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True lateral imaging during lumbar medial branch radiofrequency neurotomy: Interobserver reliability

Patrick H. Waring [a,*], Isaac Cohen [b], Timothy P. Maus [c], Belinda Duszynski [d], Michael B. Furman [e,f]

[a] Pain Intervention Center, Metairie, LA, USA
[b] Connecticut Orthopaedics, Trumbull, CT, USA
[c] Department of Radiology, Mayo Clinic, Rochester, MN, USA
[d] International Pain and Spine Intervention Society, Hinsdale, IL, USA
[e] OSS Health, York, PA, USA
[f] Lewis Katz School of Medicine at Temple University, Philadelphia, PA, USA

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ABSTRACT

Background: True lateral imaging (TLI), obtained by superimposing bilateral lumbar spine structures and aligning superior endplate cortical bone, requires deliberate rotational adjustments of the laterally positioned fluoroscope in both the axial and longitudinal planes. True lateral segmental imaging is necessary to depict true and accurate radiofrequency (RF) cannula positioning relative to bony anatomy during lumbar medial branch radiofrequency neurotomy (LMBRFN).

Objective: To determine the interobserver reliability of TLI during LMBRFN.

Methods: This was a retrospective review of a prospectively generated collection of lateral fluoroscopic images to determine the interobserver reliability of TLI during LMBRFN. Lateral fluoroscopic images were prospectively collected from 34 consecutive L4-5 and L5-S1 LMBRFN procedures during routine clinical practice. Employing International Pain and Spine Intervention Society (IPSIS) LMBRFN and TLI techniques, an RF cannula was positioned parallel to the L3 and L4 medial branches and the L5 dorsal rami. During the normal course of TLI, untrue and final true lateral segmental images were obtained and saved. An original data set of 100 pairs of true and untrue lateral images was reviewed to verify true laterality using established criteria; disagreement was resolved by consensus or discarding ambiguous cases. To measure interobserver reliability (Cohen's Kappa), two blinded expert reviewers independently reviewed the image set, identifying the true lateral image and the plane requiring correction.

Results: The observers agreed upon 98/98 true lateral RF-segment images (Kappa score 1.0 [1.00,1.00]). The observers agreed upon 86/98 maneuvers to correct the untrue RF-segment image. The Kappa score for determining the most appropriate corrective maneuver was 0.76 (0.63,0.89), showing substantial interobserver agreement.

Conclusions: The true lateral image of the targeted RF segment during LMBRFN was reliably determined with perfect interobserver agreement. Interobserver agreement was substantial regarding the maneuver to achieve TLI.

1. Introduction

When performed correctly in carefully selected patients, lumbar medial branch radiofrequency neurotomy (LMBRFN) has been shown to provide durable and effective relief of low back pain [1–3]. For LMBRFN, the primary technical consideration involves positioning the cannula's active tip parallel and adjacent to the targeted medial branches or L5 dorsal rami (DR) [1–3]. The radiofrequency (RF) thermal energy generated around the active tip coagulates a football-shaped volume of tissue through which the targeted nerve travels [4–6]. A true lateral imaging (TLI) technique has been proposed to achieve and document proper RF cannula position [7] (Figs. 1 and 2). TLI is

* Corresponding author. Pain Intervention Center, 701 Metairie Road, Metairie, LA, 70005, USA.
E-mail address: pwaring@TPICnola.com (P.H. Waring).

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accomplished by superimposing specific bilateral segmental spine structures and aligning the cortical bone of the superior vertebral endplate. The technique requires deliberate oblique (axial plane) and/or wig-wag (longitudinal plane) rotational adjustments of the laterally positioned fluoroscope [7]. Given the typical lordotic curvature and possible scoliosis, TLI must be achieved independently for each segment [8]. Just as TLI produces a *true* segmental image, failing to superimpose or align the same specific structures would necessarily result in an *untrue* image. The objective of this study was to determine the interobserver reliability of TLI during LMBRFN; these data were previously presented at the 2023 International Pain and Spine Intervention Society (IPSIS) Annual Meeting [9].

2. Methods

2.1. Study design

This was a retrospective review of a prospectively generated collection of lateral fluoroscopic images obtained to determine the interobserver reliability of TLI during LMBRFN. Images were obtained during routine clinical practice and comprised 34 consecutive L4-5 and L5-S1 LMBRFN procedures performed by the primary author (PW) at his solo private practice between December 2022 and February 2023. The study received an IRB exemption from WIRB-Copernicus Group (WCG® IRB), formerly Western IRB®.

