Review Article

Computed Tomography Fluoroscopic-guided Percutaneous Spinal Interventions in the Management of Spinal Pain

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Abstract

Local back pain and radiculopathy can be debilitating for sufferers of these conditions. There are a multitude of treatment modalities, ranging from conservative approaches such as bed rest, physical therapy and chiropractic manipulation, to more invasive options such as percutaneous spinal intervention (PSI) and surgery. We present here the techniques employed in the use of minimally invasive, image-guided percutaneous techniques under computed tomography fluoroscopy in our institutions. The inherent high spatial and tissue contrast resolution not only allows ease of trajectory planning in avoiding critical structures, but also allows precision needle placement. Cervical, lumbosacral, and sacroiliac pain can therefore be evaluated and treated both safely and effectively.

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Key words: Back pain, Fluoroscopy, Spinal injections

Introduction

Pain arising from the spine constitutes the majority of chronic pain disorders with the lifetime prevalence of 54% to 80%.[1] Detailed history taking and physical examination, followed by correlation with imaging [such as plain radiography and magnetic resonance (MR)] remains the keystone of initial assessment and often allow localisation of pain generators. Despite advances made in imaging, however, correlation with symptomatology remains poor and most patients do not receive a definitive diagnosis, and as a result experienced continued pain, with conservative treatment remaining as the mainstay of treatment for most patients, with surgery being reserved only for the minority of cases.[2]

The role of image-guided injection of analgesics to a specific area has an established role since 1980, where Mehta et al[3] described the use of fluoroscopy to confirm the injection site, with increased accuracy in needle placement. Since then, the image quality of image intensifiers has been improving due to technological advances, with portable units, being powered off electrical wall sockets, used in the operating theatre and high-quality units in angiographic rooms for vascular and cardiac catheterisation.

One limitation of conventional fluoroscopy is the ability to only demonstrate bony and calcified structures, and safe needle placement requires detailed knowledge of bony anatomical landmarks. Soft tissues such as nerve roots or epidural space therefore cannot be directly visualised on fluoroscopy and can be difficult to target. Computed tomography (CT) fluoroscopy, with the inherent high spatial and tissue contrast resolution is therefore advantageous in this aspect.

At this point, we need to stress that preference for a given technique or approach is largely due to the training and experience of the operator and does not necessarily mean that we consider the alternatives to be inferior or more dangerous. Furthermore, there is currently insufficient literature to support the superiority of any particular technique. While there is abundant literature on the use of conventional fluoroscopy in percutaneous spinal intervention (PSI), the current body of literature body on the use of CT fluoroscopy remains sparse. The aim of this article is to illustrate the techniques used in our institutions and the relevant anatomy for common PSI using CT fluoroscopy. These include techniques for nerve root blocks, epidural injections, pars injections, facet joint injections, sacroiliac joint injections

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and cervical nucleoplasty.

CT-guided Procedure and Development of CT Fluoroscopy

Prior to the development of CT fluroscopy, CT-guided interventional procedures were performed without real-time guidance, resulting in prolonged procedural time. The main bugbear was the need for repeated movement of the interventionist in and out of the CT room, between repeated scans and needle placement. While the radiation dose to the interventionist is kept to a minimum in this way, the patient-effective doses were considerably higher, compared to CT fluoroscopy.[4]

Katada et al[5] developed and were the pioneers in CT fluoroscopy. While their initial experiences were based on non-spine related intervention work such as percutaneous biopsies and drainages, they paved the way for subsequent growth in a multitude of CT-guided procedures. In 1995, Toshiba developed a commercially available improved technology, which allowed variable field of view; thinner collimation; automatic or manual table motion during CT fluoroscopy; and increased frame rate to 6-8 frames per second.[6]

Currently, with the use of low-dose CT fluoroscopy, the operator with control device in the scanner room performs real-time or near real-time scan with a foot switch. Apart from the additional advantages of superior anatomic resolution, as a result of multi-slice capability, the interventionist is able to view a stack of several image slices above and below the target level, allowing better visualisation of the target structure as well as the needle path, hence ensuring precise and safe needle advancement. This is particularly advantageous in areas such as the cervical spine, where CT allows accurate needle trajectory planning by depicting the relation of critical surrounding structures (e.g., carotid space and vertebral artery) to the incident needle path.[7]

