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An Original Contribution

Electrical Stimulation Induced Cervical Medial Branch Referral Patterns

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Study Design: Electrical stimulation of the right cervical medial branches with or without the third occipital nerves was performed in nine subjects for a total of forty-eight medial branches and eight third occipital nerves. The referral patterns of each nerve or nerve branch was mapped on a human line diagram. These diagrams were compared to facet joint (zygapophyseal joint, facet joint), myofascial, and discogenic referral patterns already published by various authors.

Objective: To determine the referral patterns of the cervical medial branches and the third occipital nerve.

Hypothesis: The cervical medial branch referral patterns created by electrical stimulation may differ from those reported from other etiologies and may prove to be useful when considering various cervical pain syndromes.

Methods: The third occipital nerve and third through eighth medial branches of the cervical posterior rami of nine subjects with and without a history of neck pain were electrically stimulated under fluoroscopic imaging. All subjects were blinded to the level of stimulation, and the referral patterns of each individual were mapped out on a human line drawing by the primary author of this study. These referral patterns were compared to referral patterns reported from other etiologies by various authors.

Conclusions: Electrical stimulation of the third occipital nerve as well as the medial branch of the right C3-C8 posterior primary rami create discrete, reproducible referral patterns which differ from those reported from other etiologies by various authors.

Keywords: Zygapophyseal joint, facet joint, medial branch, referral pattern, myofascial pain, headaches, discogenic

Neck pain is a poorly understood symptom and is often ascribed to "disk disease" or "soft tissue injury" (1). Any structure innervated by the cervical spinal nerves can be a source of neck pain and referred pain to the head, upper limb, or chest wall (2). It is important to correctly identify the appropriate pain generator in order to effectively treat neck pain. Various researchers have published data derived from the stimulation of somatic structures in order to help identify the etiology of pain syndromes when they present clinically. In 1938, Lewis (3) published the results of injecting various noxious substances into muscles, ligaments, and periosteum and found that the pain quality and pattern provoked was more dependent upon the structure injected and less dependent upon the substance injected. Also in 1938, Kellgren (4) published pain patterns derived from the injection of 6% hypertonic saline into muscles. In 1939, Kellgren and Lewis (5) combined efforts to publish a more detailed work relating to reflex and autonomic changes associated with pain produced from the injection of noxious substances into various tissues. In 1959, Cloward (6) published pain patterns obtained from the stimulation of cervical discs during discography. Facet pain (zygapophyseal, Z-joint, apophyseal joint) pain was first described by Goldwait (7) in 1911. In 1933, Ghormley (8) first coined the phrase "facet syndrome." Subsequently, a number of researchers have implicated the facet joint as a source of back pain (9-72). In 1976, Mooney and Robertson (9) published the referral patterns created by fluoroscopically guided intra-articular lumbar facet joint injections with hypertonic saline in both symptomatic and asymptomatic volunteers. In 1979, these results were confirmed by McCall et al (10). Recently, the facet joint syndrome has been called into question (12, 73). It has also been reported that a trained manual therapist can accurately identify the level and side of a painful facet joint (2) although Schwarzer et al (12) have demonstrated that history and physical examination are inaccurate in identifying painful facet joints as identified by diagnostic injections.

Cervical facet joints have been shown by many authors to be a source of neck pain (1, 74-113). Carefully performed anesthetic blocks of the medial branches of the cervical posterior primary rami are a specific and sensitive test for the diagnosis of facet joint pain (1). Each cervical facet joint below C2-C3 is supplied with sensation by the medial branch of the posterior rami above and below. The C2-C3 facet joint differs in that it is supplied by the third occipital nerve and a small, inconstant branch from the greater occipital nerve (77). The C3-C8 medial branches consistently curve around the "waist of the pillar" of the same numbered vertebrae. Many researchers do not feel that the CO-C1 and C1-C2 are not true facet joints. While they are diarthrodial joints like facet joints, they differ in that they are located anterior to the facet joint line, are innervated by the C1 and C2 anterior ramus respectively, and their spinal nerves exit posterior to the joint, not as at all other levels of the spine.

Diagnostic lumbar intra-articular injections and medial branch blocks have been used to determine the role of these joints in the production of back pain (8-

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30, 32, 35-42, 49, 57, 58, 61-68, 70-74). Similarly, diagnostic joint injections and medial branch blocks have been used to identify painful facet joints in the cervical spine (76-78, 81-113). There have been many reported methods of treating painful cervical facet joints. After carefully controlled, positive diagnostic blocks, radiofrequency neurotomy of medial branches may be effective in providing pain relief in those suffering from chronic neck pain of facet joint etiology (75, 103, 104, 108-113). There have been mixed reports regarding the efficacy of intra-articular corticosteroid injections of the cervical facet joints. Several studies tout the benefits of such injections (84, 87, 88). However, Barnsley et al (100) reported no benefit of intra-articular injection of corticosteroid following whiplash injury.

