The role of needle tip position on the accuracy of diagnostic selective nerve root blocks in spinal deformity

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Abstract

Purpose The specificity of a selective nerve root block (SNRB) is dependant on isolating only the required nerve root whilst avoiding injectate flow to traversing nerves. Needle tip position is therefore crucial. Nerve root blocks (SNRBs) in the presence of deformity can be particularly technically challenging to perform. The aims of this study were to document the relationship of needle tip position and SNRB accuracy in patients with and without spinal deformity.

Methods Over an 8-month period, all SNRBs performed by one spinal surgeon were included. Patients with radiographic evidence of spinal deformity were analysed separately and their lumbar deformity graded using the Schwab grading system. Needle tip position in relation to the superior pedicle and flow of contrast was documented.

Results 76 patients received 85 injections without deformity, 26 patients with deformity underwent 30 SNRBs. In the normal spinal alignment group, there was an overall accuracy of 70.1 % regardless of needle tip position, which improved to 91.8 % for a lateral needle tip position ($P < 0.001$). In patients with deformity, the overall

accuracy was significantly lower irrespective of needle tip position 36 versus 70 %, respectively ($P < 0.0019$).

Conclusions Selective nerve root blocks are accurate in patients without deformity where a needle tip placement lateral to the middle third of the pedicle is achieved. The presence of spinal deformity significantly reduces the accuracy of SNRBs with a higher chance of epidural infiltration.

Keywords Selective nerve root blocks · Spinal deformity · Spinal injections · Specificity

Introduction

Selective nerve root blocks (SNRBs) were first described by Macnab in 1971 as root sleeve injections. He found these particularly useful in patients in whom myelography or clinical signs could be difficult to interpret. He used fluoroscopic guidance from a postero-lateral approach to position the needle tip into the root sleeve with the use of radio-opaque dye and characteristic pain provocation [1]. Despite the introduction of CT, ultrasound and electrostimulation for guidance [2–6], selective nerve root blocks have changed little in technique and are still widely used today as a diagnostic tool [7].

The value of SLNB as a diagnostic test has, however, been debated [8]. As stated by Datta et al. [9] in their comprehensive review of the topic, the published sensitivity and specificity varies from 45 to 100 %. This has largely been due to variations in technique, volume of injectate, needle tip placement and the nomenclature used [10–12]. The terms foraminal block and SNRB are often interchanged and comparisons are drawn between the two.

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Fig. 1 Selective nerve root block with contrast flow down single nerve root

Despite this, however, a good correlation with SNRB as compared to operative findings and surgical outcome has been shown [13–16]. A number of studies have also demonstrated improved accuracy of SNRB using smaller volumes of injectate [10, 17]. As a result, a number of recent reviews have suggested moderate evidence for the use of low-volume SNRB to aid diagnosis of acute radicular pain [18–20]. With an overall accuracy of 70 % regarded as being acceptable.

The specificity of a SNRB is dependant on isolating only the required nerve root whilst avoiding injectate flow to traversing nerves. Needle tip position is therefore crucial. Pfirrmann et al. [21] in their part clinical and part cadaveric study clearly identified the ‘safe triangle’ for needle placement as well as subdividing that position into medial to the pedicle, below the pedicle (without subdivision), or lateral to the pedicle. They compared the needle tip position to the anatomic localisation of contrast to the nerve (intra-neural, extraneural or paraneural). They did not, however, look at the needle tip position in relation to contrast flow. Two further large series compared needle tip position with complication rates and immediate pain relieving effect but again did not study flow of injectate or accuracy [22, 23].

Wolff et al. are the only authors to look at the effect of needle tip placement and contrast flow. In their study, the pedicle was divided in four quadrants on the AP and lateral views. Electrostimulation was utilised for nerve root identification and a small volume (0.5 ml) of dye infiltrated. 39 lumbar nerve root blocks were performed with medial contrast flow detected in 39 %. Medial contrast flow was present in 67 % with a needle tip position below the medial half of the pedicle versus 33 % in the lateral half. This was not found to be statistically significant ($P < 0.06$ Chi-Squared test) [24]. In Wolff’s study, there

Fig. 2 Foraminal block with contrast flow into the canal and onto traversing nerve root

was inadvertent epidural spread in 39 % of injections. This was still lower than that in Castro et al. [17] using a CT-guided technique, who demonstrated inadvertent spread in 50 % of injections with their lowest volume (0.5 ml) of injectate.