2.2. Collecting the images during routine clinical practice

During routine clinical practice, images were collected from consecutive patients who underwent L4-5 and L5-S1 LMBRFN procedures. All patients signed informed consent before their procedures. Consistent with IPSIS LMBRFN and TLI techniques [7,10], an RF cannula was positioned alongside the L3 and L4 medial branches and the L5 dorsal rami. True lateral views were constructed by initially adjusting oblique (axial plane) fluoroscopic rotation to superimpose both pelvic lines and both S1 superior articular processes (SAPs) for LMBRFN at the L5 level and both SAPs at more cephalad levels [7,10]. Wig-wag (longitudinal plane) fluoroscopic rotation was then employed to superimpose the index level's superior and inferior pedicle margins and align the superior vertebral endplate parallel to the X-ray beam [7,10]. During the TLI process, initial untrue and final true lateral images were saved. For each segment, saved images were subsequently analyzed, and an untrue image was paired with the final true image to create 100 comparator slides. During slide production, the intent was to create untrue lateral images requiring only a single plane of correction. However, in a few circumstances, there was a non-superimposition of bilateral structures in both planes, but only one plane of error was dominant.

2.3. Building the testing slide set

The primary author (PW) and an experienced neuroradiologist (TM) conducted an independent review to establish the answer key for the testing slide set. All images were de-identified. Based on the above criteria, they identified the true lateral image and the fluoroscopic maneuver required to correct the untrue image. Any disagreements were resolved by consensus; if consensus could not be reached, the image pair was removed from the slide set. Two out of one hundred image pairs were considered ambiguous regarding the selection of the true segmental lateral image or corrective maneuver and were discarded due to extensive degenerative change in one case and alterations from perfect alignment in both planes in another. In two instances, disagreement on the primary plane requiring correction was resolved by consensus. The final verified slide set comprised 98 image pairs displayed in Google Slides.

During slide set creation, the perceived true image was alternated with the perceived untrue image (right to left) on each subsequent slide before randomization to prevent the observer from guessing that the first image on a slide was likely the true image or vice versa. The proportion of axial to longitudinal rotational corrective maneuvers created by the primary author was nearly equal. A 10-image pair teaching slide set was also produced (Figs. 3 and 4).

2.4. Interobserver data collection

After a brief (half-hour) video conference with the primary author using the teaching slide set, two blinded experts (IC, MF) independently reviewed the randomized and de-identified testing slide set. Each observer was asked first to determine which RF-segment image represented the true lateral image and then which maneuver [oblique (axial plane) or wig-wag (longitudinal plane) rotation] should be used to make the untrue image more closely approximate the true image. Observer selections were captured using Google Forms.

2.5. Statistical analysis

First, a simple tally was taken to determine the number of times the observers agreed or disagreed on the true lateral image. Next, a separate tally was taken to determine the number of times the observers agreed or

