

Observational Study

Unintentional Injection Into the Retrodural Space of Okada During Transforaminal Epidural Steroid Injection

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Background: Transforaminal epidural steroid injection (TFESI) is commonly used for radicular pain, but can lead to an unintentional injection into the retrodural Space of Okada (RSO), an extradural space located dorsal to the ligamentum flavum, instead of the epidural space.

Objectives: To determine the prevalence and describe the fluoroscopic imaging features of an unintentional injection into the RSO during a TFESI and to review the history of injections into the RSO.

Study Design: Observational study and original research.

Setting: This work was conducted at Jeju National University School of Medicine, Jeju, Republic of Korea.

Methods: A total of 5,429 lumbar TFESIs performed from the September 1, 2018 through October 31, 2021 were analyzed for unintentional RSO injections using fluoroscopic-guided contrast medium patterns.

Results: The rate of unintentional injection into the RSO was 0.20% (11 incidents). Contrast medium patterns in the RSO had a sigmoid or ovoid shape confined to the affected facet joint, or a butterfly-shaped pattern extending into the contralateral facet joint, but rarely extending beyond the upper or lower level.

Limitation: The rarity of unintentional injection into the RSO prevented a randomized controlled study design.

Conclusions: Careful fluoroscopic examination of contrast medium patterns during lumbar TFESI is crucial to identify needle placement in the RSO. If detected, the procedure can be corrected by slightly advancing the needle into the foramen.

Key words: Contrast pattern, epidural space, facet joint, fluoroscopy, Space of Okada, transforaminal epidural steroid injection

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Transforaminal epidural steroid injection (TFESI) is most appropriately performed in patients with radicular pain. Neurologic examinations of patients with radicular symptoms often demonstrate vague, equivocal pain patterns, and imaging studies may demonstrate nonspecific findings at more than 2 levels. When these patients are recommended for an interlaminar epidural injection, which means the injection of a relatively large volume to cover the epidural space, clinicians cannot be provided any diagnostic information regarding the specific level from which the pain originates. On the other hand, TFESI targets a specific nerve root and can deliver a low volume of concentrated drug directly into the epidural space that surrounds the nerve root (1).

Therefore, proper needle positioning is crucial for TFESI success, confirmed by fluoroscopic contrast medium imaging before drug administration. Therefore, when the needle is placed in the specified position and the dye is injected, the clinician should confirm the characteristic contrast medium pattern that indicates the needle is correctly located in the epidural space by checking a peripheral nerve shadow, an epidural fat shadow (vacuolization), and the uninterrupted flow of dye in the epidural space (2). If an anomalous contrast medium pattern is observed, the needle must be repositioned to ensure an accurate TFESI.

The retrodural Space of Okada (RSO) is a potential extradural space located dorsal to the ligamentum flavum; it can act as a channel connecting bilateral facet joints (3). In addition, it connects ipsilateral adjacent facet joints, adjacent neural foramen, paraspinal musculature, spinous processes, and adventitial bursa to the contralateral adjacent facet joints (3,4). Furthermore, these communications may act as conduits for infectious or inflammatory processes, and thus, image interpretations can play an important role in patient management (3,4). In our study we focused on the RSO's role in spinal interventions, especially regarding facet joint and epidural injection.

This space is located superficially compared to the epidural space, but clinically can be mistaken for an epidural space because its needling depth and the feeling of loss of resistance (LOR) are similar (2,4,5). More importantly, because injecting into the RSO cannot produce the medical effects of TFESI, clinicians must be aware of these differences.

The first report of an unintentional injection into the RSO was in 1981 and concerned a cervical facet joint injection. This was followed by reports of acciden-

tal injections during lumbar facet joint injections (3,4,6) and an interlaminar epidural block (5).

Actually, the RSO and the epidural space are not anatomically connected (3,7), and thus, in epidural block cases, the extradural space can be wrongly needed during the process of finding the epidural space. Moreover, during a TFESI, a peripherally performed epidural block, we found one case report regarding injection into the RSO at the cervical level and 5 case reports at the lumbar level; all had fluoroscopic guidance (2,3,8).

