ORIGINAL ARTICLE

Electromyographic Technique for Lumbar Multifidus Examination: Comparison of Previous Techniques Used to Localize the Multifidus

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ABSTRACT. Kim BJ, Date ES, Derby R, Lee SH, Seo KS, Oh KJ, Kim MJ. Electromyographic technique for lumbar multifidus examination: comparison of previous techniques used to localize the multifidus. Arch Phys Med Rehabil 2005; 86:1325-9.

Objectives: To verify and compare established techniques for needle localization in the multifidus muscle and to explore more practical techniques.

Design: Human cadaver study.

Setting: Anatomy laboratory in a university setting.

Cadavers: Six fresh human cadavers.

Intervention: A 22-gauge needle was inserted into the multifidus muscle fascicle of 6 cadavers using 2 different techniques described previously in the electrodiagnostic literature by Haig and Stein and colleagues. A mixture of colored latex and contrast dyes (0.1mL) was injected bilaterally into each fascicle at levels L1 to L5. Two electromyographers performed injections into 60 targeted muscles, affording 120 total insertions. Separate investigators dissected the muscles to determine dye position.

Main Outcome Measures: Not applicable.

Results: A total of 88 (73%) and 79 (66%) injections were successfully delivered to the targeted multifidus muscles using the Haig and the Stein techniques, respectively. With the Haig method, 22 injections (18%) were delivered to different superficial muscles. With the Stein method, 24 injections were delivered to a common tendon and 3 injections were delivered to the spinal canal.

Conclusions: This study highlights the nonoptimizing accuracy of previous techniques for multifidus needle electromyography. A modified Haig method involving less acute needle angulation relative to the skin surface and closer insertion from the midline may increase accuracy and safety.

Key Words: Cadaver; Fluoroscopy; Injections; Radiculopathy; Rehabilitation.

ELECTROMYOGRAPHIC EXAMINATION of limb and paraspinal muscles is a widely used, objective physiologic test for radiculopathy evaluation.[1-3] Determining the involved spinal nerve root levels and correlating those levels with current symptoms is crucial in evaluating radiculopathy and planning future treatment. However, precise determination is problematic because of overlapping myotomes, individual variability, and vague surface landmarks. Paraspinal muscle examination is critical in determining if the lesion site is more proximal than the lumbosacral plexus.[4,5] However, abnormal findings may be evoked in subjects without clinical evidence of radiculopathy. A few studies[6-8] have documented abnormal spontaneous waves in the lumbar paraspinal muscles of apparently "normal" subjects and have advised caution in making a diagnosis of lumbar radiculopathy based on lumbosacral paraspinal findings alone, especially in people over the age of 40 years.

The paraspinal muscle is a massive, complex bulk of individual muscle groups arising from a common embryologic precursor muscle mass, and innervation shows extensive longitudinal overlap. Because previous anatomic studies have shown that the nerve supply to this muscle is derived from a single nerve root via the medial branch of the dorsal ramus, the multifidus is of special interest to electromyographers.

Techniques for multifidus electromyography have been largely subjective. Two recent cadaver studies described techniques for improving the accuracy of inserting needles into this muscle. Haig et al[9] described a technique for the multifidi originating from T12 to L4 using needle insertion at 2.5cm lateral and 1cm cranial from the inferior tip of the spinal process, with a 45° medial direction of the needle tip relative to the surface. For the multifidus at L5, the needle is inserted at the same angle 2.5cm lateral to the midline between the posterior superior iliac spine. The needle is slightly withdrawn after contact with the periosteum. With this method, 81% of needle tips were correctly positioned in the multifidus muscle. More recently, Stein et al[10] recommended 2 techniques: (1) a midline approach, with needle insertion in the midline, midway between the spinous process, with 30° cephalad angulation and 10° to 15° lateral angulation and (2) the paramedian approach, with needle insertion perpendicular to the skin, 3mm lateral to the midline, midway between the spinous process. For both techniques, needle insertion depth was limited to between 2 and 2.5cm. The Haig and the Stein techniques significantly improved the accuracy of multifidus sampling, although there remain some challenges that may limit practical utility. Further needle insertion relative to the midline may increase the probability of erroneously detecting a multifidus muscle from the above level. Shorter distances to the midline and small angulation to the skin may likewise increase the probability of inadvertent subarachnoid puncture and erroneous insertion into a more laterally placed multifidus muscle innervated by the