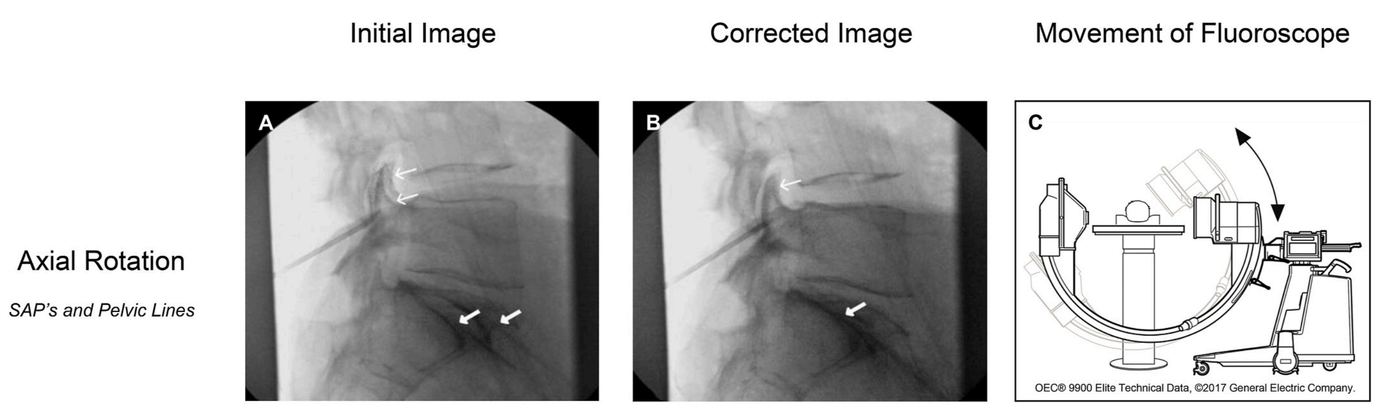

Fig. 1. TLI technique depicting oblique (axial plane) fluoroscopic rotation during LMBRFN [From Waring PH. "True" lateral imaging for lumbar radiofrequency medial branch neurotomy. Pain Med 2020; 21: 424–425. Published by Oxford University Press on behalf of the American Academy of Pain Medicine. Open Access article - Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/)]
A. Thin arrows indicate the non-superimposed anterior aspects of the L5 superior articular processes, and thick arrows indicate the non-superimposed pelvic lines. B. After oblique (axial plane) rotation, the thin arrow indicates the superimposed anterior aspects of the L5 SAPs, and the thick arrow indicates the superimposed pelvic lines. C. Oblique (axial plane) fluoroscopic rotation aids in superimposing the structures described in (A) and (B).

disagreed on the fluoroscopic maneuver to make the untrue image true. The data were reviewed and underwent Cohen's Kappa (1.0, perfect) interobserver analysis [11].

3. Results

The observers agreed upon 98/98 true lateral RF-segment images (Table 1). The Kappa score for determining the true image was 1.0 (1.00,1.00), or perfect interobserver agreement [11]. The observers also agreed upon 86/98 maneuvers to correct the untrue RF-segment image (Table 2). The Kappa score for determining the corrective maneuver was 0.76 (0.63,0.89), showing substantial interobserver agreement [11].

In assessing the true lateral image, the observers agreed with the established consensus (PW, TM) in all cases (100 %). Regarding the plane requiring correction, one observer agreed with the established consensus in 97 % of cases and the other 91 %. Among the 12 instances of observer disagreement regarding the plane of correction, one observer agreed with the established consensus on 9/12 decisions and the other observer on 3/12.

4. Discussion

While cervical TLI has been described [12], no literature regarding true lateral segmental imaging in the lumbar spine exists other than that cited in the current study [7,8]. The safety and efficacy of LMBRFN depend on the physician's ability to place the RF cannula parallel to and in contact with the medial branch while avoiding nearby vulnerable structures. Cannula placement is made challenging by the curved cortical surfaces along which the medial branch courses and the use of a planar guidance modality, fluoroscopy. The physician can only accurately localize the cannula in three-dimensional space by two-dimensional observation in multiple planes, most critically orthogonal AP and lateral views. Obtaining a true lateral view at the intervention segment requires adherence to specific criteria and is challenged by the significant overlap of bony structures and the greater tissue penetration required.

This study indicates that experienced practitioners can identify a true lateral segmental view meeting those criteria with perfect agreement. There was lesser, although substantial, agreement in the maneuver required to correct an untrue view, with considerable variation between the observers in their agreement with the established consensus. The less-than-perfect agreement regarding the corrective maneuver may reflect varying rigor and experience in systematically applying the criteria or qualitative judgments regarding which plane most needed correction.

As advocated here, a standardized approach to obtaining TLI may improve intraprocedural decision-making, reduce fluoroscopy time, and ultimately improve outcomes. The wide variability in reported LMBRFN outcomes likely reflects variability in patient selection, targeting, and physician rigor in cannula placement [3]. TLI, in combination with true AP imaging and ancillary oblique and declined views, is essential to proper cannula placement. Failure to achieve true segmental imaging may cause a properly placed cannula to appear improperly placed or an improperly placed cannula to appear properly placed [8]. Correctly performed LMBRFN provides low back pain relief that lasts many months until the nerves regenerate and the patient's typical pain returns [1–3,13]. Using TLI during repeated LMBRFN provides the same technical precision and the expectation of the same degree and duration of pain relief [1–3,8].

The TLI principles described here also apply to other fluoroscopically-guided interventional pain procedures; the verified data set used for testing in this study may be helpful in training pain and spine interventionalists.