Our study investigated the prevalence and fluoroscopic features of unintentional RSO injection during lumbar TFESIs, emphasizing the importance of accurate needle placement. We also reviewed the history of unintentional injection into this space.

METHODS

After informed consent, each patient was positioned prone with a pillow under the lower abdomen to reduce lumbar lordosis on the fluoroscopic table.

Under fluoroscopic guidance with a 20°-30° oblique and 0°-15° craniocaudal angle ipsilaterally, an oblique view was obtained with the final position of the pedicle of the corresponding vertebra aligned with the superior articular process of the inferior vertebra, the view of the "Scotty dog" appearance (Fig. 1), (1). The skin over this site was marked, sterilized with betadine, and draped in a sterile fashion.

The injection site and subcutaneous tissue were infiltrated with a local anesthetic (3 mL of 1% lidocaine). Under intermittent fluoroscopic guidance using the coaxial technique, a 22G, 3.5 Quincke spinal needle (Taechang Ind.) was inserted at the 6 o'clock position of the pedicle. It is not necessary to advance the needle until bony contact, but the needle tip position within the "traditional safe triangle" should be ensured on multiple planes of fluoroscopic imaging. The "traditional safe triangle" is described as an inverted triangle with base: inferior border of the pedicle, medial side: exiting spinal nerve, and lateral side: lateral border of the vertebral body (Fig.1) (1).

The final depth of the needle position was confirmed in anteroposterior (AP) and lateral views; inferolaterally to the pedicle in the AP view and superoanterior quadrant of the foramen in the lateral view (see the needle tip (*) on Fig. 2). After negative aspiration for blood and cerebrospinal fluid, 1-2 mL of contrast medium (nonionic iopamidol, Dongkook Pharm) was injected to check that the contrast medium spread

