

APPARATUS

The effect of introducer gauge, design and bevel direction on the deflection of spinal needles★

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Summary

This study was performed to determine how the use of an introducer affects the extent to which a needle deflects during a spinal or combined spinal-epidural injection. A polystyrene block was used to simulate the paraspinal area of the back. A line was drawn perpendicular to the edge of the block to use as a guide and to measure the deflection. The use of an introducer needle decreased the deflection in all the bevelled needles ($p < 0.001$). Depending on the direction of both the bevels, the deflection decreased as the introducer bevel was changed from the same direction, to right-angles to bevel direction and then to a direction opposite to that of the spinal needle ($p < 0.05$). Deflection was decreased when a thick introducer was used ($p < 0.001$). The use of an introducer increased the deflection of the pencil-point needle only in the deflection direction of the introducer ($p < 0.001$). The 18-gauge Tuohy needle with a 'backhole' deflected more than the corresponding needle without a backhole ($p < 0.001$), and the spinal needle inserted through the Tuohy needle with a backhole deflected more ($p = 0.002$). Besides the tip type and gauge, the deflection of a spinal needle depends upon the use of introducer, its gauge and bevel direction. The deflection of a Tuohy needle depends upon its design, gauge and the presence of a backhole.

Keywords *Anaesthetic techniques: spinal. Anaesthetic techniques: epidural. Equipment: needles.*

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It has been reported that, during its insertion, a bevelled spinal needle deflects more than a pencil-point needle, and that the deflection is related to its gauge and depth of insertion [1–3]. A bevelled spinal needle is deflected in the opposite direction to its bevel. However, the pencil-point needle deflects primarily in the direction of the distal injection orifice because of the increased 'drag' created by the irregularity of the orifice [1]. Needle deflection is decreased with the use of an introducer needle [3]. However, this needle has its own bevel and it may therefore affect the deflection of the spinal needle. Additionally, it is not known how the size of the introducer needle affects spinal needle deflection.

When a spinal needle is passed through an epidural needle, as in the combined spinal-epidural (CSE) technique, the spinal needle emerges at an angle of between 4.5° [4] and 10° [5] to the long axis of the epidural needle because of the bent tip of the Tuohy needle. Tuohy needles are also deflected to the bevel (end-hole) side by the curved tip [2]. During the CSE technique, the spinal needle will deflect further to the bevel side of Tuohy because the shaft of Tuohy needle follows a curved course to the epidural space. To our knowledge, the deflection of spinal needles during combined techniques has not been reported.

This study had three objectives: to determine how the use of an introducer affects the deflection of spinal

needles; to assess how the gauge and bevel direction of the spinal and/or introducer needles modifies this deflection; to evaluate how the design of epidural needle affects the deflection of the spinal needle during the CSE technique.

Methods

A polystyrene block with a thickness of 5 or 6 cm was used to simulate the paraspinal area of the back. These thicknesses were chosen to represent the depth of the epidural (5 cm) and subarachnoid (6 cm) spaces [2, 6]. A line was drawn perpendicular to the edge of the blocks and, using the line as a guide, needles were advanced through the block (Fig. 1). Nine studies were performed, using three new needles for each bevel orientation. For each study, a fresh portion of polystyrene block was used.

Quincke-tipped 22G, 25G, 27G and 29G spinal needles (Spinocan, B Braun, Melsungen, Germany), pencil-point 22G, 25G and 27G spinal needles (Whitacre, Becton-Dickinson, Franklin Lakes, NJ, USA), 17G and 18G Tuohy needles (Weiss, Becton-Dickinson), and an 18G Tuohy needle with a 'backhole' (Perican, B Braun) (Fig. 2) were used. Hypodermic needles sized 17G and 21G (Dongbang Medical Co Ltd, Seoul, Korea) were used as introducers for the 22G and 25G spinal needles, respectively. A 22G introducer needle (B Braun) was used as an introducer for both 27G and 29G spinal needles. For the CSE technique, a B Braun set (Espocan), comprising an 18G backhole epidural needle and a 27G pencil-point

spinal needle, and a Becton-Dickinson set (Durasafe), comprising an 18G Tuohy needle and a 27G pencil-point spinal needle, were used. In the case of the CSE technique with a 17G Tuohy needle, a 27G pencil-point spinal needle was also used.