One of the disadvantages of CT fluoroscopy compared to non-fluoroscopic CT-guided PSI is the exposure of the operator's hands to radiation. In CT fluoroscopy, the operator clamps the spinal needle hub with a long forceps, and steers the tip of the needle towards the target with real-time monitoring. Hence, there is increased dose to the operator, in particular, his hands, which are in closest proximity to the ionising radiation. And in non-fluoroscopic CT procedure, the check scan of the needle tip is done with the operator outside the room. However, in comparison to conventional fluoroscopy with experienced operators, the radiation exposure as well as procedural time needed with CT fluoroscopy is comparable to conventional fluoroscopy.[8] Paulson et al[9] measured that the mean CT fluoroscopic times for their cervical, lumbar and sacroiliac spinal injections were 18.4, 17.6 and 11.0 ms respectively. The milliampere (mA) value used during CT fluoroscopy varied from 16.4 to 16.7. In their study, they found that in the various CT fluoroscopic-guided interventions that include spinal injections, spinal biopsy, chest biopsies, abdominal aspirations, abdominal biopsies, and abdominal drainages, the overall mean radiologist radiation dose per procedure was 2.5 mrem (0.025 mSv) (whole body). Individual procedure doses ranged from 0.66 to 4.75 mrem (0.007 to 0.048 mSv), and radiation dose to the fingers was negligible. They have estimated that the patient dose, with use of a standard anthropomorphic phantom by using the technical parameters of 140 kV and 10 mA, is approximately 3.2 cGy per procedure.[9] This dose is significantly less that 1000 mGy, which is a level at which radiation-induced skin changes have been reported.[10] In comparison, a typical effective radiation dose for a normal CT study of the abdomen and pelvis is 10.9 to 13 mSv,[11] which is about the same as that the average person receives from background radiation in 3 years. While a cardiac CT angiography is quite similar to the dose given in a routine combined abdomen and pelvis, it tends to be on the higher end of the CT radiation dose spectrum.[12] One of the early large series of PSI procedures with real-time CT fluoroscopy was reported by Seibel et al in 1997. They have administered peri-radicular spinal nerve root anaesthesia therapy in 269 cases and found the use of CT fluoroscopy to reduce the procedure time and increase the safety of the interventional procedures.[13]

One less well-known disadvantage of CT fluoroscopy is the confined working space limited by the scanner gantry, but can be overcome with experience and patient positioning. In recent years, the use of more novel techniques involving ultrasound and MR-guidance are being investigated,[14,15] a reflection of continued growth of PSI in tandem with development in the imaging field.

CT Fluoroscopic-Guided PSI

General Procedural Details and Techniques

In our institutions, all the procedures are routinely performed on an outpatient basis. At all times, close discussion with the referring clinician is needed, with the prerequisite that the radiologist understands the clinical symptoms and is able to identify the target structure. Detailed review of recent imaging studies such as MR imaging or radiographs for procedure planning is crucial.

It is important that prior to performance of the image-guided procedure, the patient understands that definitive pain relief is not assured, and if there is pain relief, then the length of the relief may vary from days to months. In selected patients who are referred for the procedure, the referral is made to effect improvement of low-back and leg symptoms (i.e., epidural steroids, nerve root blocks); identify the pain

generator in a specific spinal anatomic location, reproduce the symptoms and relieve the symptoms; confirm the specific level and side of the causative pathology (selective nerve root blocks when there is bilateral or multilevel pathology).[16] Hence, close communication with the patient, referring physician and interventionist is important for an overall satisfactory outcome.

Informed consent is obtained and contraindication such as bleeding diasthesis, antiplatelet therapy, drug allergies, steroid usage and local skin infections are excluded. Of note, steroid injections can potentially cause lability in blood sugar levels in diabetics.[16]

Visual analog scale pain score is obtained before and after the procedure. Baseline vitals sign are then obtained (blood pressure, pulse rate and respiration rate). Routine intra-procedure physiologic monitoring (intermittent blood pressure and pulse rate, continuous blood oxygen saturation level) is not performed unless the patient requires sedation. Conscious sedation, if needed, comes in the form of intravenous midazolam and fentanyl, given in slow increment at 2-minute interval (1 mg midazolam, 20 mcg fentanyl at each increment).

Sterile technique is followed and the patient is positioned in the prone position in all cases, except during cervical spine PSI. A decubitus positioning opposite to the side of planned intervention is elected if the patient is unable to lie prone. Planning CT images are obtained using multi-detector CT, which has enabled fluoroscopic capabilities (Somatom Sensation 64 cardiac CT scanner, Siemens Medical Solutions, USA, and Toshiba Aquilon 64 slice CT, Toshiba, Japan), in our institutions. Three-dimensional reconstruction (Leonardo 3D, Siemens Medical Solutions, USA) is performed in complex cases to ascertain the best approach.