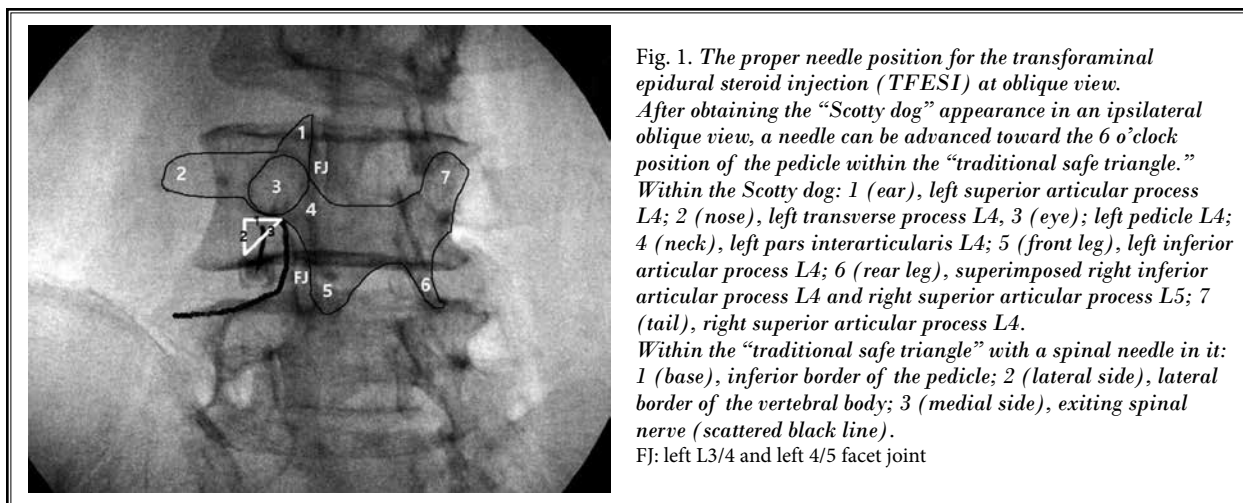


Fig. 1. The proper needle position for the transforaminal epidural steroid injection (TFESI) at oblique view. After obtaining the “Scotty dog” appearance in an ipsilateral oblique view, a needle can be advanced toward the 6 o’clock position of the pedicle within the “traditional safe triangle.” Within the Scotty dog: 1 (ear), left superior articular process L4; 2 (nose), left transverse process L4, 3 (eye); left pedicle L4; 4 (neck), left pars interarticularis L4; 5 (front leg), left inferior articular process L4; 6 (rear leg), superimposed right inferior articular process L4 and right superior articular process L5; 7 (tail), right superior articular process L4. Within the “traditional safe triangle” with a spinal needle in it: 1 (base), inferior border of the pedicle; 2 (lateral side), lateral border of the vertebral body; 3 (medial side), exiting spinal nerve (scattered black line). FJ: left L3/4 and left 4/5 facet joint

medially through the neural foramen and into the epidural space. Once epidural spread was confirmed in AP and lateral views, 10-20 mg of triamcinolone acetate and 3 mL of 0.15% ropivacaine solution was injected.

One anesthesiologist with 18 years of experience performed all TFESIs and gathered data about contrast medium patterns.

RESULTS

This retrospective study was approved by the institutional review board of our hospital (Jeju National University Hospital IRB 202307016). We performed 5,429 TFESI and identified 11 cases (0.20%) of unintentional injection into the RSO during lumbar TFESIs at the Jeju National University Hospital Pain Clinic from September 1, 2018 through October 31, 2021.

A summary of the characteristics of the 11 cases are shown Table 1. We obtained typical fluoroscopic features of the RSO in 3 of these cases (Fig. 2).

Case 1

A 60-year-old man was referred with an aching pain in his right buttock area. His magnetic resonance imaging (MRI) scan revealed degenerative listhesis of L4/5 with right foraminal stenosis and lateral recess stenosis of L4/5. At first, we advanced the spinal needle to the superoanterior quadrant of the L4 foramen in the lateral view. When we injected contrast medium, we were able to confirm a triangular-shaped spread overlying the inferior aspect of the facet joint (Fig. 2A). Accordingly, we advanced the needle a little more into the foramen and performed a right L4 TFESI correctly; we confirmed the L4 spinal nerve shadowing below the

L4 pedicle on AP view. Then for the right L5 TFESI, we advanced the needle slightly deeper from the beginning and immediately succeeded (Fig. 2AB).

Case 2

An 87-year-old man presented with a history of right leg pain. His MRI scan revealed decreased interspinous process and suspected Baastrup disease in L3/4, and L4/5. Fifteen years previous, he received an L4/5 and L5/S1 partial hemilaminectomy. We scheduled a right L4 TFESI. The AP view showed the typical needle tip position over the right L4 neural foramen. But contrast medium injection revealed a butterfly-shaped pattern. This indicates contrast filling of the right L4/5 facet joint with flow to the contralateral left L4/5 facet joint through the RSO (Fig. 2C). We were able to confirm 2 facet joint injection traces in the lateral view (Fig. 2D; needle tip [**] in the RSO). Accordingly, we slightly advanced the needle into the foramen and reperformed The right L4 TFESI successfully; we confirmed the L4 spinal nerve shadowing below the L4 pedicle on a followup AP view (Fig. 2C; needle tip (*) in the epidural space).

Case 3

An 81-year-old woman was referred for right buttock pain and L3 dermatome paresthesia. Her MRI scan showed severe central canal stenosis and bilateral foraminal stenosis at L3/4.

We decided to perform A right L3 TFESI. The lateral view showed a typical needle tip position over the right L3 neural foramen. However, an unintentional contrast medium spread around the right L3/4 facet joint was de-