4.1. Strengths/limitations

The study's strengths include the inclusion of consecutive RFN procedures, verification of the dataset by two physicians reaching consensus, and the blinded, randomized process applied to the tested observers. Its shortcomings include the small sample size and the use of only expert instructors. Further study could involve evaluating practitioners of varying experience levels. Another limitation of this study relates to the TLI technique itself. To establish TLI, two structures were used for axial plane fluoroscopic adjustments, and two different structures were used for longitudinal plane adjustments. Different bony elements, such as the posterior vertebral body (at levels above L5) or the entire superior articular process, might enhance segmental TLI. Nevertheless, a TLI technique utilizing different spine elements has yet to be described.

5. Conclusion

Experienced observers reliably identified true lateral segmental imaging during LMBRFN. There was also substantial agreement in the mechanism to correct untrue lateral views. This preliminary study supports the only described TLI technique for establishing accurate cannula placement before thermal coagulation during LMBRFN. Future studies could assess the ability of observers with varying levels of experience to recognize true lateral segmental imaging during LMBRFN, which may identify a need for including and promoting the teaching of this technique in LMBRFN curriculum. The applicability of this TLI technique in the performance of other interventional lumbar spine

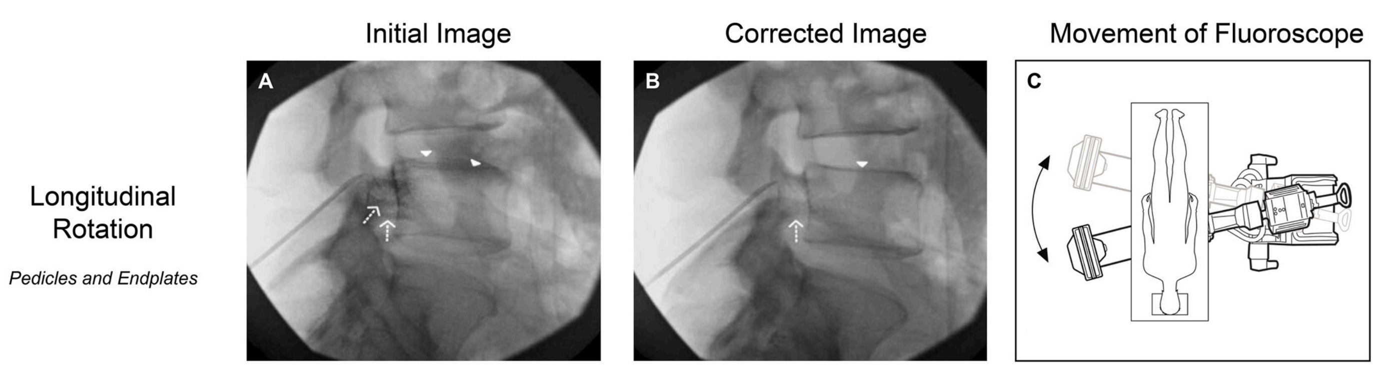

Fig. 2. TLI technique depicting wig-wag (longitudinal plane) fluoroscopic rotation during LMBRFN [From Waring PH. "True" lateral imaging for lumbar radiofrequency medial branch neurotomy. Pain Med 2020; 21: 424–425. Published by Oxford University Press on behalf of the American Academy of Pain Medicine. Open Access article - Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/)]
A. Dashed arrows indicate the non-superimposed inferior aspects of the L5 pedicles, and arrowheads indicate the non-aligned L5 superior endplate. B. After wig-wag (longitudinal plane) rotation, the dashed arrow indicates the superimposed inferior aspects of the L5 pedicles, and the arrowhead indicates the aligned L5 superior endplate. C. Wig-wag (longitudinal plane) fluoroscopic rotation aids in superimposing/aligning the structures described in (A) and (B).