Studies published by Dwyer et al (75) and Fukui et al (96) have demonstrated that the distention of asymptomatic and symptomatic cervical facet joints with non-ionic contrast medium may provoke neck pain and referred pain (Fig. 1). Stimulation of the C2-C3 facet joint provokes occipital head pain, stimulation of the C4-C5 through C6-C7 provokes shoulder pain, and stimulation of the C7-T1 facet joint provoked interscapular pain (94). Dreyfuss et al (83, 88) has demonstrated that provocation of the CO-C1 joint provides a variable referral pattern and C1-C2 joint consistently refers pain to the occiput.

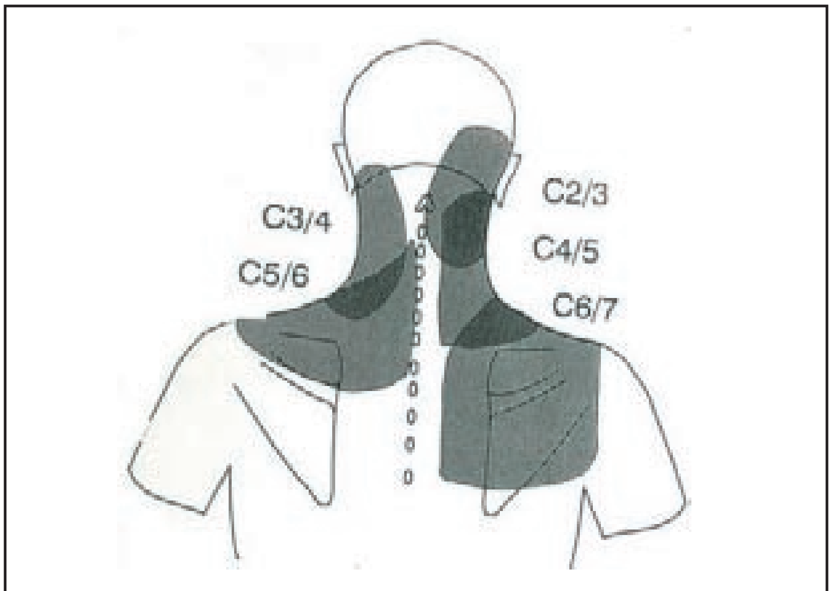


Fig. 1. A map of the characteristic areas of pain referral from cervical facet joints of C2-C3 through C6-C7 (75).

The object of this study was to stimulate the cervical medial branches and third occipital nerve to determine if there was a consistent referral pattern that is distinct from the referral pattern arising from the previously published intra-articular stimulation of the cervical facet joints.

Methods

Nine healthy subjects with and without a history of neck pain and headaches were selected for this study. All nerve studied were on the right side of the neck. Forty-one medial branches and eight third occipital nerves were evaluated. The principal author performed the procedure on all subjects. The subjects were placed prone on a radiolucent fluoroscopy table. The posterior aspect of their neck and shoulder girdles were prepped with isopropyl alcohol and povidone iodine 10% solution in a sterile manner and draped with sterile towels. For upper cervical stimulation, the head was rotated slightly to the left side to remove the mandible from the relevant fluoroscopic view. The image intensifier was rotated in a slightly caudal manner to make the pillar view more prominent. The waist of the pillar view and lateral border of the C2-C3 facet joint was identified in all subjects. The skin and subcutaneous tissues was infiltrated with buffered 1% Lidocaine prior to initiating stimulation. Care was taken to avoid anesthetizing the facet joints or medial branches. A Radionics RFG Plus unit (Radionics, 22 Terry Avenue, Burlington, MA 01803) was utilized for each procedure and subject was appropriately grounded.