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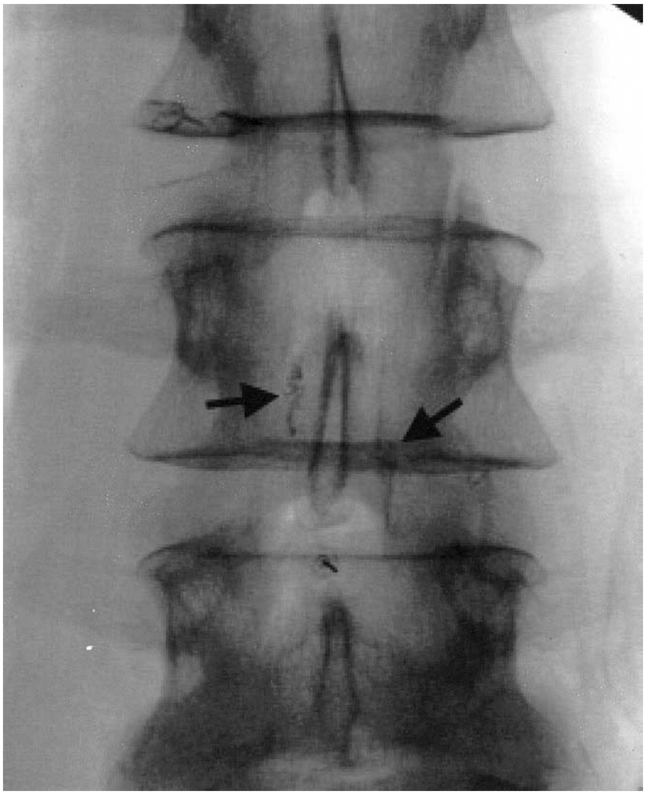

Fig 1. Anteroposterior (AP) fluoroscope image showing contrast dye in the multifidus fascicle (arrow).

above segment roots. Needle insertion of short depth may avoid this risk but can also cause needle position error.

In this study, we verified and compared the Haig et al[9] technique and the Stein et al[10] paramedian approach using fluoroscopy to confirm needle position relative to a bony landmark.

METHODS

Six fresh human cadavers were used. No cadaver had notable lumbar spine abnormalities. A mixture of colored latex dye and contrast dye (0.1mL) was injected into each multifidus muscle fascicle with a 22-gauge spinal needle and a tuberculin syringe (fig 1). The procedure was performed at 5 levels bilaterally, arising from lumbar spinous processes L1 through L5. Use of both the Haig and the Stein (paramedian approach) techniques, including angle and depth of needle insertion in the 6 cadavers, afforded a total of 20 injections per cadaver. Two electromyographers qualified by the American Board of Electrodiagnostic Medicine repeated whole injections at different lumbar levels in each cadaver, for a total of 40 injections per cadaver. Different latex colors were used, which allowed concurrent use of different techniques in a single cadaver. To prevent dye from staining the needle track, needle tips were cleaned before each insertion, and insertions were performed with aspiration. A fluoroscope was used to increase needle insertion accuracy, permitting strict adherence to the needle angles suggested by Haig and Stein (45° and 90° relative to the skin, respectively) (fig 2). We also used fluoroscopic imaging for accurate identification of spine level rather than lumbosacral palpation, which may cause erroneous injection into different locations.

If fluoroscopy showed that the needle tip inserted by one investigator was positioned in contrast dye injected by a previous investigator, the needle was considered to be in the same position and injection was aborted. An orthopedic surgeon and another investigator, who were neither injectors nor observers when the injections were administered, dissected the muscles to determine the origin and insertion of the dye-containing fascicles (fig 3A). The true location of dye relative to the multifidus fascicles was then recorded. An injection was judged to be correct if dye was in a fascicle originating from the spinous process immediately above it.

RESULTS

Fresh human lumbar specimens were harvested from 6 donors (4 men, 2 women) with a mean age of 73.8 years at the time of death (age range, 49–92y). Fluoroscopy showed that none of the spines were seriously deformed. Two investigators injected 60 different sites (both sites of L1-S1 level in 6 cadavers) each, giving a total of 120 injections per technique. Each site was evaluated using 2 techniques with different latex dyes (table 1).

Using the Haig method, 14 needle tip positions were confirmed by fluoroscopy to be located in contrast dye injected by a previous investigator. Dissection showed that 76 injections accurately targeted the multifidus. Of the 14 needle insertions located in previously injected dye, 12 were found in the multifidus, giving a total of 88 successful injections (73%). For 20 injections, latex dye was found in superficial muscles rather than the targeted multifidus muscle fascicles. Of the 14 insertions for which dye injection was aborted, 2 were cases of there being dye in superficial muscles, affording a total of 22 injections (18%) directed into superficial muscles. Two injections were into subcutaneous fat. Eight injections were not found in dissection and were defined as missing injections. No injections were into the ligamentum flavum or spinal canal.

