

A Technical Improvement for Percutaneous Puncture of the Intervertebral disc by Passing Lateral to the Superior Articular Process Using the Isocenter Puncture Method

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Abstract

Purpose: Percutaneous intervertebral disc puncture is useful in various situations. The isocenter puncture method enables easy, accurate, and safe punctures under fluoroscopic guidance. Herein, we present a clinical application of this technique that improves upon percutaneous puncture of intervertebral discs.

Material and Methods: We performed percutaneous punctures of intervertebral discs slightly lateral to the superior articular process using the isocenter puncture method in 19 cases (10 men, 9 women; mean age, 64.5 years; range, 23-87 years). We assessed the technical success rate, procedure time, and complications.

Results: We achieved successful punctures in all cases, with a median puncture time of 14.5 min (mean, 18.7 ± 11.3 min; range, 8-49 min). No patients complained of complications that were permanent or required treatment.

Conclusions: Improved puncture of intervertebral discs seems to be possible using the isocenter puncture method.

Key words: pyogenic spondylodiscitis, intervertebral disc, isocenter puncture

(Interventional Radiology 2021; 6: 112-116)

Introduction

Percutaneous intervertebral disc puncture techniques are useful for discography, intradiscal electrothermal therapy, biopsy, drainage, and chemonucleolysis with chondrolyase [1-3].

In conventional disc puncture, the selected pathways for needle and applied methods depend on the operators' preferences. In some reports, the optimal path into the intervertebral disc is slightly lateral to the superior articular process (SAP) and is at a midpoint between endplates [1, 4]. Applying this pathway through the so-called "safe window," a needle can arrive at the disc, passing posterior to the nerve root and exiting from the neural foramen [4]. We believe that this method can be improved and can achieve more accurate fluoroscopic puncture. Takizawa et al. developed and

advocated a new puncture method termed "isocenter puncture" (ISOP) that enables easy, accurate, and safe puncture under fluoroscopic guidance [5]. Herein, we present a clinical application of this technique that improves upon the method for percutaneous puncture of intervertebral discs.

Material and Methods

This retrospective study was approved by the institutional review board at our institution. The need to obtain informed consent was waived based on the study's retrospective nature.

Patients

We performed percutaneous puncture of intervertebral discs slightly lateral to the SAP using the ISOP method for

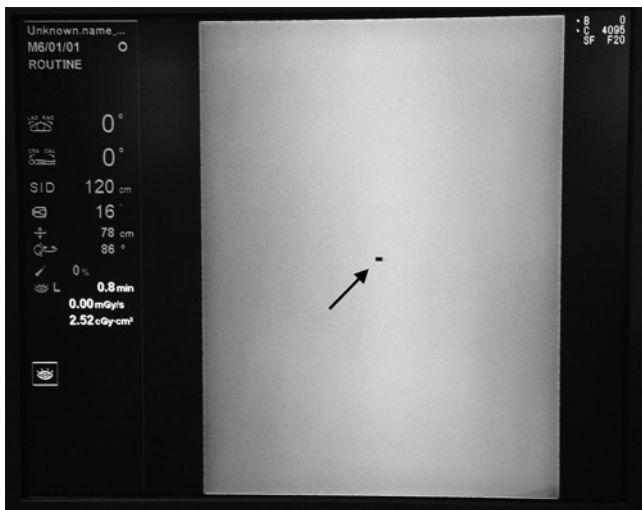


Figure 1. Isocenter marker.

A square, black marker displayed arbitrarily on the center of the monitor (arrow). This marker is only displayed on the monitor and is not reflected on the fluorogram.

19 patients (10 men, 9 women; mean age, 64.5 years; range, 23-87 years). The procedures were performed between January 2008 and April 2020. We placed an indwelling drainage catheter and achieved aspiration, biopsy, and chemonucleolysis with chondriase.