More recently, a number of factors have been introduced to try to improve accuracy including use of a low volume of injectate, CT guidance or electrostimulation [2, 4, 5, 10, 11]. CT guidance and electrostimulation such as the Stimuplex® D needle (Braun medical) can indeed help to guide needle placement to the required nerve root but do not address the problems with inadvertent spread of injectate onto traversing nerve roots.

When used for diagnosis it is essential to limit injectate flow to the desired nerve root only to allow interpretation of results (Fig. 1). When aiming for pain relief only then placing the injectate around the nerve foramina with subsequent flow onto traversing nerve roots may be beneficial (Fig. 2).

When patients experience characteristic pain provocation with the needle tip lying in a position lateral to the middle third of the pedicle, the nerve root is stimulated after it has exited the foramen. We postulated that this additional ‘lateral’ needle tip position could further increase the accuracy of SNRBs by lowering the rate of inadvertent epidural contrast flow.

In addition, SNRBs in the presence of deformity can be particularly technically challenging to perform and with unpredictable results. Surprisingly, there is no documentation of the accuracy of SNRBs in the presence of spinal deformity.

Purpose

The aims of this study were to document the relationship of needle tip position and SNRB accuracy in patients with

Table 1 Outline of the Schwab grading system

Grade	Degree of lumbar lordosis L1–S1 (°)	L3 obliquity in the frontal plane (°)
Type 1	>55	<15
Type 2	35–55	15–25
Type 3	<35	>25

The higher parameter determines the grade, e.g. lordosis >55 and L3 obliquity >25 then it is graded as a type 3

and without spinal deformity. We hypothesised that a more medial needle tip position would increase the likelihood of contrast flow into the canal, and hence reduce accuracy.

Methods

Over an 8-month period, all SNRBs performed by one spinal surgeon (ALK) were included. The indication for the NRB was to diagnose the level of pathology causing radicular pain when there was ambiguity between the patient's symptoms and imaging studies. A standardised injection technique and documentation pro forma was used. Clinical outcome following injection was not investigated in this study. All post-contrast images were saved to archive for future analysis. All lumbar spine injections were included. Sacral nerve root injections as well as those patients in whom post-contrast images were not available were excluded. All patients were consented and Caldicott approval gained.

Patients with radiographic evidence of spinal deformity were analysed separately and their lumbar deformity graded using the Schwab grading system [25–27] (Table 1; Fig. 3). Patients were excluded from this group if adequate

plain radiographs were unavailable for deformity grading or if no deformity was present.

The saved post-contrast images were then reviewed separately by one of the two authors (ALK or A Irwin). Needle tip position in relation to the superior pedicle (lateral, middle or medial to the middle third of the pedicle on the AP view) and flow of contrast (flow along nerve root only versus contrast seen in the canal) was documented. Fisher's exact test was used for statistical analysis between the groups with statistical significance indicated by $P < 0.05$.

Technique

All injections were performed using a standardised technique. Following consent, the patient was positioned prone on a radiolucent operating table (Mizuho OSI Jackson table with flat top). A postero-lateral approach was used and the appropriate level marked with a pointer under X-ray guidance. The patient was then prepped and draped and 1 % lidocaine infiltrated subcutaneously for analgesia with no sedation. A 152-mm 22-gauge needle was then inserted and advanced towards the 'safe zone' under X-ray guidance.

The patient was observed for characteristic pain provocation by the needle tip. Once encountered the needle tip was withdrawn slightly until the pain eased. AP and lateral X-rays were then performed to confirm an acceptable position; up to 0.5 ml of Omnipaque 240 contrast (GE Healthcare) was infiltrated and a further AP image saved post contrast. 40 mg of depomedrone in 1 ml with a further 1 ml of 0.5 % chirocaine was then infiltrated to complete the diagnostic test. The procedure and results were documented on a standardised pro forma.

