Case Report
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OBLIQUE BIPLANAR APPROACH GUIDED BY BONE LANDMARKS: AN ALTERNATIVE TO LUMBAR DISC PUNCTURE IN TRANSFORAMINAL ENDOSCOPIC SURGERY

ACESSO BIPLANAR OBLÍQUO GUIADO POR REFERÊNCIAS ÓSSEAS: UMA ALTERNATIVA PARA PUNÇÃO DISCAL LOMBAR NA CIRURGIA ENDOSCÓPICA TRANSFORAMINAL

ABORDAJE BIPLANAR OBLICUO GUIADO POR REFERENCIAS ÓSEAS: UNA ALTERNATIVA A LA PUNCIÓN DISCAL LUMBAR EN CIRUGÍA ENDOSCÓPICA TRANSFORAMINAL

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ABSTRACT

Minimally invasive endoscopic surgery of the lumbar spine has transformed the way degenerative disorders of this segment are understood and treated. However, the technological advances associated with this modality have required surgeons to face a new and challenging learning curve. Among the technical aspects, the transforaminal endoscopic lumbar access has stood out due to the complexity of disc puncture, a critical step for procedural success. During training, this phase has represented one of the main barriers to skill acquisition, and the accumulation of unsuccessful attempts has been a determining factor for withdrawal among many surgeons. In this context, an alternative technique based on osseous landmarks was proposed, using an oblique biplanar access, aiming to improve positional safety during disc puncture and to provide greater predictability for surgeons in the early stages of training in this approach. ***Level of Evidence IV; Technique Description and Case Report.***

Keywords: Spine; Diskectomy; Endoscopic Surgical Procedures; Surgical Procedures, Minimally Invasive.

RESUMO

A cirurgia endoscópica minimamente invasiva da coluna lombar tem revolucionado a forma como compreendemos e abordamos a evolução das doenças degenerativas desse segmento. No entanto, os avanços tecnológicos associados a essa modalidade exigem dos cirurgiões uma nova e desafiadora curva de aprendizado. Dentre os diversos aspectos técnicos, o acesso endoscópico lombar transforaminal destaca-se pela complexidade da punção discal, etapa crítica para o sucesso da abordagem. Durante o processo de capacitação, essa fase costuma representar um dos maiores obstáculos na aquisição de habilidades, sendo o acúmulo de insucessos um fator determinante para a desistência de muitos profissionais. Diante desse cenário, propomos uma técnica alternativa baseada em referências ósseas (landmarks), utilizando um acesso biplanar oblíquo, com o objetivo de aprimorar a segurança posicional durante a punção discal e oferecer maior previsibilidade aos cirurgiões em fase inicial de treinamento nessa abordagem. ***Nível de Evidência IV; Descrição de Técnica e Relato de Caso.***

Descritores: *Coluna Vertebral; Discectomia; Procedimentos Cirúrgicos Endoscópicos; Procedimentos Cirúrgicos Minimamente Invasivos.*

RESUMEN

La cirugía endoscópica lumbar mínimamente invasiva ha revolucionado la forma en que entendemos y abordamos la progresión de las enfermedades degenerativas en este segmento. Sin embargo, los avances tecnológicos asociados a esta modalidad exigen a los cirujanos una nueva y desafiante curva de aprendizaje. Entre los diversos aspectos técnicos, el acceso endoscópico lumbar transforaminal destaca por la complejidad de la punción discal, un paso crucial para el éxito del abordaje. Durante el proceso de formación, esta fase suele representar uno de los mayores obstáculos para la adquisición de habilidades, siendo la acumulación de fracasos un factor determinante para el abandono de muchos profesionales. Ante esta situación, proponemos una técnica alternativa basada en referencias óseas, utilizando un abordaje biplanar oblicuo, con el objetivo de mejorar la seguridad posicional durante la punción discal y ofrecer mayor previsibilidad a los cirujanos en la fase inicial de formación en este abordaje. ***Nivel de Evidencia IV; Descripción de Técnica y Caso Clínico.***

Descriptores: *Columna Vertebral; Discectomía; Procedimientos Quirúrgicos Endoscópicos; Procedimientos Quirúrgicos Mínimamente Invasivos.*