For cutaneous and tract local anaesthesia, 1% lidocaine is infiltrated using a 22G needle. Under real-time CT fluoroscopic guidance, a 22G spinal needle will be directed to the site of interest, hence avoiding nearby vital organs and visible vessels. A 50/50 mixture of triamcinolone acetonide suspension (Shincort 10, Yung Shin, Hong Kong SAR) as a long-acting steroid and bupivacaine hydrochloride (Marcaine 0.25% [AstraZenaca, Hong Kong SAR]) as a long-acting local anaesthetic are used. The volume of injectate varies according to the site of injection. Post-procedural care assessment (pain scoring, parameter monitoring) will be performed prior to discharge.

Procedures

Selective nerve root block (SNRB) (Figs. 1 and 2)

Selective nerve root block (SNRB) is indicated in the management of patients with radicular symptoms in the cervical, thoracic and lumbar, or sacral region. It is effective in determining the causative level of nerve root conflicts, especially when there are multilevel nerve roots impingement on MRI. In addition, it can provide a period of either temporary or prolonged symptomatic relief, which may offer the patient a pain-free window to derive further benefit from active physical therapy and other non-operative treatments. Other indications of such use include acute discogenic symptoms without nerve paralysis that is resistant to conventional medical therapy and post-discectomy syndrome.[17,18]

Anatomically, the perineurium and epineurium form the thin membrane covering the spinal nerve roots. The perineurum is a continuation of the dura and covers the proximal 6 mm to 8 mm of the spinal nerve. While the epineurum is a continuation of the epidural membrane and surrounds the nerve to form the epiradicular space,[19] the goal of SNRB is the placement of the injectate within this epiradicular space.

With the patient in the prone position, initial CT fluoroscopy image is obtained with the spinal needle placed over the skin surface to determine the site of the skin entry corresponding to the vertebral level of interest as indicated by the CT laser marker. Local anaesthetic (LA) is then administered via a 23G needle. The syringe is subsequently removed and the needle left in place. A CT fluoroscopy image is obtained with the LA needle in place to serve as a guide for the placement and planned trajectory of the spinal needle. Using the CT laser marker beam as a guide, the initial anaesthetic needle is removed and a 22G 5-inch spinal needle is then placed over the optimal surface spot near the previous site of the anaesthetic needle; the hub of the spinal needle is then lined up with the CT laser beam and advanced toward the nerve root via the transforaminal route. This technique is effective as it ensures that the spinal needle does not deviate from the intended straight-line trajectory as it is advanced toward the nerve root. It effectively reduces both the CT fluoroscopy time and radiation dose to the patient. The spinal needle is maneuvered directly adjacent to the nerve root (Fig. 1C) in the outer neural foramen by using incremental low-dose CT fluoroscopy via a posterolateral approach. The patient can report reproduction of symptomatic pain along the nerve distribution as the needle nears the appropriate location.[20] Once the tip of the spinal needle is in place, a small amount of contrast (1-2 mL) is administered to confirm optimal needle placement (Fig. 1D). This is done to avoid any inadvertent intrathecal or intravascular injection. Once completed, the spinal needle can be withdrawn.

Pertinent vascular anatomy in the region of the thoracolumbar junction relates to artery of Adamkiewicz. It originates from the aorta and is the largest of the spinal radicular arteries. The course of the artery of Adamkiewicz

varies significantly but occurs on the left in 70% to 80% of patients[21] and most commonly occurs between the T9 and L1 levels. Injection of particulate steroid into this radicular artery can cause thrombosis of the anterior spinal artery and subsequent devastating neurological complications.[22] Care must therefore be taken when performing SNRBs to scrutinise active CT fluoroscopic contrast injection for filling of this artery.

Apart from the aforementioned possibility of thrombosis of the radicular artery serving the spinal cord, intrathecal and intravascular injection, other complications include infection and bleeding due to skin puncture, contrast allergy, systemic often self-limiting side-effects of the steroid i.e., diarrhoea, face flushing, insomnia, mood swings, disc entry and nerve laceration.[16]

Perineural cysts, if visualised in the pre-procedural MR study, are usually not problematic when performing an SNRB due to the more lateral needle position. It is seen mostly if a subpediculate target is used, and this can contribute to intrathecal needle placement.

During the cervical SNRB (Fig. 3), care should be taken to avoid the anterior aspect of the neural foramen and to remain in the lateral aspect of the foramen because of the close proximity of the vertebral artery (Fig. 3B).