Fig. 3 Use of the Schwab grading system in a patient with deformity: a lumbar lordosis measuring 32° and L3 obliquity of 27° (type 3)

Table 2 Spinal level of nerve root injection in both groups

Level of nerve root block	Without deformity (no. of injections)	With deformity (no. of injections)
L2	1	0
L3	7	0
L4	25	11
L5	55	19

Table 3 Contrast flow in relation to needle tip position with normal spinal alignment

Position of needle tip in relation to the middle third of the pedicle	Number of SNRBs	Number with contrast flow to nerve root only	Number with contrast flow into canal
Lateral	49	45	4
Below	29	15	14
Medial	7	0	7

Results

119 patients received SNRBs over an 8-month period between January and July 2008. 76 patients received 85 injections without deformity with 9 patients receiving a SNRB at more than one level or at the same level on the contra lateral side. 43 patients were identified as having a deformity of which 17 patients were excluded due to lack of adequate AP and lateral radiographs for deformity classification. 26 patients with deformity underwent 30 SNRBs.

Of the 102 patients included, 65 % were females with 35 % males. Age range was 45–85 years with the median being 70 years of age. The spinal level of nerve root block in both groups is included in Table 2.

Normal spinal alignment group

Of the 85 injections, 49 were lateral to the middle third of the pedicle at onset of pain provocation, 29 were below, and 7 were medial to the middle third. Contrast flow for each group is detailed in Table 3. There was a significantly higher rate of single nerve root isolation with a lateral needle tip position compared to a needle position below or medial ($P < 0.001$). There was an overall accuracy of 70.1 % regardless of needle tip position, but that improved to 91.8 % for a lateral needle tip position.

Of the four patients in the lateral group in which there was contrast flow into the canal, two were due to medial migration of the needle tip on insertion of the syringe onto the needle for contrast infiltration. As a result, a Leur lock mechanism was used on all subsequent cases rather than a taper lock, eliminating this problem. Excluding these two

Table 4 Needle tip placement in relation to type of deformity

Type of deformity	Number with lateral needle tip position	Number with needle tip position below middle third	Number with medial needle tip position
1	12	9	0
2	3	3	0
3	2	1	0

Table 5 Contrast flow in relation to needle tip position in the presence of spinal deformity

Needle tip position in relation to the middle third of the pedicle	Number of SNRBs	Number with contrast flow to nerve root only	Number with contrast flow into canal
Lateral	17	8	9
Below	13	3	10

instances the accuracy increases to 95.7 % for a lateral needle tip position.

Spinal deformity group

Of the 30 injections, 3 were performed in patients with type 3 deformity, 6 with type 2 deformity and 21 in type 1. The results of needle tip placement in relation to type of deformity are outlined in Table 4. Type of deformity did not influence the needle tip position. The relationship of needle tip placement with respect to the superior pedicle and flow of contrast is detailed in Table 5. In the presence of deformity there was no significant difference in isolated nerve root infiltration between needle tip positions. In addition, the severity of the deformity did not affect the chance of isolating the desired nerve root.

The overall accuracy was significantly lower in the group with spinal deformity irrespective of needle tip position 36 versus 70 %, respectively ($P < 0.0019$). The accuracy of a lateral needle tip position to infiltrate only the desired nerve root in the presence of deformity was 47 % compared to 91.8 % in those with normal spinal alignment ($P < 0.0003$).

Discussion

Selective nerve root blocks are frequently used as an adjunct to the clinical history, examination and MRI findings to localise which nerve root may be responsible for the patient's symptoms. To be accurate, the injectate must be isolated to the required nerve root only without spread to adjacent or traversing nerve roots.

Although, there is a good correlation between nerve root isolation and surgical outcome, there is debate with regard

Fig. 4 Lateral placement of the needle tip with the pedicle divided into thirds

to the ability to isolate the required nerve root only. Ours was the first study to document the accuracy of a so-called ‘lateral’ needle tip position in relation to the middle third of the pedicle (Fig. 4). In our series with modest numbers we demonstrated an overall accuracy of 70 %. This would be regarded as the cutoff for an acceptable accuracy but still considerably higher than previously documented by Wolff et al. [11] or Castro et al. [17] in their series. This could demonstrate a lower sensitivity in identifying the contrast in the canal particularly compared to the use of CT in Castro’s study. However, to combat this, a relatively high concentration of 0.5 ml Omnipaque 240 contrast was used and the image saved prior to infiltration of local anaesthetic and steroid. It could also be due to a higher proportion of more accurate lateral compared with medial needle placements 49 versus 7, respectively.