With the Stein method, 26 needle tips were located in contrast dye injected by a previous investigator. Twenty-four injections failed to deliver dye because of high pressure during injection. Dissection showed that 55 injections were into the targeted muscle fascicle; 24 of these were instances when the second investigator aborted dye injection after fluoroscopic confirmation that the needle was inserted into a locus containing previously injected dye. Therefore, there were a total of 79 successful injections (66%). Ten injections were found in a laterally located multifidus fascicle originating from upper spinous processes rather than in the targeted fascicle. Two of these 10 injections involved needle tips positioned in contrast dye areas previously injected by an investigator. Three injections were found in the spinal canal, and 2 injections were missing.

DISCUSSION

The multifidus is the largest and most medial of the lumbar back muscles. The multifidus comprises a series of fascicles of varying lengths, originating from the laminae and spinous processes of lumbar vertebrae via a common tendon. There is a repetitive pattern of caudal attachments. The lamina fibers, which are the shortest and deepest fascicles of the multifidus, originate from the caudal end of the dorsal surface of each vertebral lamina and insert into the mamillary processes of vertebrae, which are 2 levels caudad. Larger fascicles that compose the bulk of the lumbar multifidus radiate from the spinous processes and are arranged in 5 overlapping groups. Each lumbar vertebra gives rise to 1 group (fig 3B).[11] Fascicles arising from the spinous process of a vertebra are innervated by

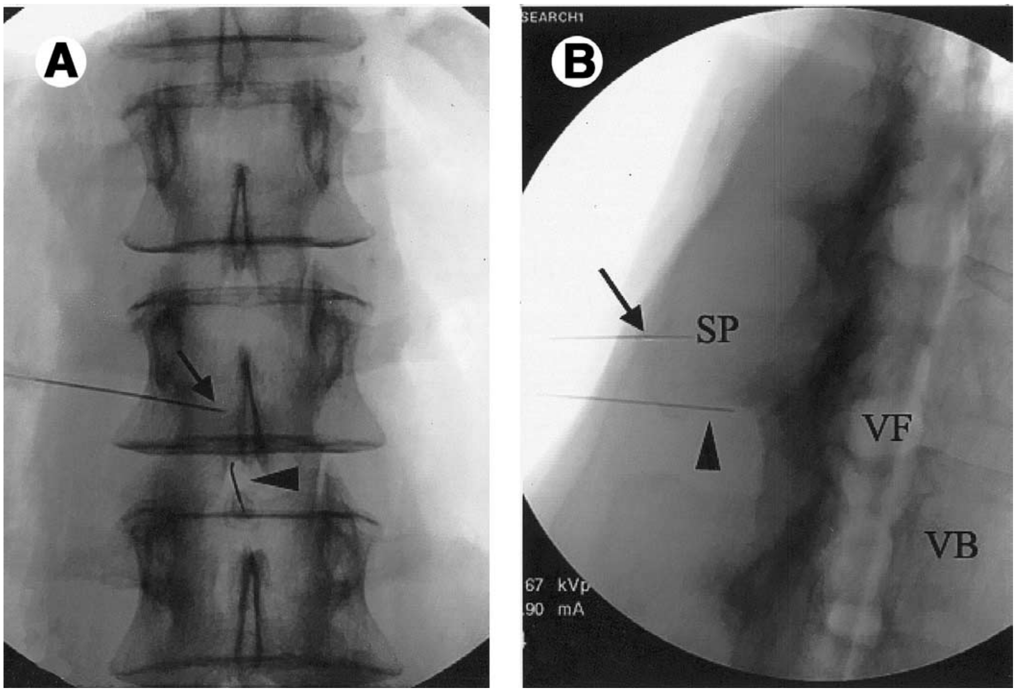

Fig 2. The Haig and the Stein method needle positions. (A) AP fluoroscope view showing needle positions of the Haig (arrow) and the Stein (arrowhead) methods. (B) Lateral view. Needle tip is positioned into a fascicle close to the origin using the Stein method. With the Haig method, the needle tip is located more superficially and inserted into a muscle belly originating from the upper segment spinous process. Abbreviations: SP, spinous process; VB, vertebral body; VF, intervertebral foramen.

the medial branch of the dorsal ramus issuing from below that vertebra.[11-13] For electrodiagnostic study in the evaluation of suspected radiculopathies, accurate positioning of the needle into the multifidus muscle innervated by a suspected nerve root is critical.