The SNRB technique of the cervical segments is essentially the same as that of the lumbar spine except for a unique anatomic consideration. The nerve root has a more horizontal course and a close proximity to the vertebral artery. In addition, one must remember that the first 7 cervical nerves exit on top of the similarly numbered pedicle and the eighth nerve exits underneath the associated pedicle as do the thoracic and lumbar nerves. Another point of caution, it is imperative that the interventionist reviews any prior MR images of the cervical spine to avoid puncturing an aberrant or tortuous vertebral artery.[23]

Epidural injections

Epidural steroid injection (ESI) is commonly used for the relief of back pain secondary to spinal stenosis, disc herniation with or without radicular pain, back pain with absent imaging findings. It is used to delay or prevent surgical treatment. When combined with physical therapy and anti-inflammatory medications, it can provide satisfactory pain relief in patients who are not surgical candidates. It is infrequently used in relief of acute exacerbation of pain.[1,23]

Dorsal interlaminar, sacral hiatus, and foraminal approaches may be used for lumbosacral epidural injections. Each technique will have inherent advantages and disadvantages.[20] The interlaminar approach is directed more closely to the assumed site of the pathology; hence, requiring less volume than the caudal route. However, the caudal entry is relatively easily achieved, with minimal risk of inadvertent dural puncture. The transforaminal approach is target specific with the smallest volume as it is directed specifically at the ventrolateral epidural space, the primary site of the pathology.[1]

Our experience with ESI is primarily through the dorsal interlaminar approach. With the patient in the prone position, the midline is palpated and using the posterior or posterolateral approach, the needle is advanced until the epidural space is entered. Under CT fluoroscopy, the expected location of the epidural space can be confirmed with slow injection of either contrast or air. Another technique, used commonly by anaesthesiologists, localises the position of the needle tip within the epidural space via loss of resistance. This is encountered as the needle advances through the interlaminar ligaments, and ligamentum flavum into the epidural space. The "loss of resistance" is experienced because the epidural space has a pressure slightly less than the ambient pressure.[23]

Complications associated with ESI include dural puncture, infection, abscess formation, epidural lipomatosis, pneumothorax, nerve damage, headache, death, brain damage, increased intracranial pressure, intravascular injection, pulmonary embolus and effects of steroids. Both spinal cord trauma and epidural haematomas, though rarely seen, are disastrous complications.[1]

Facet joint and pars defect injections (Figs. 4 and 5)

Clinical symptoms of facet joint pain include hip and buttock pain, cramping leg pain involving the thigh but not radiating below the knee, low back stiffness (worse in the morning), and absence of paraesthesias.[20] Ravel et al had devised a clinical criterion to select the subset of patients that will benefit the most from facet joint block. The criteria include age older than 65 years; pain not exacerbated by hyperextension, forward flexion or extension rotation; pain not worsened by coughing; pain well relieved by recumbence. If a patient has pain well relieved by recumbency and fulfills at least 5 of the above criteria, then the sensitivity and specificity would be 92% and 80% respectively.[24]

Under CT fluoroscopy, a 22G needle is advanced into the joint and the injectate delivered (Fig. 4B). In areas where access may be limited by bridging spurs, periarticular injection is performed. Facet joint blocks are either done with injection into the joint (intra-articular) or by blocking the nerves that innervate the joint (peri-articular). The peri-articular injection involves anaesthesing both the medial branches that innervate the target joint. One must appreciate the complex innervation of the facet joints. Each facet joint is innervated by the medial branch of the dorsal ramus one above it and at the same level, except at L5-S1 where the facet joint is innervated by the dorsal ramus itself, and not

a medial branch.[25]

Complications from lumbar facet blocks are uncommon. Two per cent of the cases experience an exacerbation of pain lasting as long as 6 weeks to 8 months. Another infrequent complication include inadvertent dural puncture; this can result in spinal anaesthesia or chemical meningitis. Other complications that are few and far between include paraspinal infections, facet capsule rupture, and vertebral artery puncture (in cervical blocks).[23]

Bilateral pars defect can be complicated by anterior spondylolisthesis. Often the sequelae of spondylolysis include acceleration of degenerative changes and intervertebral foraminal stenosis. Spondylolytic anterolisthesis at L5-S1 is often associated with lateral disc herniations. Both the foraminal stenosis and the herniation result in impingement of the L5 spinal nerves in the intervertebral foramen. However, the injection for spondylolysis is often used for unexplained local pain at the affected level.[20]

Like the facet joints, the pars defects are easily identified at CT. The procedure is similar to a CT-guided facet joint injection (Fig. 5). A 22G spinal needle is used, and the injectate is injected on each side.

Sacroiliac joint injections (Fig. 6)

The sacroiliac joint is a diathrodial synovial joint. It receives an abundance of innervation and is capable of being a source of low back pain and referred pain in the lower extremity.[26]

Injections within the sacroiliac joints are used for acute or chronic sacroiliac joint pain that is not adequately controlled with non-steroidal anti-inflammatory agents. Not infrequently, the procedure is performed in patients with seronegative inflammatory sacroiliitis.[20]

Under CT fluoroscopy, the middle third of the joint is accessed via a dorsal angulated approach in a prone patient. The upper portion of the joint is fibrous. The needle will negotiate through the strong posterior longitudinal ligaments, and once traversed, an abrupt decrease in resistance to forward motion is appreciated. CT fluoroscopy is effective during advancement of the needle to ensure that the needle tip has not transversed the anterior ligamentous structures and passed into the presacral space. Possible complications from sacroiliac joint injections include infection, haematoma formation, neural damage, trauma to the sciatic nerve and other complications related to drug administration.