Except for the trials that compared small and large gauge introducers, all the bevelled needles were inserted with the aperture (bevel) orientated to the left. For the pencil-point and Tuohy needles, the bevel was orientated to the right. A deflection to the right from the perpendicular line was regarded as positive, and the deflection to the left was termed negative. Using a 6-cm thick block, spinal needles were advanced through the introducer needles, which had been advanced to a depth of 3 cm, the apertures (bevels) of which either faced in the same direction, at right angles to, or in the opposite direction to the aperture of the spinal needle. Deflections from the intended direction were measured at 0.5 mm intervals at the position where the needle emerged from the polystyrene block. The total deflection of the CSE needle, namely the deflection of the spinal needle when inserted through a Tuohy needle, was measured as follows: immediately after the whole end-hole of the Tuohy needle protruded from the 5-cm thick block, the spinal needle was advanced a further centimetre through the Tuohy needle. The deflection of spinal needle tip from the extension of the perpendicular line was measured in the horizontal plane.

The deflections of the bevelled spinal needles were compared when inserted through introducers of

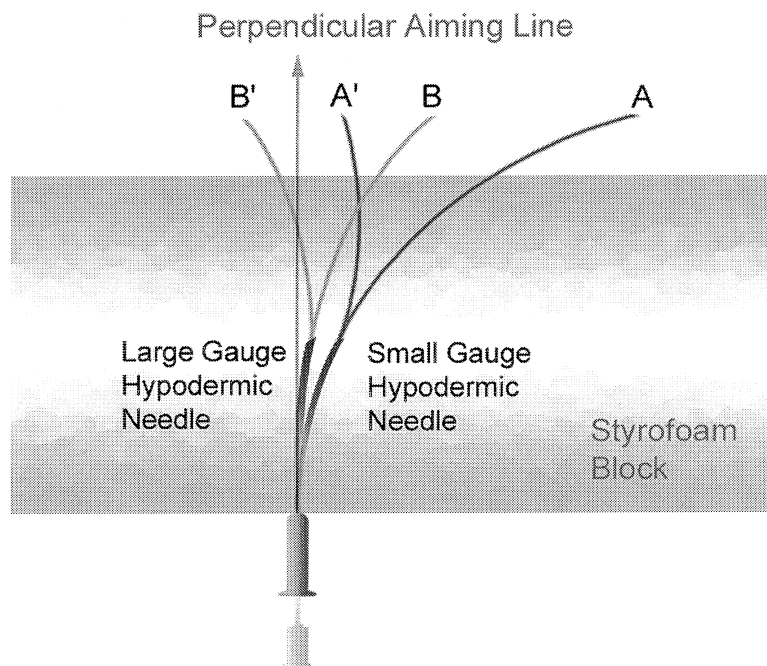


Figure 1 Schematic diagram showing the effect of the gauge and bevel direction of introducer (hypodermic needle) on spinal needle deflection. Arrow: route of needle if no deflection. A, B: deflection when the bevels of the spinal and introducer needles face in the same direction. A', B': deflection when the bevels of both needles are at 180° to each other. Styrofoam = polystyrene.