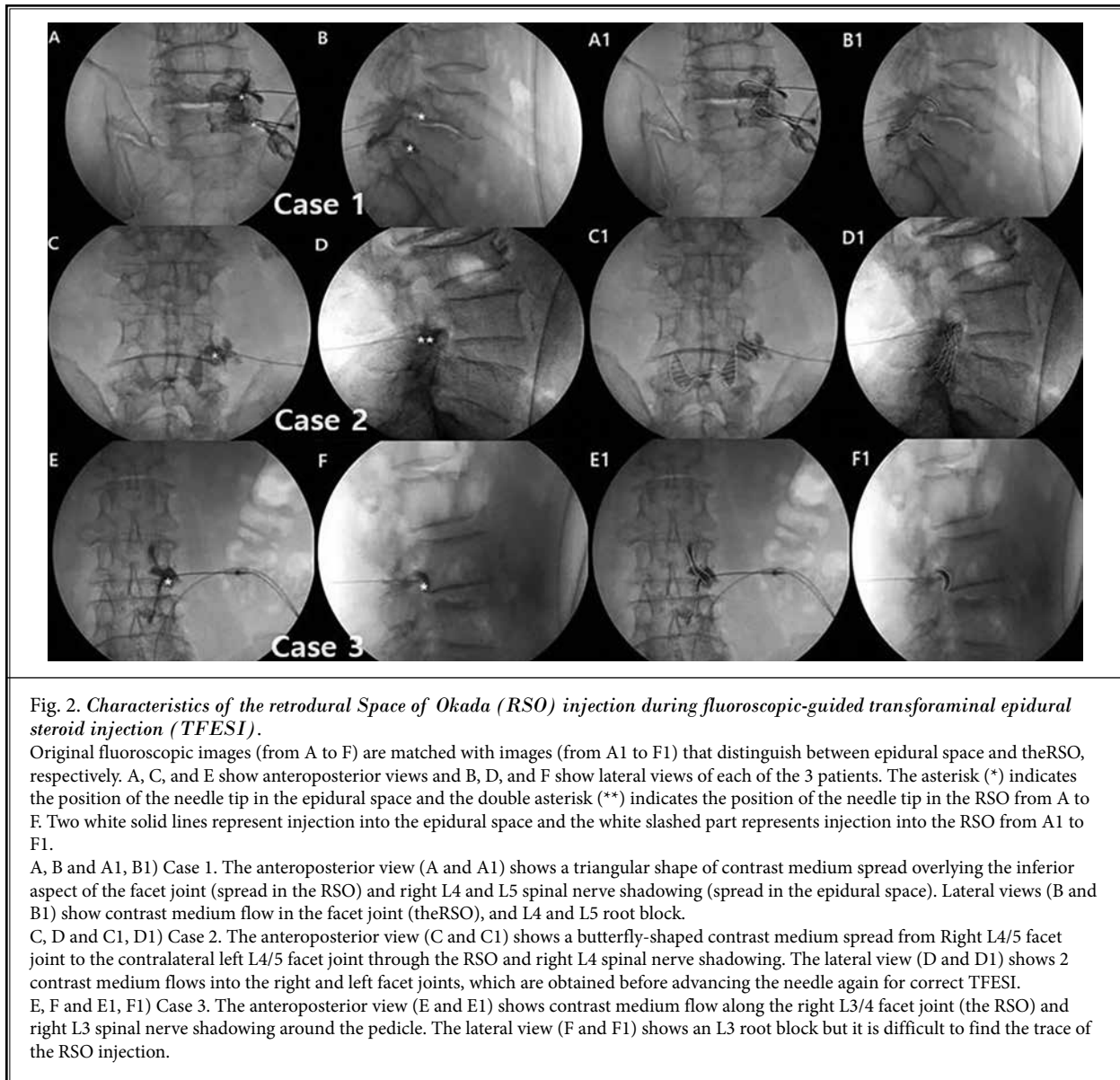


Fig. 2. Characteristics of the retrodural Space of Okada (RSO) injection during fluoroscopic-guided transforaminal epidural steroid injection (TFESI).

Original fluoroscopic images (from A to F) are matched with images (from A1 to F1) that distinguish between epidural space and the RSO, respectively. A, C, and E show anteroposterior views and B, D, and F show lateral views of each of the 3 patients. The asterisk (*) indicates the position of the needle tip in the epidural space and the double asterisk (**) indicates the position of the needle tip in the RSO from A to F. Two white solid lines represent injection into the epidural space and the white slashed part represents injection into the RSO from A1 to F1.