Cervical nucleoplasty

Degenerative disc disease in the vertebral column can usually present with neck or back pain related to posterior displacement of the contents of the intervertebral disc. This can occur at the cervical, thoracic or lumbar levels, and the posterior disc bulges can cause impingement on the nerve roots or narrowing of the exit foramina. There can also be compression of the thecal sac or impingement on the spinal cord in more severe cases.

Percutaneous disc decompression has been performed with a wide variety of methods, including both mechanical or surgical decompression, as well as decompression using laser, thermal energy or radiofrequency techniques. These interventions would be useful for patients with symptoms of back pain which have not responded to conservative management including rest, analgesia, epidural or selective nerve root injections and physiotherapy.

Percutaneous nucleoplasty is one of the newer methods of disc decompression and it utilises bipolar radiofrequency energy to cause disassociation of molecules. This results in breakdown products of smaller-sized molecules and gases. This also occurs at a relatively lower temperature of between 40°C and 60°C, as compared to higher temperatures in conventional radiofrequency ablation or intradiscal electrotherapy (IDET). There is also relatively little thermal or structural damage to the surrounding tissues.[27] Reduction of the intradiscal pressure was also demonstrated in cadaver studies, which potentially reduces the pressure exerted by the outer surface of the disc on the adjacent structures as well.[28]

Prior published series of cervical nucleoplasty utilised image intensifier fluoroscopy or X-ray guidance for needle placement.[29,30] However, accurate needle placement in the cervical spine is technically more challenging as compared to the lumbar spine. This is primarily due to the smaller height and volume of the cervical disc space as compared to the lumbar disc space, as well as the presence of multiple other structures in close proximity within the neck. In particular, the thyroid gland, common carotid artery and internal jugular vein typically lie in the expected path for a cervical disc puncture utilising an anterolateral approach.

The use of CT fluoroscopy as the guidance method for cervical nucleoplasty also confers other advantages. Direct visualisation of the carotid and jugular vessels with contrast opacification allows for avoidance of these structures. The selection of the skin puncture site as well as the track of the needle can be planned, without the need to depend on bony landmarks. Immediate complications can also be detected, such as inadvertent vascular puncture or haematoma formation. In addition, when the needle is placed in the CT scan plane, there is no need for multiplanar AP and lateral views of the cervical spine as would be required in fluoroscopy.

An anterolateral approach is the most common access route to the cervical intervertebral disc, passing anterior to the carotid and jugular vessels (Fig. 7). This also allows a relatively short path into the disc space from the skin. With CT fluoroscopy guidance, the initial administration

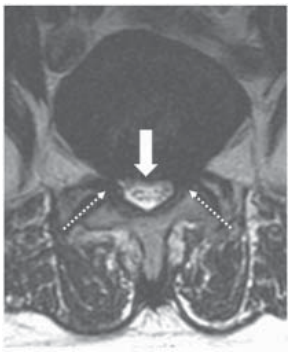


Fig. 1A.

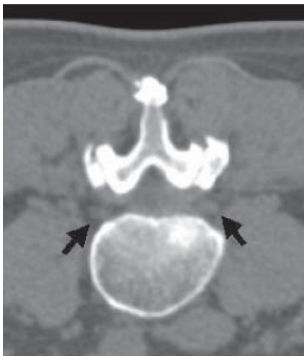
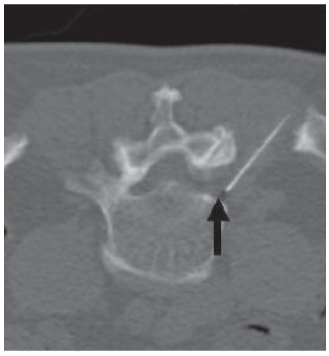


Fig. 1B.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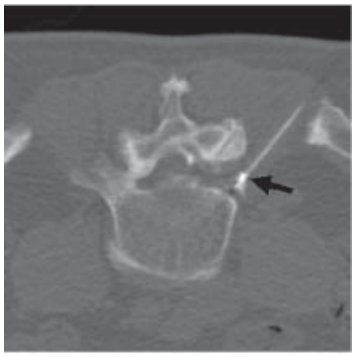
Fig. 1D.