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INTRODUCTION

In recent years, minimally invasive endoscopic lumbar spine surgery has promoted a paradigm shift in the management of degenerative disorders of the vertebral segment. The combination of technical versatility, continuous technological development, and progressive optimization of the surgeons' learning curve has created a favorable environment for the application of this modality across a broad spectrum of pathologies. Growing evidence has indicated that clinical outcomes are comparable and, in many cases, superior to those of conventional techniques, with the additional advantages of reduced tissue trauma, shorter recovery time, and lower postoperative morbidity.[1,2,3]

In general, lumbar endoscopic access can be classified into two main approaches: posterior (interlaminar) and posterolateral (transforaminal). In the transforaminal technique, puncture of the target disc region represents a critical step for proper execution of the procedure. During the learning curve, this phase has been recognized as one of the most challenging aspects of skill acquisition, and the high number of unsuccessful attempts has been a determining factor for withdrawal among many surgeons in training. This difficulty becomes even more pronounced in the presence of significant anatomical alterations, such as those observed in advanced degenerative disease, which may distort conventional landmarks and compromise puncture accuracy.[4,5,6]

Given the well-recognized challenges of lumbar transforaminal puncture, particularly among spine surgeons in the early stages of the learning curve, we proposed an alternative technique based on osseous landmarks, termed the oblique biplanar approach. This method aimed to improve accuracy and positional safety throughout disc puncture, minimizing risks and increasing procedural predictability. The technique is illustrated through a clinical case to demonstrate its practical applicability and potential benefit in the training of surgeons in minimally invasive endoscopic procedures.

CASE REPORT

This study was approved by the Institutional Review Board of Hospital Samaritano (protocol 3540420.5.0000.5487). A 36-year-old male patient, height 1.63 m and weighing 83 kg, was evaluated. Following a prolonged sedentary lifestyle, worsened by the social isolation imposed during the COVID-19 pandemic, the patient gained approximately 15 kg, with predominant fat accumulation in the lumbar, gluteal, and femoral regions.

Since late 2022, the patient had experienced right-sided sciatica with a remitting–recurrent pattern, triggered by physical exertion. After eight weeks of symptom progression, pain radiated predominantly along the dermatomal distribution of the L5 nerve root, with no motor deficits observed on physical examination.

Radiological investigation ruled out evident segmental instability and demonstrated a right paracentral disc herniation at L4–L5, without migration, causing narrowing of the ipsilateral lateral recess and compression of the descending L5 root. Electroneuromyography showed findings consistent with mild irritative L5 radiculopathy, corroborating the clinical presentation.

An initial conservative strategy was adopted for four weeks, including relative rest, physical therapy, optimized analgesia, and neuropathic pain medication, without satisfactory clinical improvement. A subsequent lumbar foraminal analgesic block was performed on the right side at L3–L4, L4–L5, and L5–S1, resulting in short-term symptom relief lasting less than four weeks.

Considering the clinical scenario and imaging findings, the mechanical component of nerve root compression within the right lateral recess at L4–L5 was considered a major contributor to symptom generation. Therefore, transforaminal endoscopic lumbar discectomy at L4–L5 combined with foraminoplasty was indicated.

The procedure was performed under general anesthesia, with the patient in the prone position, a pelvic bolster in place, and a radiolucent surgical table adjusted to allow slight hip flexion and reduction of lumbar lordosis, thereby facilitating surgical access and adequate endoscopic visualization.

Transforaminal Puncture Technique Description

The disc puncture technique employed was referred to as oblique biplanar approach. Fluoroscopy was initially used in the neutral position, enabling alignment of the spinous processes with the medial interpedicular distance. The C-arm was then adjusted to the coronal and oblique planes until complete visualization of the safe working zone for disc access, as described by Kambin[1,2], was achieved.