A, B and A1, B1) Case 1. The anteroposterior view (A and A1) shows a triangular shape of contrast medium spread overlying the inferior aspect of the facet joint (spread in the RSO) and right L4 and L5 spinal nerve shadowing (spread in the epidural space). Lateral views (B and B1) show contrast medium flow in the facet joint (the RSO), and L4 and L5 root block.

C, D and C1, D1) Case 2. The anteroposterior view (C and C1) shows a butterfly-shaped contrast medium spread from Right L4/5 facet joint to the contralateral left L4/5 facet joint through the RSO and right L4 spinal nerve shadowing. The lateral view (D and D1) shows 2 contrast medium flows into the right and left facet joints, which are obtained before advancing the needle again for correct TFESI.

E, F and E1, F1) Case 3. The anteroposterior view (E and E1) shows contrast medium flow along the right L3/4 facet joint (the RSO) and right L3 spinal nerve shadowing around the pedicle. The lateral view (F and F1) shows an L3 root block but it is difficult to find the trace of the RSO injection.

tected. Therefore, we advanced the needle a little farther into the foramen and successfully performed the right L3 TFESI correctly (Fig. 2E). We confirmed the L3 spinal nerve shadowing along the L3 pedicle on AP view and nerve root shadowing on the lateral view but the RSO injection was not seen on the lateral view (Figs. 2E, 2F).

DISCUSSION

In this article, we have provided some examples of contrast medium flow pattern images obtained after inadvertent RSO injection during fluoroscopic-guided lumbar TFESI.

The RSO was first described by Okada, et al (6) in 1981. In their study, 80% of facet blocks showed these communications with RSD (6). Subsequently, RSO was also reported during lumbar facet joint arthrography in which the authors described that it is less commonly encountered than cervical facet injection but no specific number of prevalence was shown (3,4,7). The most commonly observed feature of unintentional injection into the RSO is contrast medium flow into a facet joint or toward the midline, then into the contralateral facet joint at the same level, but not beyond or below the vertebral level (3). However, one case report described

contrast medium spread into a facet at a lower vertebral level (9). In this case, the patient had a pars interarticularis defect in the ipsilateral side (3,4,9).

The pars interarticularis serves as a boundary between the synovial spaces of vertically adjacent facet joints (the inferior articular process of the upper level and the superior articular process of the lower level). A defect in this boundary can lead to communication between these ipsilateral facet joints (9). Moreover, the ligamentum flavum is absent at the level of the pars interarticularis, which can permit this communication to the contralateral facet joint (3).

The occurrence of inadvertent injection into the RSO during an interlaminar epidural injection is significantly lower than during a facet joint injection. It has been reported to be 2.9% for computed tomography (CT) guided cervical interlaminar epidural injection (5) and 3.6% - 5.9% for fluoroscopic-guided lumbar interlaminar epidural injection (10,11). It has also been reported that the incidence increased up to 7.5% when interlaminar lumbar epidural injection was performed under CT fluoroscopic guidance rather than conventional fluoroscopic guidance (12). We experienced a 0.2% prevalence of lumbar TFESI by fluoroscopic guidance, which was lower than the above results. We presume the reason is that TFESI is implemented peripherally as opposed to interlaminar epidural injection. All of the procedures included in our study were performed by one anesthesiologist, which may have introduced referral, selection, or physician's skill-associated bias (4,10).

The RSO can be contiguous with bilateral facet joints, so it seems likely for the needle to enter it while attempting a facet joint injection. Entering the RSO less frequently occurs in an interlaminar epidural injection, and even less in a TFESI than in an interlaminar epidural injection, according to the facts listed above (3). Regardless of the type of procedure, there are specific fluoroscopic features of inadvertent RSO injection. The clinical significance of this is that even experienced clinicians can confuse these spaces on imaging (5,9). Therefore, clinicians must be aware of these contrast medium patterns because if they are not recognized, the effectiveness of the procedure may be diminished by inappropriate medication delivery, and results may be misinterpreted (10,12).

When an injection is made into the RSO, contrast medium spreads into the adjacent facet joint to produce a triangular/sigmoid/ovoid configuration of contrast medium overlying the inferior aspect of the facet joint. Contrast medium can then cross midline to

Table 1. Characteristics of 11 cases of an unintentional injection into the retrodural Space of Okada.