Fig. 1A. Axial T1-weighted image of L5-S1 intervertebral disc space shows a large posterior disc protrusion (white arrow), indenting and displacing the thecal sac posteriorly with crowding of the nerve roots and narrowing of both foramina at this level (dotted white arrows).
Fig. 1B. Localisation CT image obtained over L5/S1 disc space level with the patient in prone position. The exiting L5 nerve root is easily identified (black arrows) and allows visualisation of all surrounding soft tissue structures for planning of needle trajectory.
Fig. 1C. CT scan obtained with patient in the prone position demonstrates tip of the needle in close proximity to the right L5 nerve root (black arrow).
Fig. 1D. Real-time CT fluoroscopy allows monitoring of contrast material (black arrow) injections to exclude intrathecal or intravascular injection of therapeutic solution.
Fig. 1. SNRB via a transforaminal approach.

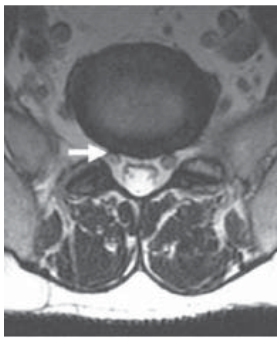
Fig. 2A.

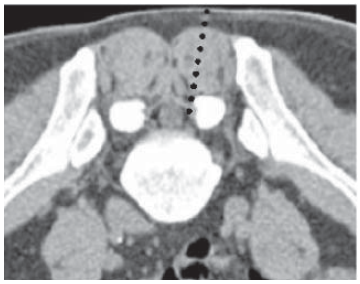
Fig. 2B.

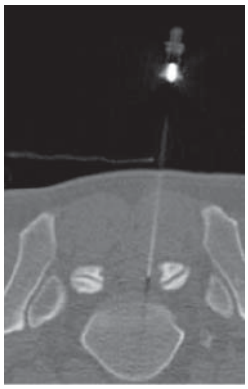
Fig. 2C.

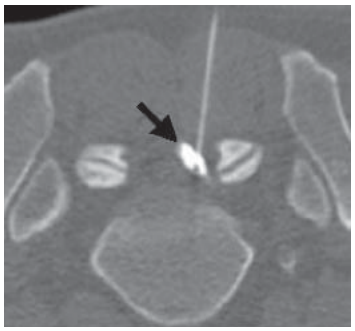
Fig. 2D.

Fig. 2A. Axial T2-weighted image of L5-S1 intervertebral disc space shows narrowing of the right lateral recess with impingement (white arrow) of the descending right L5 nerve roots.
Fig. 2B. Localisation CT image obtained over the L5/S1 disc space level with the patient in the prone position demonstrates the optimal site of needle entry and trajectory (black dotted line) for a translaminar approach.
Fig. 2C. CT scan with the patient in a prone position showing the tip of the spinal needle via the translaminar approach. A 22G spinal needle was used to access the site near the right L5 nerve root.
Fig. 2D. Position of the needle tip at the right epidural space was confirmed with contrast (black arrow).
Fig. 2. SNRB via a translaminar approach.

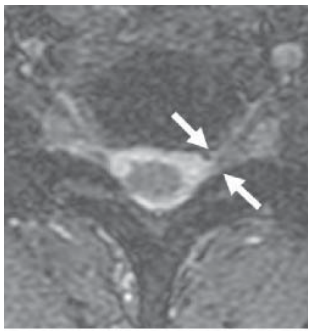
Fig. 3A.

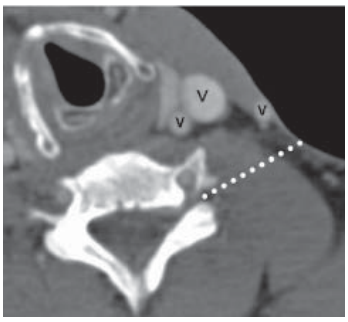

Fig. 3B.

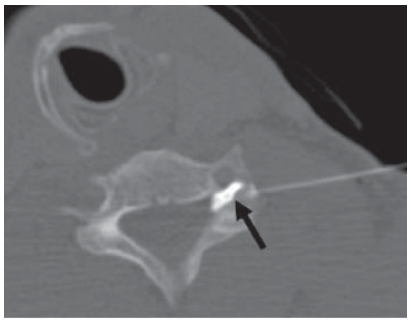
Fig. 3C.