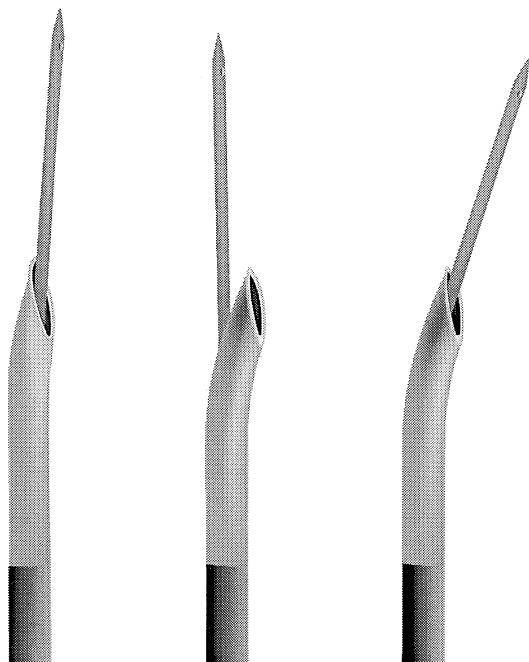


Figure 2 Protrusion pattern of a spinal needle through the Tuohy needle during the combined spinal-epidural technique. Left: Tuohy needle without backhole. Middle: Tuohy needle with a backhole. Right: Tuohy needle with a backhole when the spinal needle protrudes out of the end-hole rather than the backhole.

different gauges (Fig. 1). After insertion of the introducer to a depth of 3 cm, the spinal needle was successively advanced in two stages with the bevel

orientated in the same and the opposite direction to the bevel of the introducer needle (Fig. 1).

Before beginning the study, a sample size calculation was performed. Based on the pilot study, we calculated a sample size that would permit a type I error rate of two-tailed $\alpha = 0.05$ with a type II error of $\beta = 0.2$, i.e. power = 0.8. We considered a 1.5-mm difference to be significant when we performed our power analysis. This required nine repetitions in each group. Most of the deflections were compared using analysis of variance. The Tukey test was used for *post hoc* comparisons. Comparisons of the deflections between thin and thick introducers, or between Tuohy and CSE needles, were performed with the unpaired *t*-test. All results are expressed as mean (SD) [range]. Significance was set at the 5% level.

Results

Small-gauged bevelled spinal needles deflected significantly more than larger ones ($p < 0.05$) (Fig. 3), and the use of an introducer decreased the deflection in all bevelled needles ($p < 0.001$). However, the deflection was dependent on the angle formed between the bevels of the spinal and introducer needles: the deflection decreased as the introducer bevel was changed from the same direction, to right-angles to and to opposite directions to its spinal needle ($p < 0.05$).

The use of an introducer increased the deflection of the pencil-point needle only in the deflection direction of the introducer ($p < 0.001$) (Table 1). The 27G pencil-point

Figure 3 Deflection of bevelled spinal needles depending on the use of an introducer and the direction of the bevels of the spinal and introducer needles during insertion through a 6-cm polystyrene block. Error bars indicate SD. $N = 9$ for each variation. * $p < 0.001$ compared with deflection of the needle with an introducer. † $p < 0.05$ compared with deflection of the needle when the bevels were at right angles or facing in the opposite direction. ‡ $p < 0.05$ compared with deflection of the needle when the bevels were facing in the opposite direction. § $p < 0.05$ compared with deflection of all the other bevelled needles without introducer. ¶ $p < 0.05$ compared with deflection of all the other bevelled needles without introducer.