In the coronal plane, a cranial–caudal adjustment was performed until precise alignment of the superior endplate of the L5 vertebra was obtained, ensuring an adequate anatomical reference for the transforaminal route. In the oblique plane, ipsilateral lateral rotation of up to 30° was performed, which corresponds to the maximum angulation of most image intensifiers available in the operating room. With this positioning, full exposure of the boundaries of Kambin's triangle was achieved, providing safe access to the disc working zone (Figure 1).[1,2]

While fluoroscopy was still being adjusted in the coronal plane, the limits of the cutaneous projection of the vertebral body immediately superior to the target segment were used as references to accurately define the skin entry point. This definition was established through the bicortical measurement of the middle third of the vertebral body (Figure 2), strategically selected because it represents an anatomical region that remains relatively stable over time, even in the presence of degenerative disc-osteophyte changes or age-related modifications. This anatomical stability provided greater predictability and safety for planning the puncture trajectory.

After defining the distance reference to be used, fluoroscopy was adjusted to the oblique plane with ipsilateral lateral rotation

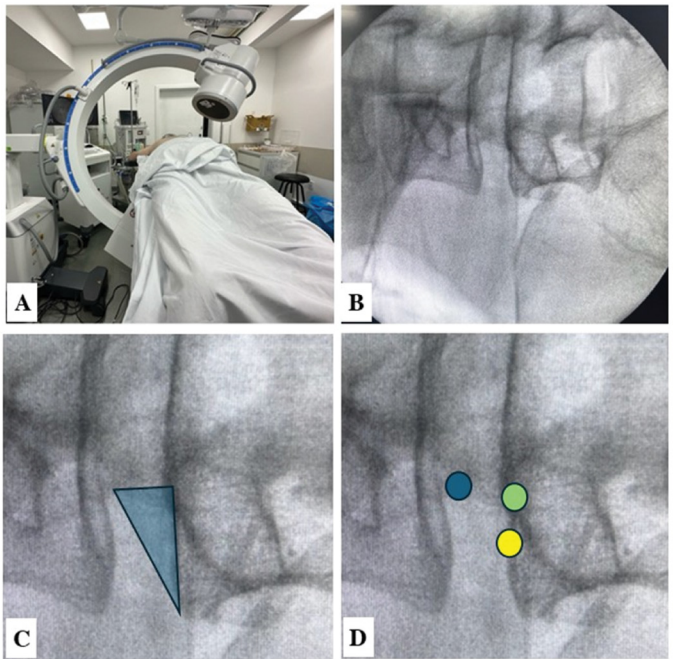

Figure 1. With fluoroscopy properly adjusted in the coronal plane through cranial displacement and in the oblique plane with 30° ipsilateral lateral rotation relative to the surgical access (A), optimal visualization of the osseous structures of the disc portion of the right L4–L5 intervertebral foramen was achieved, without bony overlap (B). This angulation allowed precise delimitation of the safe zone for disc access, clearly demonstrating Kambin's triangle, whose boundaries were defined by the ventral border of the superior articular process of L5 and the superior endplate of the L5 vertebra (C). In this position, the main osseous landmarks for anchoring the disc puncture needle were clearly identified: the superior limit of the L5 superior articular process (blue point), the inferior limit of its ventral border at the pedicular junction (green point), and the superior vertebral notch of L5 (yellow point) (D).

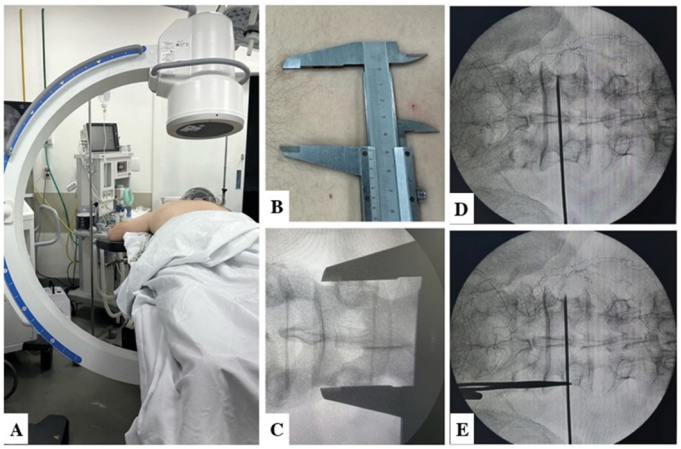

Figure 2. With fluoroscopy properly adjusted in the coronal plane, precise alignment of the superior endplate of the L5 vertebra was achieved (A), establishing a reliable anatomical reference for access planning. Subsequently, measurement of the cutaneous projection of the middle third of the lumbar vertebra immediately superior to the target level became essential for defining the skin entry point (B, C). In practice, the disc puncture needle itself was positioned over the patient's skin, exactly at the previously determined area of interest (D). Using a grasping instrument, the bicortical distance of the middle third of the vertebral body of the superior vertebra was then measured (E).