Using an "en pointe" approach, with a 22G 100.5 mm SMK probe with an exposed, curved active tip or a 20G 145 mm SMK probe with a 5mm curved, active tip was used for the procedure. The active electrode was initially placed down to the waist of the pillar view for stimulation of the C3-C6 medial branches, the junction of the C7 superior articular process and the C7 transverse process for stimulation of the C7 medial branch, and the T1 superior articular process and the T1 rib for stimulation of the C8 medial branch. For the third occipital nerve, the active tip was initially placed down to the lateral mid point of the C2-C3 facet joint (78). Once the probe was in an adequate radiographic position, the nerve was stimulated at 50 Hz. In each case, the probe was manipulated until the sensory threshold was less than 0.5 volts however; the threshold was usually less than 0.35 volts. In each individual, the third occipital nerve was found either at the mid point of the convexity of the C2-3 facet joint or at the junction of the middle and lower third of the convexity of the C2-C3 facet joint. The C7 medial branch was also slightly variable in location. In five individuals it was found and the junction of the C7 superior articular process and the C7 transverse process however in the other four individuals it was found further laterally and caudally on the transverse process. During each stimulation, the referral of stimulation was mapped on a human line drawing by the second author with direction from the patient and the first author. At no time was there radicular stimulation. No complications were observed.

Results

Relatively reproducible referral patterns were identified in each subject and for each medial branch or third occipital nerve stimulated (Table 1A and 1B). In all subjects, stimulation of the third occipital nerve caused paresthesia immediately caudal to the nuchal ridge and immediately lateral to the C2-C3 joint. In addition to this region of stimulation, one of the subjects reported a "vibration" throughout the ipsilateral occiput (Fig. 2A). Stimulation of the C3 and C4 medial branch caused a quar-

Table 1A. Sketches of medial branch referral patterns of subjects 1-5 on a human line drawing by level.