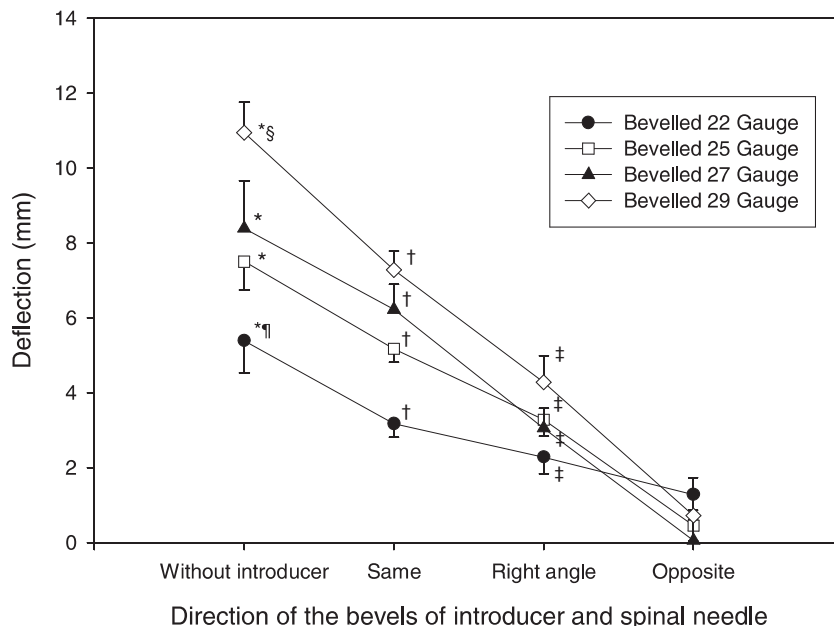


Table 1 Deflection of pencil-point spinal needles depending on the use of an introducer and the direction of the bevel of the introducer needles. Data are mean (SD) [range].

	Deflection without introducer; mm	Deflection with introducer; mm Bevel direction (relative to injection orifice)		
		Same	Right angle	Opposite
Pencil-point 22G	0.2 (0.9) [-1.0–1.5]*	2.2 (0.5) [1.5–3.0]	0.5 (0.6) [-0.5–1.5]*	1.9 (0.9) [1.0–3.0]
Pencil-point 25G	0.4 (0.8) [-1.0–1.5]*	3.3 (0.7) [2.5–4.5]	0.7 (0.8) [0.0–2.0]*	3.2 (0.6) [2.5–4.0]
Pencil-point 27G		3.4 (0.8) [2.0–4.5]	0.5 (0.5) [-0.5–1.0]*	3.4 (0.6) [2.5–4.0]

* $p < 0.001$ compared with deflection produced with same and opposite bevel directions. The 27G pencil-point needle could not be advanced without an introducer.

Table 2 Deflection of bevelled spinal needles depending on the gauge and bevel direction of introducers. Data are mean (SD) [range].

	Direction of bevels	Needle deflection; mm		
		17G introducer	21G introducer	22G introducer
Quincke 25G	Same	5.3 (0.6) [4.5–6.0]	5.9 (0.6) [5.0–6.5]	
	Opposite	-1.9 (1.0) [-3.0–0.0]	1.6 (0.7) [1.0–3.0]*	
Quincke 27G	Same	5.4 (0.7) [5.0–7.0]		7.3 (0.7) [6.0–8.0]*
	Opposite	-1.4 (1.1) [-2.5–0.5]		1.9 (0.9) [1.0–3.5]*
Quincke 29G	Same	6.4 (0.8) [5.0–7.5]		7.7 (0.9) [6.5–9.5]†
	Opposite	-3.2 (1.3) [-5.0–1.0]		-0.1 (0.6) [-1.0–0.5]*

* $p < 0.001$ compared with 17G needle used as an introducer.

† $p = 0.006$ compared with 17G needle used as an introducer.

Table 3 Deflection of the Tuohy needle and of a combined spinal-epidural needle when the spinal needle was advanced 1 cm out of the end of the Tuohy needle. Data are mean (SD) [range].

Tuohy needle size	Manufacturer	Backhole	Deflection of Tuohy needle; mm	Deflection of spinal needle; mm
18G	Becton-Dickinson	No	1.3 (0.4) [1.0–2.0]*	1.8 (0.5) [1.0–2.5]†‡
17G	Becton-Dickinson	No	2.2 (0.4) [1.5–3.0]*	3.2 (0.6) [2.0–4.0]‡
18G	B Braun	Yes	3.1 (1.0) [2.0–4.0]*	3.1 (1.2) [2.0–5.5]

* $p < 0.001$ between Tuohy needles.

