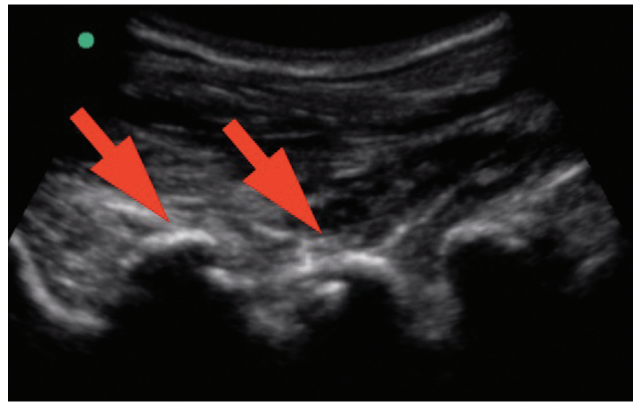

Fig. 6 Facet joints resembling to "mountains and valleys".

Fig. 7 Needle tip going through the flavum ligament. A resistance is felt at this moment.

Fig. 8 Needle, guide wire, dilator, working cannula and endoscope insertion.

to identify the flavum ligament as part of the posterior complex (►**Fig. 4**).

4. Going laterally, it is also possible to see the anterior complex, formed by the posterior longitudinal ligament, disc, and ventral dura mater (►**Fig. 5**).
5. Proceeding with the transducer for approximately 1 cm more laterally, it is possible to identify more rounded hyperechoic structures resembling "mountains and valleys", which corresponds to the facet joints (►**Fig. 6**).
6. With the ultrasound positioned longitudinally in a paramedian position for approximately 1 to 1.5 cm, having identified the most lateral portion of the laminas and visualizing it on the ultrasound screen, the puncture needle is introduced in a caudal to cranial direction in-plane with the ultrasound probe. The puncture needle is inserted with its direct visualization by the ultrasound screen, progressing from a caudal to cranial direction, parallel to the laminas, until it touches the flavum ligament of the correspond level. At this point, resistance is felt due to the presence of the flavum ligament. The puncture needle is inserted with its blade positioned posteriorly, and the bevel opening is in a cranial direction in order not to enter the lamina of the superior vertebra (►**Fig. 7**).
7. After contact with the flavum ligament, a guide wire is inserted through the needle up to the flavum ligament. The needle is removed, and an incision of approximately 1 cm is made in the skin and muscle fascia (►**Fig. 8**).
8. The dilator is inserted up to the flavum ligament (►**Fig. 8**).

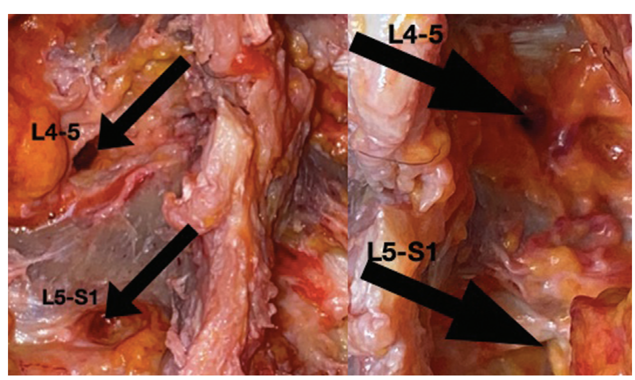

Fig. 9 Punctions sites.

9. The working cannula is inserted over the dilator, with its blade directed laterally and the bevel opening medially until it reaches the flavum ligament (►**Fig. 8**).
10. A 30° endoscope is introduced with an optical adapter from the endoscope camera to a smartphone and portable endoscopic lighting, visualizing the flavum ligament. The ligament is opened at this site with endoscopic scissors. These steps are performed in L4 to 5 and L5 to S1, bilaterally (►**Fig. 8**).

The ultrasound enabled the identification of the interlaminar space in all the punctures performed.

In all punctures, the opening of the ligamentum flavum was performed in the most lateral part of the interlaminar window, near the junction of the superior and inferior articular processes of the corresponding vertebrae (►**Fig. 9**).

Discussion

Endoscopic spine surgery has been increasingly used to treat spinal cord and nerve roots pathologies, promoting a paradigm shift in minimally invasive spine surgery.[9] The beginnings of this technique date back to 1983, when Forst and Hausmann[10] used an arthroscope to access the intervertebral disc, followed by the first description of an endoscopic discectomy by Kambin et al., in 1988.[11]

The intraforaminal, or transforaminal, approach Is the oldest technique allowing intradiscal and extradiscal access.[12] The transforaminal endoscopic approach was initially the most used procedure for performing endoscopic discectomies.[13] However, in 2006, Choi et al.[14] reported for the first time the successful endoscopic removal of a herniated L5 to S1 disc using the interlaminar approach, which is currently one of the most used techniques for percutaneous decompression procedures.