Fig. 3A. Gradient-echo image through C7-T1 which demonstrates narrowing of the left exit foramen (white arrows).
Fig. 3B. Intravenous contrast administered in this patient clearly delineate the vessels (V). The patient's neck is turned to the contralateral side, this positions the carotid sheath away from the intended path of the needle's trajectory (white dotted line).
Fig. 3C. Contrast injected to confirm optimal placement of the needle tip (black arrow) prior to administration of the injectate.
Fig. 3. Cervical SNRB

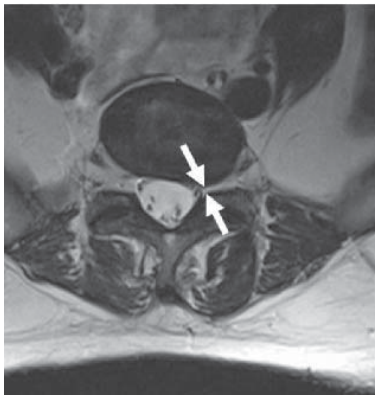

Fig. 4A.

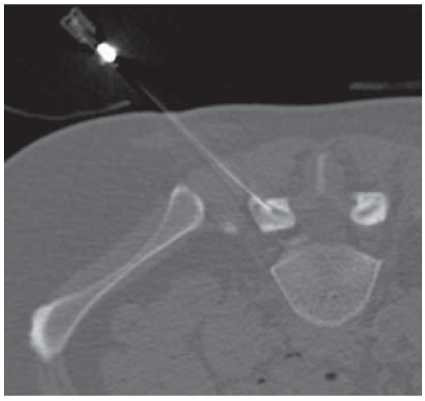

Fig. 4B.

Fig. 4A. Axial T2-weighted scan showing mild left neural foramina stenosis (white arrows) at L5-S1 due to mild left foraminal disc protrusion and facetal arthropathy at the same level.
Fig. 4B. CT scan showing left facet joint injection with the tip of the needle engaged within the middle of the facet joint.
Fig. 4. Facet joint injection.

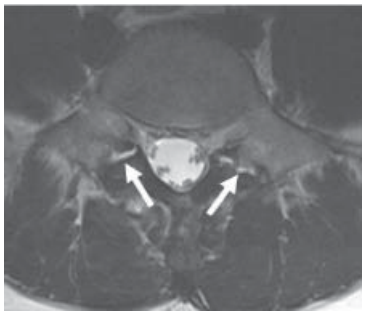

Fig. 5A.

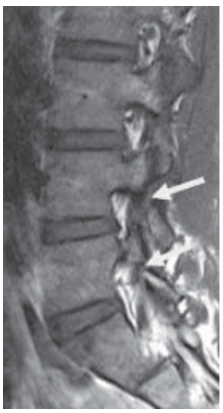

Fig. 5B.

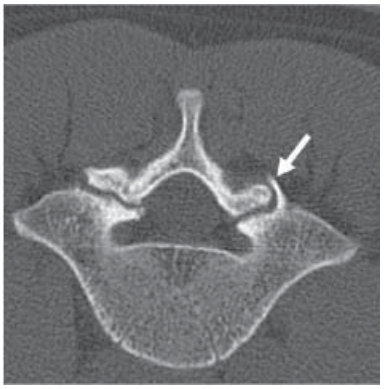

Fig. 5C.

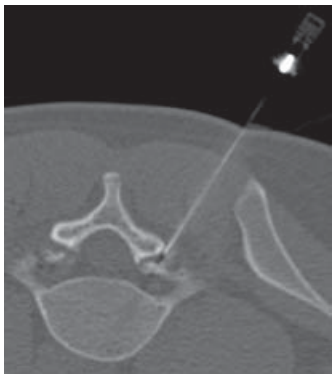

Fig. 5D.

Fig. 5A. Axial T2-weighted image demonstrating bilateral L5 pars defect (white arrows).
Fig. 5B. Sagittal T1-weighted image of the same patient demonstrating right-sided L4 and L5 pars defect (white arrows).
Fig. 5C. L5 localisation scan shows the presence of osteophyte (white arrow) "covering" the right L5 pars defect.
Fig. 5D. Needle angled inferior to the aforementioned osteophyte at the right L5 pars defect.
Fig. 5. Pars defect injection.

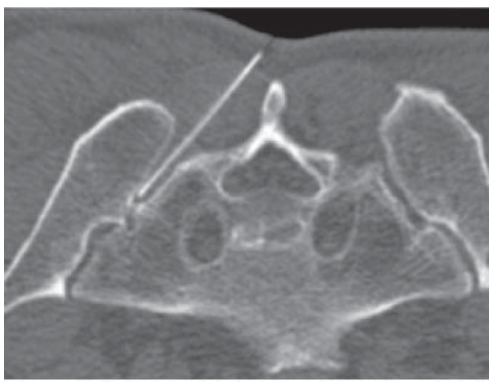

Fig. 6. Left sacroiliac joint injection. CT scan of a patient in a prone position at the level of the sacroiliac joint demonstrating a left-sided sacroiliac joint injection.