We postulated that a lateral needle tip position would reduce medial flow of injectate and therefore improve accuracy, as it would preferentially flow away from the canal, whereas a medial needle tip position would flow into the canal. Overall, the accuracy with a lateral placement was 80 % for patients with and without deformity. That improved to over 90 % in patients without deformity. This was statistically significant as compared to middle or medial placement ($P < 0.001$). In this series, diagnostic outcome or pattern of paraesthesia post injection was not studied. As a result, conclusions cannot be drawn as to how

this accurate lateral placement relates clinically. In addition, one surgeon who was also involved in the review of the saved images performed all the injections. This significantly limits the transferability of these findings as well as obviously introducing the risk of bias to the results.

In adults with spinal deformity and radicular pain, MRI as well as clinical examination can be difficult to interpret. MRI will frequently demonstrate more than one possible levels of compression that are often adjacent. As a result, SNRBs are an important tool to isolate the correct nerve root causing the symptoms if planning a limited procedure. This is the first paper to attempt to identify the accuracy of SNRBs in this population.

The Schwab grading system was used to classify the deformity as it has recently been validated and shown to have excellent inter- and intra-observer reliability [25–27]. In this series, only one observer was used to classify the deformity (A Irwin). This could obviously introduce bias; however, the good validity of the rating system should reduce this risk. The severity of the deformity (types 1–3) did not appear to influence the needle tip placement in relation to the pedicle or indeed the risk of contrast flow medially. This was however, a small population studied to identify such differences. Presence of deformity did significantly reduce the accuracy to isolate only the desired nerve root without medial flow compared to patients with normal spinal alignment, 36 versus 70 %, respectively ($P < 0.0019$). A lateral needle tip placement in patients with deformity improved the accuracy to 47 % but this was not statistically significant ($P = 0.26$).

This small series of 30 blocks in patients with deformity highlights the difficulties in interpretation of results in this group. In addition, only 9 patients were identified as having significant deformity of types 2 or 3 with 21 of the injections in patients with type 1 deformity. Lateral radiographs were performed on all patients prior to contrast infiltration to ensure acceptable needle tip position. However, this needle tip position was not saved to archive at time of procedure and therefore could not be analysed in a similar fashion to Wolff’s four-quadrant principle [11]. This is a significant weakness in this study especially in patients with lumbar deformity who are also more likely to have a rotational deformity of the vertebrae and therefore difficult radiographic interpretation. This would make accurate needle tip placement on the lateral radiograph essential and possibly more likely to influence contrast flow than lateral placement on the AP film.

Wolff et al. is the only previous author to document the role of needle tip placement on the accuracy of SNRBs as a diagnostic tool. They documented a rate of inadvertent medial spread of contrast in 38 % of cases with improved to 33 % with needle tip placement under the lateral half of the pedicle with the use of electrostimulation and

fluoroscopy for needle tip placement [11]. As a result, they concluded that SNRBs were not selective and caution should be taken in the interpretation of results. Our series demonstrated an accuracy of up to 96 % with a needle tip position lateral to the middle third of the pedicle, no deformity and a low volume of contrast (0.5 ml). As previously stated there were significant limitations to this study including a relatively small sample size particularly in the deformity group, a single surgeon performing the injections, the lack of blinding and no reference to the clinical outcome. Despite this, papers evaluating SNRBs should consider analysis of the needle tip position dividing the pedicle into thirds, the presence or absence of spinal deformity and contrast media confirmation of injectate flow as these variables could reduce accuracy and introduce misleading results unless accounted for.

Conclusions

This relatively small study with its limitations demonstrated that selective nerve root blocks are accurate in patients without deformity where a needle tip placement lateral to the middle third of the pedicle is achieved, with characteristic concordant pain reproduction in the selected nerve distribution and under fluoroscopic guidance. The presence of spinal deformity significantly reduces the accuracy of SNRBs with a higher chance of epidural infiltration and a potentially high false positive rate. Therefore, its use as a diagnostic test in deformity may be less reliable and results of these tests interpreted with caution.

Conflict of interest None.

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