toward the side of access. At this stage, the tip of the disc puncture needle was positioned on the patient's skin exactly over the desired anchoring target: the superior vertebral notch, close to the medial border of the pedicle (TV point) (Figure 3).With this anchoring point maintained, the previously obtained measurement was used to determine the skin entry point, preferably located below the line corresponding to the inferior endplate of the superior vertebra, while respecting the limits of the neural portion of the foramen. The anatomical constraints imposed by the iliac crest were also considered to define the cutaneous access point (P point), thereby ensuring a safe and effective trajectory for the transforaminal approach (Figure 3)

The disc puncture needle was introduced toward the previously selected anchoring point under real-time biplanar oblique fluoroscopic guidance, allowing continuous monitoring of the trajectory until bone contact was achieved. Upon reaching the superior vertebral notch of L5 on the right, preferably near the medial border of the pedicle, fluoroscopy was repositioned to obtain standard anteroposterior (AP) and lateral views in order to confirm proper needle placement (Figure 4).

In the present case, the skin entry point was located approximately 11 cm from the midline (Figure 3D). This value could vary according to patient body habitus, and such adjustment was essential to ensure safety and accuracy of the transforaminal access.

After positional confirmation, the conventional transforaminal endoscopic steps were initiated. The initial approach consisted of performing a foraminoplasty, with drilling of the ventral border of the superior articular process of L5 until direct visualization of the medial border of the L5 pedicle was achieved. From this anatomical landmark, flavectomy was performed, followed by discectomy. At the end of the procedure, the lateral recess was completely free, the descending L5 nerve root was widely exposed, and the limits of the neural portion of the L4 foramen were fully decompressed.

In the immediate postoperative period, the patient reported significant relief of the previously described sciatic pain. The patient was discharged within 24 hours, without the need for analgesic medication, and demonstrated improvement in limb range of motion. During outpatient follow-up at 30, 60, 90, and 120 days, the patient remained asymptomatic, adhering strictly to the physical rehabilitation protocol and the weight reduction plan. Given the absence of symptoms and the satisfactory recovery, follow-up imaging was not performed.

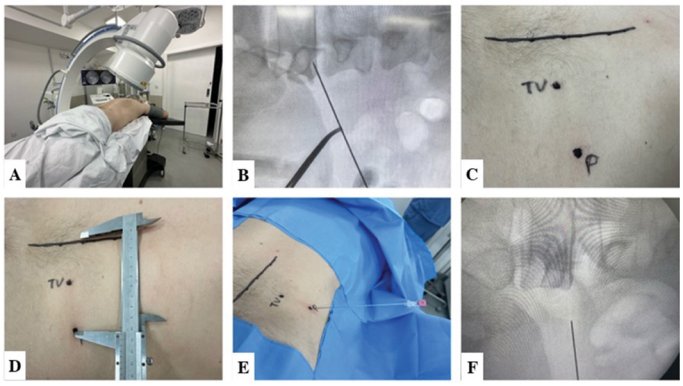

Figure 3. With fluoroscopy properly adjusted in the coronal plane through cranial displacement, and in the axial plane with 30° ipsilateral lateral rotation toward the side of access (A), an optimal view for puncture trajectory planning was obtained. The fluoroscopic image demonstrated the tip of the disc puncture needle positioned over the patient's skin precisely at the intended anchoring target: the superior vertebral notch near the medial border of the pedicle (TV point) (B). Cutaneous marking of the projection of the anchoring point (TV) and of the skin entry point (P) was then accurately performed (C). The mean distance from point P to the midline was approximately 11 cm, although it could vary according to the patient's body habitus (D). The puncture needle was subsequently introduced at point P, following the previously planned trajectory (E). A subsequent fluoroscopic image confirmed alignment between the skin entry point (P) and the anatomical limits of the anchoring point (TV), ensuring safe and effective access to the disc space (F).