Haig[9] and Stein[10] and colleagues reported 81% and 88% success rates for accurate needle insertion, respectively. Our results show lower success rates (73% and 66%, respectively). Haig[9] reported the frequency of erroneous superficial needle positions as 16%. Needle positions were all in the superficial adipose tissue directly overlying the correct muscle, with no other muscles in between. Haig[9] suggested that electromyographic guidance would have afforded correct positioning. However, this approach does not consider the erector spinae, which is more superficially located than multifidus muscle. In our study, 22 injections (18%) were into superficiolateral muscle rather than into adipose tissue. Although superficiolaterally located muscle is thin, the risk of erroneous needle placement can be greater in obese patients. Compared with the Stein paramedian technique, the Haig technique affords a more superficially located needle tip (see fig 2).

In the Stein paramedian technique, the distance from midline for needle insertion is very close (3mm). Stein[10] claimed greater anatomic accuracy relative to the Haig technique because of the greater proximity of the needle insertion site to surface landmarks. Our results showed greater repeatability between 2 examiners in the Stein paramedian technique than in the Haig technique (24 vs 14 injections that were aborted due to same needle position with previous investigator) but less accurate needle placement into targeted muscles.

Needle insertions relatively close to the midline may afford inadvertent insertion into the spinous process. The problem can be solved clinically through needle redirection guided by insertional activity, but needle insertion into midline structures such as bony process and ligament may evoke pain and interrupt accurate examination. As shown in our study, redirection can also involve erroneous insertion into lateral fascicles originating from upper segments and innervated by upper roots (12/120 insertions [10%]). Failed injections obtained with the Stein technique may be related to needle insertion into the common tendon of the long multifidus fascicles. Twenty-four injections failed to inject dye due to high pressure.

Occasionally, we found dye around tendons along the needle path. If the electromyographer has not detected insertional activity using the Stein technique, slight caudal angulation would place the needle correctly. Although Stein suggested reduced inadvertent subarachnoidal puncture relative to the Haig technique, we documented 3 injections into the spinal canal, whereas the Haig technique afforded no spinal canal injections. Needle insertion depth was limited to 2.5cm, based on the distance from the skin to the epidural space (3–7.8cm in the midlumbar area, related to patient weight).[14] However, extreme caution is required, especially with slender women. Shiroyama et al[15] recently reported a median depth of 3.5cm (range, 2.5–6.5cm). Distances from the skin to the epidural space in the Japanese obstetric population were 3 to 4cm in 80% of cases. Although needle depth was limited to 2.5cm during the procedure using the Stein technique, there was still a risk of inadvertently inserting the needle into the subarachnoid space, especially in low-weight, slender patients.

The targeted multifidus fascicle is supplied by a root that exits directly above the intervertebral foramen and is located more medially, and at a deeper site, adjacent to the lamina.[12,13] One accurate method for needle placement involves insertion toward the base of the lamina and spinous process, with subsequent withdrawal after contacting bone. In the