Case	Gender	Age (years)	Magnetic Resonance Image Findings
1	Man	60	Degenerative listhesis of L4/5 with right foraminal stenosis lateral recess stenosis of L4/5
2	Man	87	Decreased interspinous process and suspected Baastrup's disease in L3/4, L4/5
3	Woman	81	Severe central canal stenosis and bilateral severe foraminal stenosis at L3/4
4	Woman	84	Bulging discs at L2-S1, moderate central stenosis and bilateral L2/3, L3/4, L4/5 severe foraminal stenosis
5	Man	73	L4/5 severe central stenosis
6	Woman	73	L4 acute compression fracture L4/5 mild central stenosis with bilateral severe foraminal stenosis
7	Woman	75	L4/5 severe central stenosis
8	Man	66	Bilateral severe foraminal stenosis at L5/S1
9	Man	68	Lumbar disc herniation at L3/4 or L4/5 and right foraminal stenosis
10	Man	75	Right foraminal stenosis at L5/S1
11	Man	75	Degenerative spondylolisthesis at L4/5 with right lateral recess stenosis

the contralateral facet joint to produce a wing-shaped/ butterfly-shaped pattern and flow into the interspinous bursa (7,10,12). However, it does not spread above or below the vertebral level; this lack of spread is conclusive evidence that an epidural block has not been achieved. A typical epidural injection has a crescent contrast medium pattern that can spread to the cranial or caudal vertebral level and exhibits negative filling defects caused by fat globules (vacuolization) (3,10). When attempting an interlaminar epidural block, there may be a false, premature LOR as the needle enters the RSO, which is similar to the LOR experienced during an injection into the epidural space, but feel slightly more superficial (11).

Yang, et al (11) confirmed the presence of the extradural RSO by 3-dimensional micro-CT and in cadaveric specimens. They investigated RSO's contrast pattern characteristics during fluoroscopic-guided lumbar interlaminar epidural injections (11). They revealed that degenerative and pathologic facet joint changes (osteoarthritis, hypertrophy, effusion, and cysts) were significantly associated with inadvertent spread into the RSO. Nevertheless, it was not established whether

the extradural space is a normal anatomical space in the human spine, though it was shown that the extradural space is situated between the ligamentum flavum and interspinous ligament and that its anatomical location can contribute to a false LOR. It was also shown that the extradural space should be naturally separated from the epidural space by the ligamentum flavum (11). This anatomical structure is best illustrated in Fig. 1.

Yang, et al (11) also found that the prevalence of severe central stenosis was closely related to unintentional RSO injection (11). Kim, et al (10) reported that all 20 patients that experienced such an injection during fluoroscopic-guided lumbar interlaminar epidural injection had central stenosis, and that 75% had severe grade stenosis. It was concluded that this stenosis may have caused a narrowing of the epidural space and facilitated injection into the RSO and produced a false LOR feeling (11).

During TFESI, we usually place the needle in the superoanterior quadrant of the neural foramen, the “traditional safe triangle,” which delivers the injectate to the ventral epidural space, the most common site of disc herniation (13). But many patients who visit our

pain clinic have foraminal stenosis (Table 1), in which needle placement dorsally in the superoposterior quadrant of the neural foramen is bound to be acceptable because it is hard to advance needle forward in patients like this (13). And especially in these cases, an RSO injection can happen (10).

It has been reported that CT is better at identifying injections into the RSO (2). However, most procedures are performed clinically under conventional fluoroscopic guidance, which means clinicians must be familiar with fluoroscopic images of non-epidural contrast medium flow patterns. In this sense, our study can be meaningful for clinically performed lumbar TFESIs (3,5,12).

While attempting a TFESI, the spread of contrast medium in the RSO can result in an intrafacet injection. However, slight forward advancement of the needle in the same direction can result in a successful epidural block (3-5,10,12). To avoid misinterpreting procedure effects, clinicians must be aware of RSO’s existence as a potential extradural communication, and be able to interpret contrast medium patterns during fluoroscopic-guided spinal procedures.

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