Puncture methods

Fluoroscopic apparatus

We performed the procedures using a fluoroscopic apparatus set (Infinix Celeve VC; Toshiba Medical [now Canon Medical Systems], Tochigi, Japan) set in the angiography suite. The apparatus has a flat-panel detector on a single plane C-arm, which can acquire CT-like images by performing fluorography during rotation of the C-arm. Moreover, the monitor can display a 12.8×10.2 -pixel square black isocenter marker (ICM) arbitrarily on the center (Fig. 1), as developed by Kobayashi et al. and Toshiba Medical (now Canon Medical Systems), showing the center of the radiation field [6].

Positioning

We placed all patients in the prone position for the procedures.

As the first step of ISOP, we rotated the C-arm to evaluate the lateral view of the spine. Then, we adjusted the bed's height and slide position to overlap the ICM with the target point of the disc (Fig. 2a).

Next, we rotated the C-arm to the anteroposterior position to be at the front of the patient's vertebral body, meaning that the distance from the spinous process to bilateral pedicles became symmetrical. Subsequently, we only slid the bed laterally to overlap the ICM with the target point (Fig. 2b). Note that it is important to slide the bed only laterally and not longitudinally during the second step.

When we finished the position adjustments, the ICM always overlapped the target point, no matter how the C-arm

was rotated, as long as the C-arm bed was not slid or moved vertically. Thus, the operators could easily reach the target point by puncturing the ICM tangentially.

Keeping the bed fixed, the C-arm was then rotated cephalad or caudad to align the vertebral endplates and subsequently rotated laterally to adjust the ICM to be slightly lateral to the SAP in the disc space (Fig. 2c).

Needle placement

After fixing the position, as described above, we injected local anesthesia hypodermically and made a small skin incision to facilitate the subsequent puncture. Then, we used a 14- to 22-G needle to puncture the ICM tangentially (Fig. 3). When we had advanced the needle a sufficient distance, we rotated the C-arm to the lateral position to evaluate the depth of the puncture, and then we advanced the needle deeply to reach the ICM (Fig. 4).

Assessment

We assessed the technical success rate, puncture time, and complications. We defined technical success as successfully reaching the target point. Puncture time was defined as the interval from preprocedural imaging to the image confirming that the needle had reached the target point. Complications were defined as nerve injury during puncture, clinically relevant hemorrhage, or other adverse events associated with puncture.

Results

The Table shows the patients' characteristics and results of the procedures. In all the cases, the discs were successfully punctured. We changed the puncture site during the procedure in one case (Case 10) because the puncture was difficult to perform due to the severely narrowed disc space. The median puncture time was 14.5 min (mean, 18.7 ± 11.3 min; range, 8-49 min). No patients complained of complications that were permanent or required treatment.

Discussion

Generally, percutaneous puncture of various organs is performed under the guidance of ultrasonography, fluorography, or computed tomography (CT). Regarding the intervertebral disc puncture, although there are reports of disc space drainage under CT guidance [7], we consider the fluoroscopic puncture as advantageous. The needle tip can be monitored in real-time. Moreover, in cases with drainage, the guidewire and catheter are easy to operate following the puncture. Furthermore, operators unfamiliar with CT-guided puncture are more likely to accept fluoroscopy-guided procedures, especially orthopedic surgeons.

The isocenter concept was originally widely accepted in radiotherapy. Takizawa et al. advocated the ISOP as a new support method for transpedicular punctures of vertebral bodies [5]. By initially matching the center of the radiation field to the center of C-arm rotation, both centers remain matched even if the C-arm is rotated, unless the bed is slid