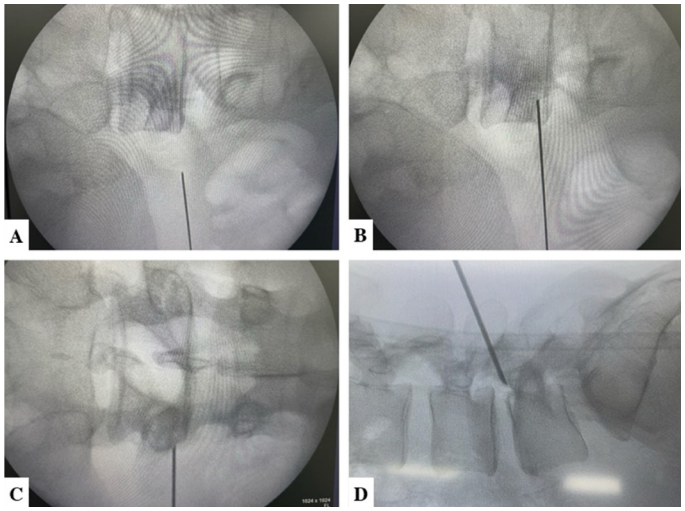

Figure 4. The fluoroscopic image illustrated the skin entry point P and the anatomical limits of the transforaminal anchoring point (TV) (A). The puncture was guided by real-time biplanar oblique fluoroscopy, allowing precise monitoring of the needle trajectory until contact with the intended bony landmark was achieved, in this case the superior vertebral notch of L5, near the medial border of the right pedicle (B). Positional confirmation was obtained through anteroposterior (C) and lateral (D) projections, with the C-arm appropriately repositioned to ensure access accuracy.

DISCUSSION

Classical techniques for planning and marking the skin entry point for disc puncture have traditionally relied on single radiographic planes, either axial or coronal, used in isolation under conventional fluoroscopy.[4-7] Although historically consolidated, this approach did not allow dynamic monitoring of the puncture phases until the predefined anatomical target was reached. For highly experienced spine surgeons, this limitation could be partially compensated by familiarity with anatomical landmarks. However, for most surgeons in the early stages of the learning curve, this technical restriction impaired spatial perception of

the trajectory, making accurate assessment of depth and orientation more difficult. Consequently, the risk of inadvertent injury to adjacent structures increased, and the safety boundaries for lumbar disc access, as described in Kambin's studies, were not clearly visualized.[1,2,4]

During standard anteroposterior fluoroscopic acquisition, superimposition of bony structures, particularly the facet complex, reduced clarity in identifying the anchoring point for puncture. Moreover, the absence of three-dimensional depth perception could result in unsafe trajectories, with a higher likelihood of damage to critical structures when a well-defined bony endpoint was lacking. Conversely, in true lateral views, although visualization of the intervertebral foramen improved, depth perception remained limited. Without a bony barrier along the needle path, there was a considerable risk of injury to ipsilateral neural elements, intraspinal structures, and, depending on insertion depth, even contralateral components. These aspects reinforced the importance of real-time biplanar fluoroscopy, particularly during the learning curve, to enhance safety and precision in transforaminal lumbar access.

Historically, several anchoring points have been proposed for safe access to the discal portion of the lumbar vertebral foramen[8]. Nevertheless, the puncture phase has consistently posed challenges related to accurate needle positioning, mainly because fluoroscopic images were obtained in simple, isolated planes. This uniplanar approach compromised spatial accuracy, hindered three-dimensional identification of the ideal trajectory, and increased the likelihood of technical deviation during intervertebral disc access.

In general, these anchoring strategies could be divided into two broad categories: those with a final endpoint in soft tissues and those with a final endpoint in bony structures.