The interlaminar approach is an interesting option for the most caudal levels of the spine, especially L5 to S1, making it possible to avoid the iliac crest and to access more medially based pathologies.[15] The chance of herniated lumbar disc to occur either at L4 to 5 or L5 to S1, in patients between 25 and 55 years old, is approximately 95%.[16] Besides, medial disc herniations (central and subarticular) are more common than lateral ones (foraminal and extra foraminal), corresponding to 79 and 21%, respectively.[7] These are some of the reasons associated with the growing indication of the interlaminar approach.

In a recent meta-analysis, Kim et al.[17] showed the endoscopic lumbar discectomy having better results than the open lumbar discectomy concerning improvement to the visual analogue scale for pain and the Oswestry disability index, resulting in lower hospital stay and operative times.

The radiation dose to which patients and medical professionals who work with the use of fluoroscopy in the intraoperative period are exposed is of great concern, and it is good practice to develop strategies that can minimize the use of such methods. Ahn et al.[18] published a prospective study aiming to determine the radiation dose to which surgeons are exposed during percutaneous endoscopic lumbar discectomy; their results demonstrated that, without proper radiation protection, a surgeon performing 291 endoscopic discectomies annually would be exposed to the maximum allowable radiation dose.

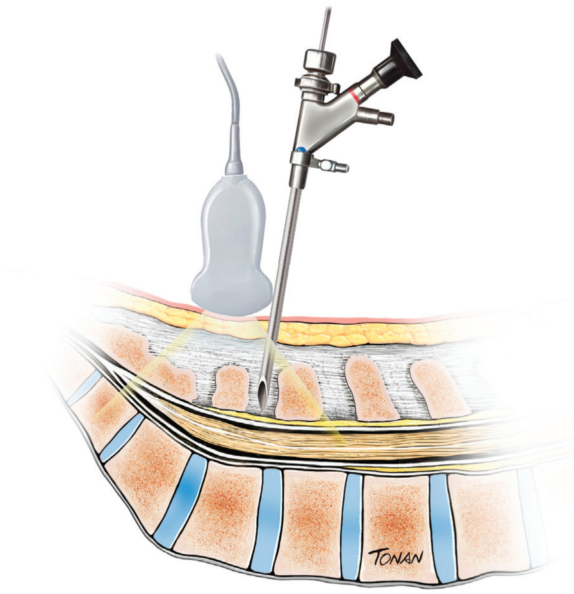

Fig. 10 Ultrasound Guided lumbar interlaminar in plane endoscopic approach.

Ultrasonography has been used either as a complement or a replacement to the use of radioscopy for surgical procedures in several areas. To visualize the lumbosacral spine sonoanatomy, a low frequency (2–5MHz) curvilinear ultrasound probe is used, as the adult lumbar spine's neuraxial structures are situated in a depth of 5 to 7 cm.[19] In the spine, ultrasound allows medical professionals to perform percutaneous procedures such as facet and foraminal infiltrations, enabling the visualization of spinal structures to reduce the use of intraoperative radioscopy with favorable results.[20] While radioscopy-guided procedures are based in the extrapolation of the position of soft tissues, such as muscles, blood vessels, and nerves, based on their anatomical relationship to the bone structures visualized, the ultrasonography makes it possible to visualize bones, muscle layers, nerves, and blood vessels directly, while also eliminating, or at the very least reducing, radiation exposure for both patients and healthcare professionals. Moreover, this method enables the visualization in real time of the needle's insertion, facilitating the use of instruments during the procedures.[21]

This is the first publication in the literature describing the step by step use of ultrasound to guide the in-plane, interlaminar, lumbar endoscopic approach (►**Fig. 10**). The technique is feasible and viable, minimizing the risks of exposure to radiation for the patient and surgical team, as well as making it possible to visualize bone and ligament structures.

Conclusions

The in-plane, interlaminar, endoscopic approach can be successfully performed under ultrasound guidance. Herein, we describe the step by step process to an unprecedented technique of the ultrasound-guided, in-plane, interlaminar, lumbar approach for endoscopic spine surgeries, with a smartphone-adapted endoscope and portable light source. This technique has the potential to minimize the exposure of patients and health care professionals to radiation while using fluoroscopy.

Declaration of Authors' Contribution

Each author contributed individually and significantly to the development of this article entitled "Ultrasound Guided Lumbar Interlaminar In-Plane Endoscopic Approach with Smartphone-Adapted Endoscope and Portable Light Source: Description of a New Surgical Technique." Castro JPS: writing and performing the dissection; Brock RS: data analysis and performing the dissection; Teixeira MJ: review of the article; Figueiredo EG: review of the article and intellectual concept of the article.

Conflict of Interests

The authors have no conflict of interests to declare.

Acknowledgment

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