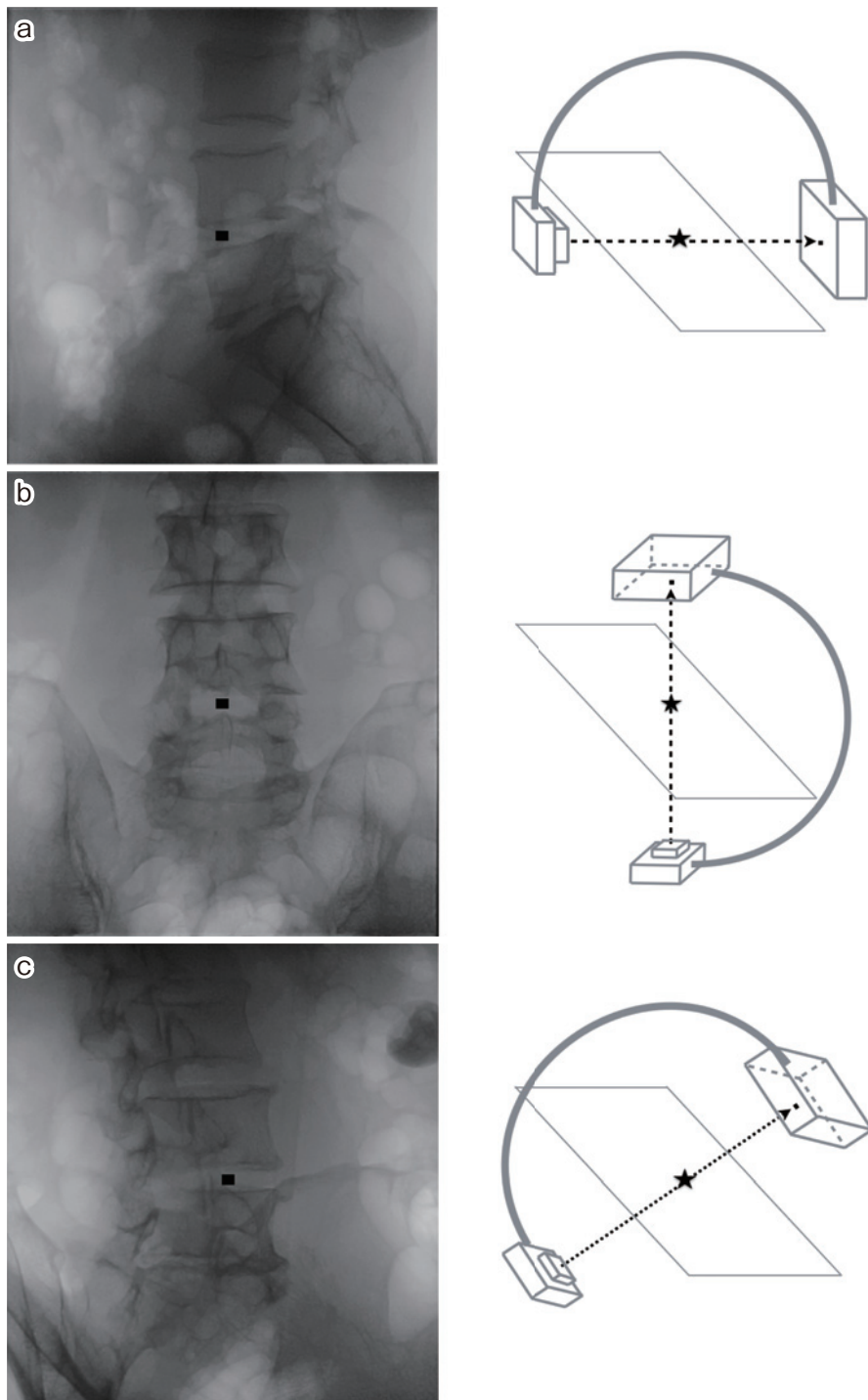


Figure 2. Case 4 with drainage for pyogenic spondylodiscitis.