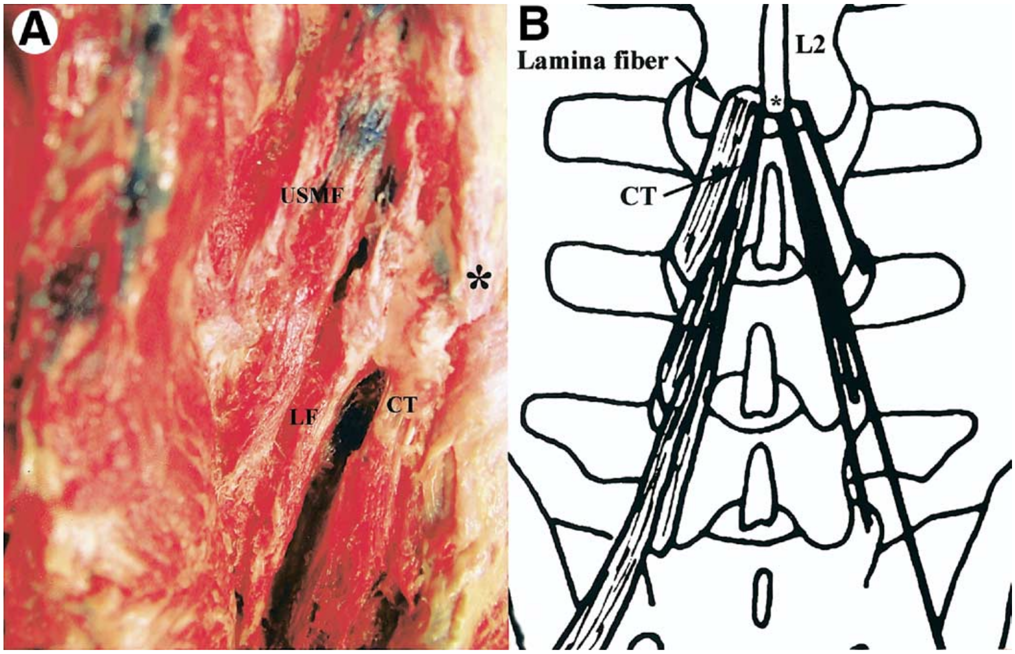

Fig 3. (A) Cadaver dissection. Colored latex dye is located in the muscle fascicle. (B) Schematic diagram of multifidus muscle fascicles originating from L2 and innervated by the L2 nerve root.[11] Abbreviations: CT, common tendon of longer fascicles that diverge caudally to attach separately to mamillary processes, the iliac crest, and the sacrum; LF, lamina fiber arising from the caudal end of the dorsal surface of the vertebral lamina, inserted into the mamillary process of the vertebra 2 levels caudad; USMF, multifidus fascicles originating from the upper vertebra. *Inferior margin of the L2 spinous process.

Haig technique, a 45° angulation relative to skin affords a greater probability of superficial needle location. The Stein technique is ideal for inserting the needle into deep muscle, with the disadvantage of inadvertent subarachnoid puncture risk and erroneous sampling of fascicles innervated by the upper root. Less acute angulation, with a closer distance from the midline relative to the Haig technique, may increase needle positioning accuracy and decrease the risk of inadvertent subarachnoidal puncture. We suggest a modified Haig method involving less acute needle angulation relative to the skin surface and closer insertion from the midline. This recommendation is based on this study's empirical data and has not been tested. In addition, we can consider the matter of difference in multifidus muscle size related to age. We used cadavers of older donors (mean age, 73.8y), which may have had atrophied multifidus muscles, resulting in difficulty in placing an electromyographic needle into the muscle. This age effect may explain the differences in success rates of needle placement into the multifidus between our study and previous studies. However, previous studies have not mentioned the age of cadaver subjects.

Table 1: Comparison of Dye Localization Utilizing 2 Techniques

Injection Result	Haig Technique (n=120)	Stein Technique (n=120)
On target*	76	55
Missed target		
Into wrong muscle	20	10
Into subcutaneous fat	2	0
Into spinal canal	0	3
Failed injection†	0	24
Missing	8	2
Aborted injection (correct + incorrect)‡	14 (12+2)	26 (24+2)
Successful needle position, n (%)§	88 (73)	79 (66)

*Dye found in targeted multifidus fascicle.
†Dye injection failed because of pressure resistance.
‡Second electromyographer aborted injection after fluoroscopic confirmation of needle position in the same location as the first electromyographer; correct, first electromyographer injection found in the targeted multifidus fascicle.
§On-target injections plus correct injections aborted after fluoroscopic confirmation.

Many medical procedures such as blind epidural injections, paraspinal electromyography, and chiropractic maneuvers rely on palpation to accurately locate anatomic sites in the lumbosacral spine. In addition, the studies by Haig[9] and Stein[10] and colleagues also used palpation only for needle placement into the targeted muscle. A few studies[16-20] have suggested that palpation alone is not accurate enough to determine exact locations of commonly accepted bony landmarks in the lumbosacral spine. Bates et al[17] showed that a line drawn across the iliac crests could identify the L4 spinous process. However, this technique has been criticized. In a radiographic study of 163 patients, the spinal intersection of a line joining the iliac crests coincided with L4 in only 78% of the patients.[18] Therefore, the iliac crest rule does not apply to all patients. The high frequency of spine anomalies also contributes to palpation errors. As many as 11% of people have sacralization of L5 and an additional 5% have an L6 vertebra.[19] Obesity also plays a role in decreasing the accuracy of lumbar interspinous space identification when using only palpation.[20] Use of fluoroscopy in our study may also explain the difference in the success rate of accurate needle placement compared with previous studies.

CONCLUSIONS

Our results show nonoptimizing accuracy of previous techniques for multifidus needle electromyography. Modified techniques based on previous methods can offer more accurate, safer examinations. This muscle electromyography study may allow a more precise localization of root levels in lumbar radiculopathy. Further study in the clinical setting is required to evaluate clinical utility.

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