In the group using soft-tissue endpoints, access to the intervertebral disc could be achieved through different anatomical corridors, whether lateral to the foramen[9], at the foraminal leve[10] or medially near its inner margin[11]. Each approach presented specific technical nuances and risks, requiring careful anatomical evaluation and procedural expertise to ensure safety and effectiveness in transforaminal access.[11]

When the final endpoint involved bony structures, their rigidity provided an important tactile and visual reference, acting as a natural limit against inadvertent advancement of the puncture needle. This feature tended to enhance procedural safety, particularly in image-guided percutaneous techniques. Several studies have highlighted specific osseous anchoring points as reliable references:

- The superior vertebral notch has been described as a reliable point for transforaminal access.[12]
- The distal extremity of the superior articular process of the inferior vertebra has also been recognized as a safe anatomical landmark for puncture.[4]
- The lateral and superior border of the pedicle of the inferior vertebra, particularly in extraforaminal approaches, has represented another anchoring point with demonstrated safety.[13]
- The inferior limit of the ventral border of the superior articular process of the inferior vertebra, at the level of the pedicular junction, has been emphasized as facilitating not only access but also the performance of foraminoplasty.[8]

These osseous landmarks not only increased procedural safety but also contributed to the standardization of access techniques, reducing risks and optimizing clinical outcomes.

The superior vertebral notch near the medial pedicular border was selected as the primary bony anchoring point because it provided circumferential osseous support around the needle tip and represented the location most distant from the neural portion of the foramen and, consequently, from the exiting nerve root at that level.

In a series of 100 patients with L5–S1 disc herniation associated with a high iliac crest, transforaminal endoscopic discectomy was performed by three spine surgeons, each with experience exceeding 500 cases using this technique. In the first 50 cases, the conventional disc puncture method was applied. Among these, access to the intervertebral disc could not be achieved in 8 patients (16%), even after 20 consecutive attempts, characterizing access failure. In contrast, in the subsequent 50 cases, biplanar oblique fluoroscopic guidance was used. In this cohort, puncture was successful in 100% of patients. Moreover, the 8 cases initially classified as failures with the conventional technique were subsequently revisited using the biplanar oblique approach, achieving success in all instances.[14]

These findings supported the superiority of the biplanar oblique fluoroscopic technique in anatomically unfavorable scenarios, such as the presence of a high iliac crest, particularly at L5–S1, where traditional transforaminal access may become especially challenging. The spatial accuracy provided by biplanar fluoroscopy appeared to be a determining factor for successful disc puncture in these cases, contributing to procedural safety and effectiveness.

The biplanar oblique fluoroscopic view of the lumbar segment allowed precise identification of crucial osseous references, even in the presence of anatomical distortion. This enhanced visualization improved depth perception and enabled safe delineation of the transforaminal trajectory. C-arm positioning was individualized, initially aiming to expose the optimal working window. This strategy permitted detailed observation of the bony boundaries forming the Kambin triangle and significantly reduced the risk of adverse events during puncture, including among less experienced operators.

The cutaneous projection of the lumbar vertebra obtained through fluoroscopy, used to measure the bicortical distance and define the skin entry point, was influenced exclusively by patient body habitus. These variables affected the linear distance between the true anatomical landmark and its skin projection. Consequently, patients with smaller body frames and lower adiposity tended to present entry points closer to the midline compared with individuals with larger body habitus and greater fat distribution. Conversely, variations in C-arm height relative to the surgical site did not modify real anatomical distances, altering only global image magnification without affecting marking accuracy.

CONCLUSION

The proposed alternative puncture strategy was primarily intended for spine surgeons in the early phase of the learning curve of transforaminal endoscopic access, as well as for those who may have discontinued the technique because of difficulties during disc puncture. This approach may serve as an adjunct for skill acquisition for two main reasons: (1) it allowed precise visualization of the needle anchoring point, which may vary according to the pathology being treated, without interference from osseous overlap on imaging; and (2) it enabled continuous and controlled monitoring of the entire insertion process through real-time fluoroscopic acquisition, thereby providing greater procedural control and operator confidence.

Further investigations are warranted to confirm the effectiveness and safety of the proposed technique.

CONFLICT OF INTEREST

All authors declare no potential conflict of interest related to this article.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and substantially to the development of this manuscript. DCP, RRA, CC: investigation, original draft preparation. RRA, CC, MBSB, RSV, SEL, JPMB: formal analysis, data curation. ETU, SEL, JPMB: writing – review and editing.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

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