† $p = 0.002$ compared with other spinal needles.

‡ $p < 0.001$ compared with tip of Tuohy needle.

needle could not be advanced through the polystyrene block without an introducer.

Comparing the deflections of spinal needles through the thin and thick introducer needles, the use of the thin introducer produced a greater deflection in the deflection direction of the introducer, and the deflection centred more about the perpendicular aiming line with the use of a thick introducer ($p < 0.001$) (Table 2), i.e. there was less deflection.

The 17G Tuohy needle deflected more than the 18G Tuohy needle ($p < 0.001$). However, the 18G backhole Tuohy needle deflected more than the other Tuohy needles ($p < 0.001$) (Table 3). With the CSE technique,

the total deflection of the B Braun set with the 18G Tuohy needle was the same as that of the Becton-Dickinson set with the 17G Tuohy needle, and greater than that of the Becton-Dickinson set with an 18G Tuohy needle ($p = 0.002$).

Discussion

Needle design and gauge, the use of an introducer, and the introducer's gauge and bevel direction can influence the direction of a needle's passage during spinal, epidural or CSE techniques. The use of a large gauge introducer produces less deflection and, when using a pencil-point

needle, the deflection of the introducer largely determines that of the spinal needle.

The size and bevel direction of the introducer needle can affect the path that a spinal needle will take on its way to the subarachnoid space. This effect should be taken into account when performing spinal injections. When advancing a small gauge spinal needle through an introducer, a spinal needle stabilizing method that ‘anchors’ the spinal needle to the introducer may be used to maintain the bevel directions of both needles [7]. When using a pencil-point needle, which suffers minimal deflection in itself, the use of an introducer increases its deflection in the direction of the introducer needle’s own deflection. When performing a spinal block with a pencil-point needle, the bevel direction of the introducer will therefore be the most important factor in terms of needle deflection.

To investigate the deflection of a CSE needle, a 5-cm thick block was used to simulate the needle path to the epidural space. As the epidural space is composed of loose connective tissue, fat and a plexus of veins, a further 1 cm advance of the spinal needle out of the Tuohy needle is unlikely to produce a noticeable additional deflection. Spinal needle deflection during the combined technique was greater for the 18G backhole Tuohy needle than for the corresponding needle without backhole. This seems to be due to the design of the curved tip, which may be longer in order to allow the space for a backhole, and the fact that it has a more malleable shaft. Unexpectedly, the 17G Tuohy needles produced more deflection than the 18G needles, which also seems to be related to the design of the curved tip – the 17G needle has a longer curved portion. As the total deflection of the spinal needles was the same, we think that the backhole of the 18G Tuohy needle has a similar degree of deflection to the end-hole of 17G Tuohy needle. Thus, the optimal length of spinal needle to be passed beyond the tip of a Tuohy needle seems to be similar in both the types of CSE block kits. However, if the spinal needle protrudes out of the end-hole rather than the backhole, the angle of entry into the subarachnoid space will be more acute, which may be a reason for CSE block failure [8].

Deflection of bevelled spinal needles has been demonstrated in a sheep’s spine preparation [6]. Polystyrene may

not adequately mimic the *in vivo* situation, but the relative tendency to deflect must be consistent regardless of the block material. Thus, we think that polystyrene can adequately simulate tissue for comparative scientific or educational purposes [2]. As the needle deflection in chuck steak was approximately 25% less than in polystyrene [2], the actual needle deflection may be over-emphasised by this study. We should therefore be cautious in interpreting the degree of deflection in the intact human being.

Needle design and bevel direction, the use of an introducer, and its gauge and bevel direction, can affect the deflection of a spinal needle. Clinicians can take advantage of this deflection in controlling the path and angle of entry into the subarachnoid space, as the angle of entry into the dura may affect cerebrospinal fluid leakage and therefore the incidence of postdural puncture headache [9].

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