- a) The isocenter (square) is adjusted to the target (star) at a point one-quarter from the anterior edge of the L4/5 disc space in lateral view.**
- b) The isocenter (square) is adjusted to the target (star) in anteroposterior view.**
- c) The isocenter (square) is adjusted to immediately lateral to the SAP in the disc space (square) by rotating the C-arm.**

or the height of the bed or C-arm is changed. When we set a puncture target on the center, we can achieve an exact puncture by approaching perpendicular to the ICM under fluoroscopic guidance. ISOP was originally developed for puncturing vertebral bodies, such as in percutaneous vertebroplasty (PVP) or biopsy of vertebral tumors [5, 8]. A

more accurate puncture was possible with the ISOP method compared with that with the landmark method in a swine experiment reported by Komemushi et al. [9]. As a result, a more accurate puncture of a site within the intervertebral disc is achievable compared with that with conventional methods. In addition, Sakaino et al. reported that the ISOP

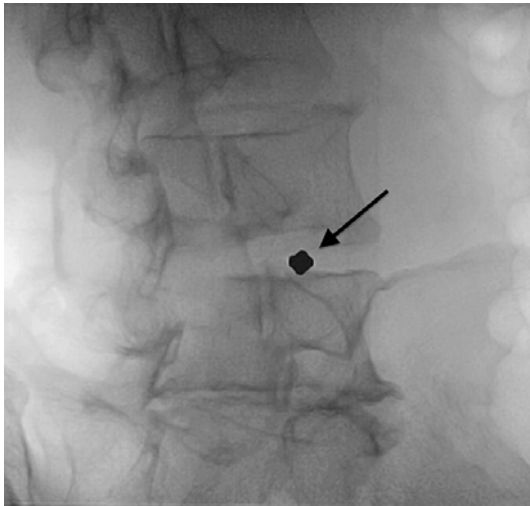


Figure 3. A tangentially punctured needle is seen overlapping the isocenter (arrow).

method improves the PVP completion rate and reduces fluoroscopy time compared with the conventional methods under fluoroscopic guidance [8]. They attributed this result to reduced radiation exposure. The ISOP method, considering the underlying principles, is thought to be applicable in various scenarios for percutaneous puncture. These reports, indicate that applying the ISOP method to intervertebral discs should reduce fluoroscopy time compared with that of the conventional methods. A more accurate puncture should reduce complication rates. In this study, we retrospectively reviewed the ISOP method applied to intervertebral discs. To the best of our knowledge, this is the first review to do so.

Percutaneous puncture methods under 3-dimensional (3D) fluoroscopic guidance software installed in the C-arm fluoroscopic apparatus have been recently reported [10], but such software is not used widely. In contrast, the ISOP procedure is feasible without such software. If an arbitrarily displayable ICM is not provided with the fluoroscopic monitor, then the ISOP procedure is easily adopted by adding a simple device, such as pasting a small radiopaque marker on the center of a flat-panel detector or positioning a small piece of colored tape on the center of the monitor surface, serving the same purpose as the ICM. There are two limitations regarding the ISOP technique. First, the puncture pathway can easily become incorrect if the patient moves during positioning. Therefore, it is critical for the patient to not move until sufficiently deep needle puncture has been achieved. Posture mats can prevent body movement. Moreover, the positional relationship between ICM and SAP should be evaluated with only a short duration of fluoroscopy each time the needle is advanced to some extent. Nevertheless, if the patient moves and the ICM and SAP fall out of alignment before the puncture needle reaches a sufficient depth, the process of positioning would have to be restarted. Another issue is that the hands of the operators may enter the radiation field under this method. Therefore, steps to minimize radiation exposure are necessary, such as perform-