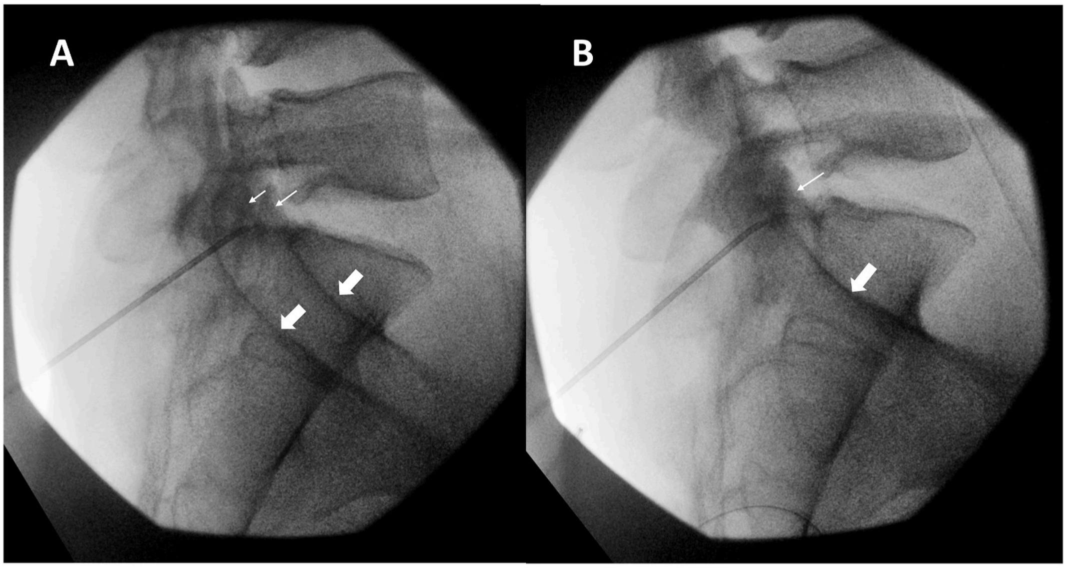

Fig. 3. Teaching set figure depicting untrue (A) and true (B) lateral images. Oblique (axial plane) fluoroscopic rotation is indicated to superimpose the non-superimposed SAPs (thin arrows) and pelvic lines (thick arrows) in (A) to achieve TLI with superimposed SAPs (single thin arrow) and pelvic lines (single thick arrow) in (B).

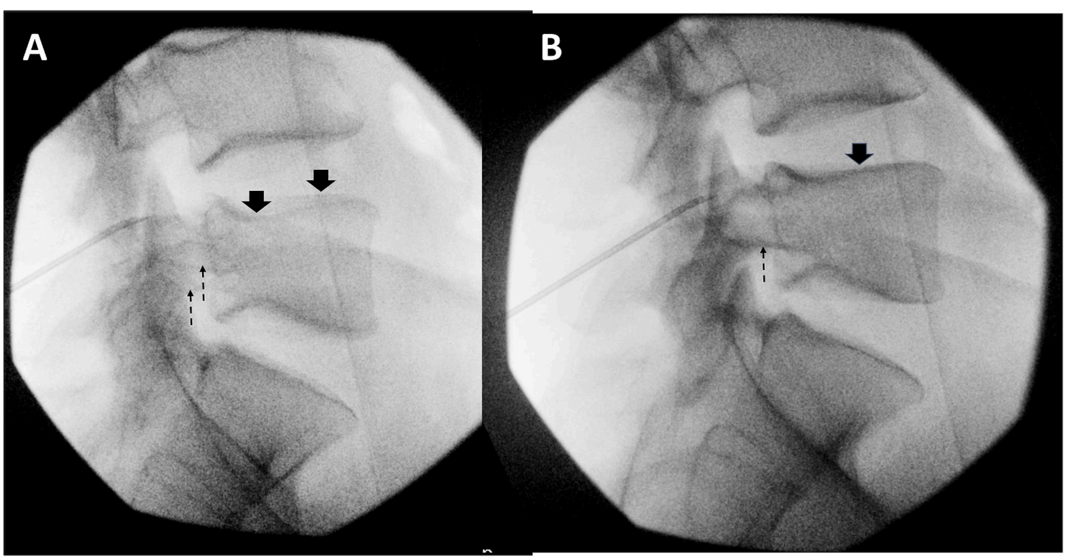

Fig. 4. Teaching set figure depicting untrue (A) and true (B) lateral images. Wig-wag (longitudinal plane) fluoroscopic rotation is indicated to superimpose the non-superimposed pedicles (dashed arrows) and align the non-aligned superior endplate (thick arrows) in (A) to achieve TLI with superimposed pedicles (single dashed arrow) and aligned endplate (single thick arrow) in (B).

Table 1
Interobserver reliability - true or untrue lateral image.

Observer 1 \ Observer 2	TRUE	UNTRUE
TRUE	49	0
UNTRUE	0	49

Table 2
Interobserver reliability - plane of corrective fluoroscopic maneuver.

Observer 1 \ Observer 2	AXIAL	LONGITUDINAL
AXIAL	40	5
LONGITUDINAL	7	46

procedures also merits investigation. Finally, future research should be conducted to report on the safety and efficacy of LMBRFN when this TLI technique is meticulously implemented.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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