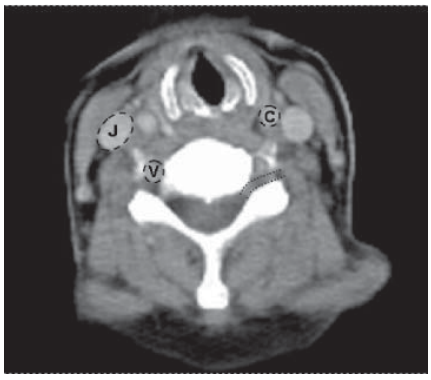

Fig. 7. Contrast enhanced axial CT image through a cervical vertebra. This figure demonstrates the relationship of jugular vein (J), carotid (C) and vertebral (V) arteries, and the exiting cervical nerve root (interrupted parallel lines). Hence, demonstrating the potential hazards encountered during needle entry.

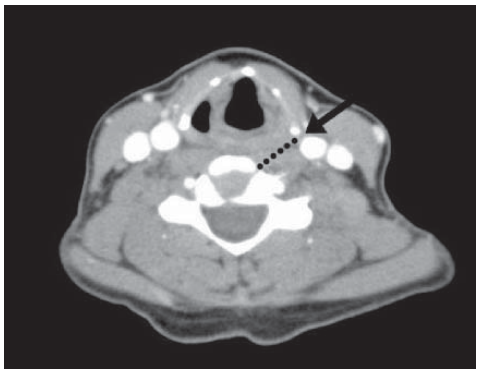

Fig. 8A. Axial CT localisation scan at the C5-C6 disc level with intravenous contrast administered to identify vascular structures and for planning of needle trajectory. The narrow gap between the thyroid cartilage and the carotid artery and jugular vein is noted (black arrow), with the planned needle track leading into the cervical disc space (black dotted line).

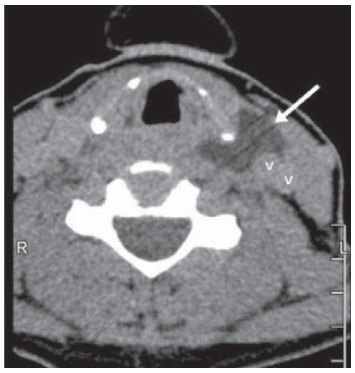

Fig. 8B. Axial CT fluoroscopic section of same section showing widening of gap (white arrow) with local anaesthetic (1% lidocaine). This displaces the carotid and jugular vessels (V) posteriorly, reducing the risk of vascular injury with the nucleoplasty needle.

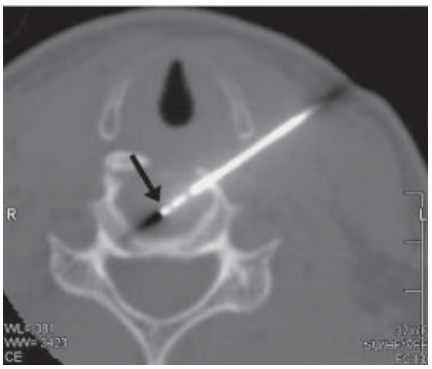

Fig. 9. Axial CT fluoroscopic section showing the nucleoplasty electrode deployed, with the tip in the central portion of the disc space (black arrow).

of local anaesthesia into the neck can displace the carotid and jugular vessels posteriorly. This provides a tract for the nucleoplasty needle to be inserted, reducing the risk of vascular injury (Fig. 8). Angulation of the nucleoplasty needle can also be altered during the procedure, allowing the needle tip to be placed in the central portion of the intervertebral disc.

Once the nucleoplasty electrode has been inserted, its position can be assessed on CT scan with reference to the margin of the disc (Fig. 9). Again, this allows for more accurate visualisation of the needle tip within the disc space, as compared to dependence on bony landmarks such as the adjacent vertebral endplates. There may be some degree of distortion or deformity of the cervical vertebral endplates due to osteophyte formation. Accurate visualisation of the disc height with image intensifier fluoroscopy also requires angulation of the X-ray beam.

After verification of the nucleoplasty electrode tip position, the power level is set and the foot controller activated. If there is involuntary twitching, this may indicate unwanted nerve stimulation, and the electrode is repositioned or withdrawn slightly. Once in a satisfactory position, coblation is activated for 8 seconds while the electrode is rotated around 180 degrees. Another one or two coblation zones can then be created, with CT fluoroscopic verification of the electrode tip before each activation, if the disc volume allows. The electrode and introducer needle can then be withdrawn.

Conclusion

To conclude, CT fluoroscopy is a useful tool in PSI. It is a feasible alternative to conventional PSI, and has the potential to refine and expand current PSI techniques.

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