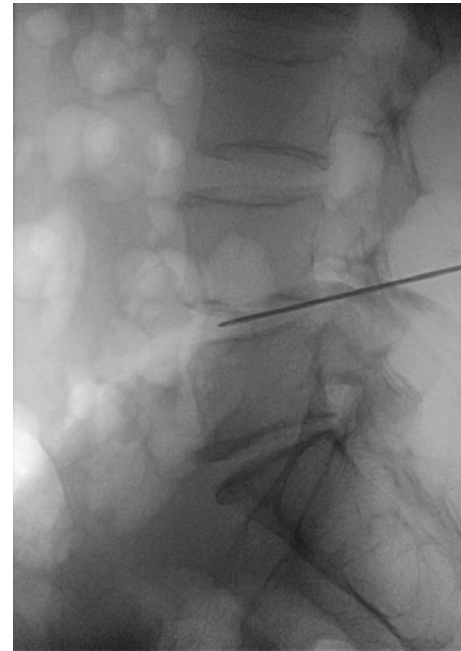


Figure 4. Fluorography to confirm the position of the puncture needle in lateral view.

ing needle insertion while gripping the needle tail with forceps.

In this study, three cases (Cases 6, 9, and 10) required puncture times markedly exceeding 30 min. In Case 10, the patient showed pyogenic discitis with endplate irregularity and severe disc space narrowing. In Case 6, barium remained in the colon and obstructed the view. In Case 9, we experienced difficulty maintaining position during the procedure due to dementia and delirium. Thus, puncture in these three cases could have been technically more difficult compared with that in the other cases. Moreover, 12 out of 19 cases (63.2%) showed nerve root symptoms of the lower extremities before puncture, caused by severe compression of the dural sac and neural foramina due to abscess or comorbid disc hernia. Two out of the 19 cases (10.5%; Cases 2 and 11) complained of temporary numbness of the lower extremities during puncture, which disappeared after conservative treatment. In both cases, the patients showed nerve root symptoms of the lower extremities before the puncture. Thus, in this study, adoption of this puncture route helped avoid nerve injury that could be permanent or require treatment.

This study had some limitations. First, the study design was retrospective, so we could not confirm several punctures from electronic charts. Second, this study included a small number of patients. Third, although the purpose of this study was to evaluate the puncture method, we included various procedures. Moreover, procedure time and rate of nerve root injury had not been mentioned in previous reports to the best of our knowledge; thus, our results are not directly comparable with findings from previous reports.

Table Patients' Characteristics and Results.

Case	Age/ Sex (years)	Level	Technical	Puncture time (min)	Preprocedural nerve root symptoms of lower extremities	Complications	Remarks
1	73/M	L1/2	Success	29	None	None	
2	38/F	L3/4	Success	15	Right	Temporary numbness of left thigh	Severely narrowed disc space
3	75/F	L1/2	Success	13	None	None	
4	59/M	L4/5	Success	14	Bilateral	None	
5	38/M	L4/5	Success	8	None	None	
6	70/M	Th12/L1	Success	35	Right	None	Barium remaining in colon
7	63/M	L1/2	Success	21	None	None	
8	71/F	L4/5	Success	10	Right	None	
9	85/F	L5/S	Success	37	None	None	Dementia/delirium
10	81/F	L4/5	Right: Failure Left: Success	49	None	None	Severely narrowed disc space
11	77/F	L4/5	Success	23	Right	Temporary numbness of right sole	
12	53/F	L4/5	Success	16	Right	None	
13	23/M	L4/5	Success	12	Bilateral	None	
14	87/M	L2/3	Success	9	None	None	
15	76/F	L4/5	Success	N/A	Right	None	
16	78/M	L2/3	Success	9	Bilateral	None	
17	62/F	L1/2	Success	15	Left	None	
18	45/M	L3/4	Success	12	Left	None	
19	71/M	L3/4	Success	9	Right	None	

M, male; F, female

Conclusion

In addition to the previously reported pathway immediately lateral to the SAP, improved puncture of intervertebral discs may be possible using the ISOP method.

Conflict of Interest: None

Disclaimer: Hidefumi Mimura is one of the Senior Editors of Interventional Radiology and on the journal's Editorial Board. He was not involved in the editorial evaluation or decision to accept this article for publication at all.

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