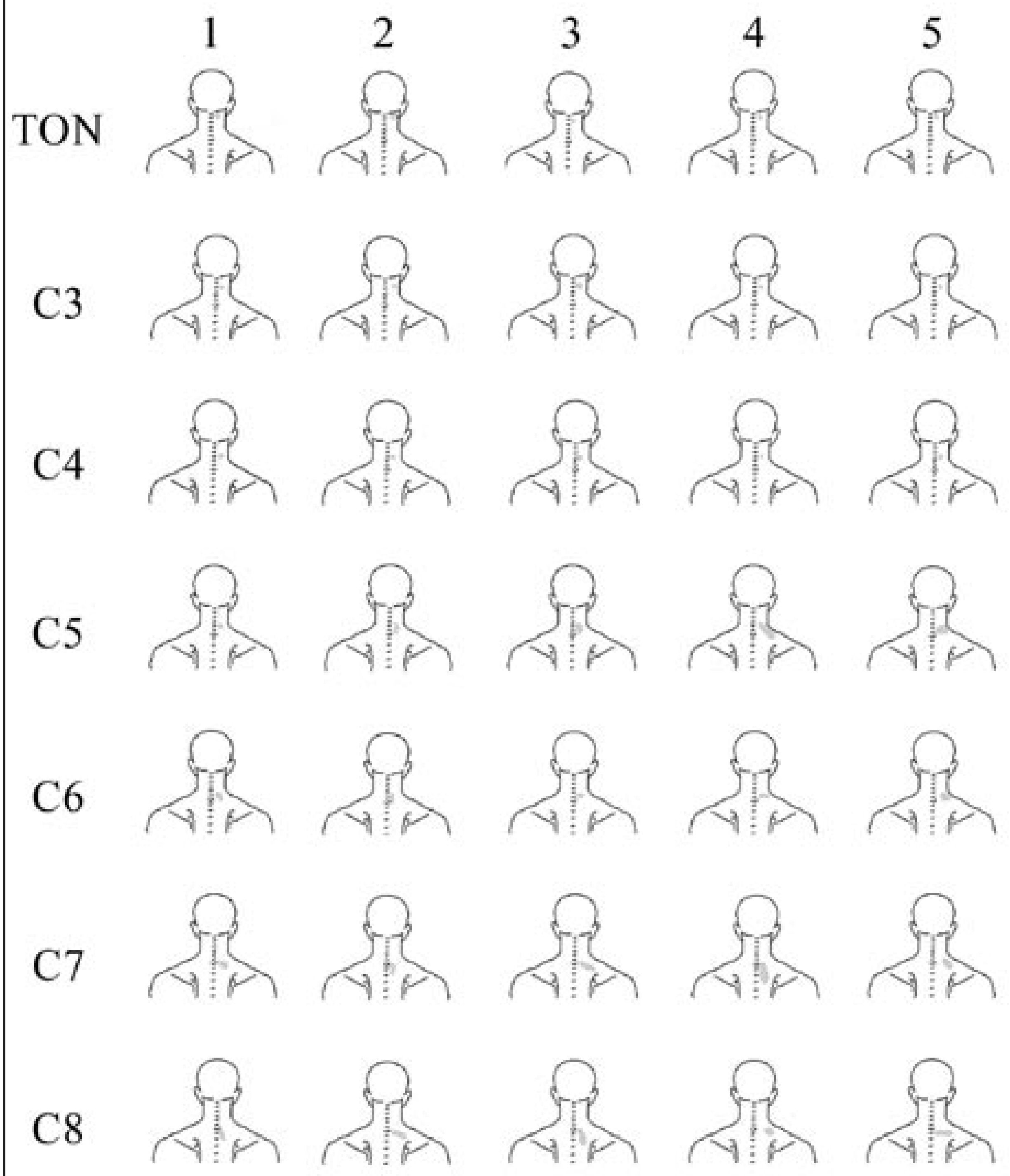
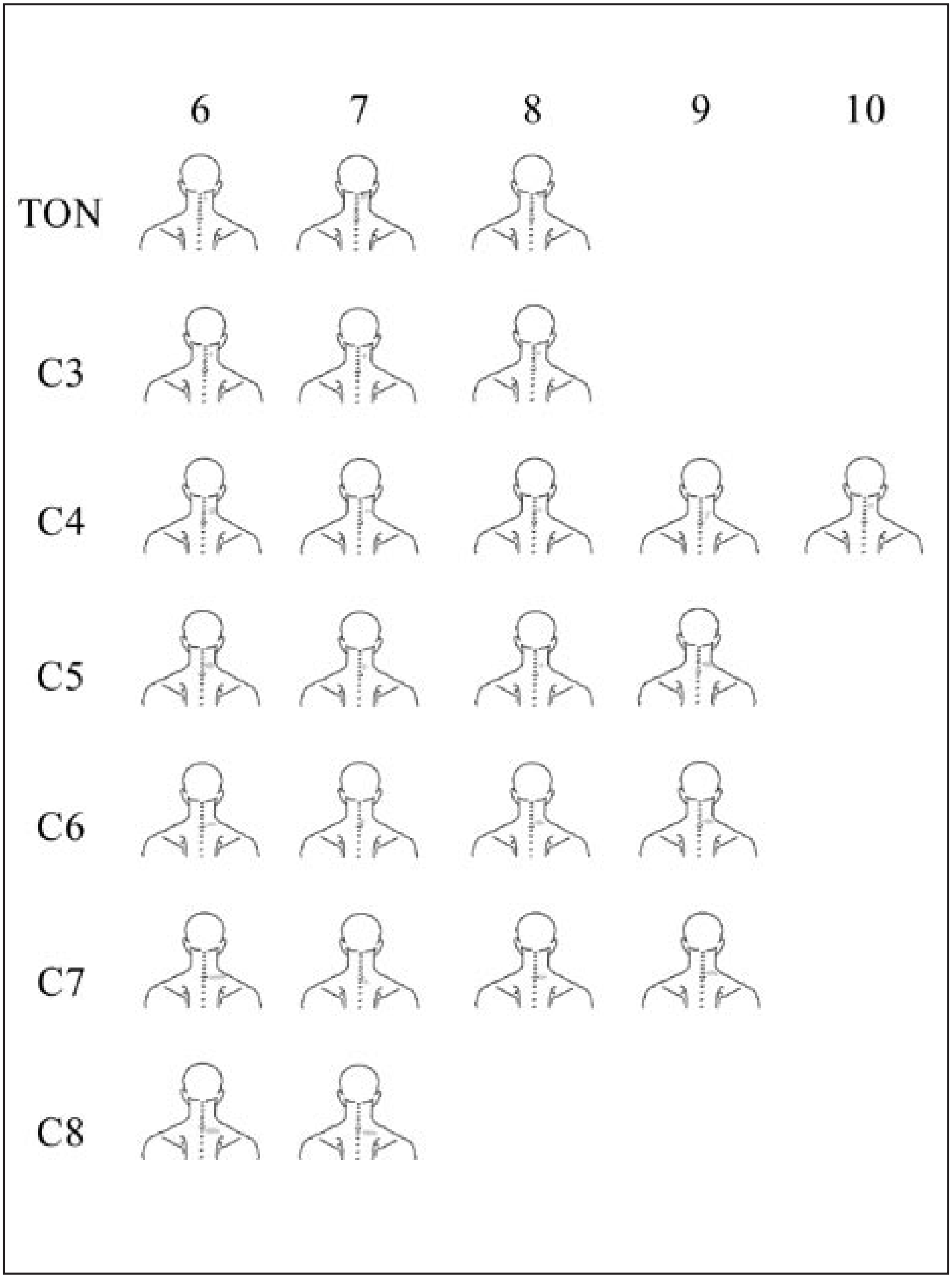


Table 1B. Sketches of medial branch referral patterns of subjects 6-10 on a human line drawing by level.



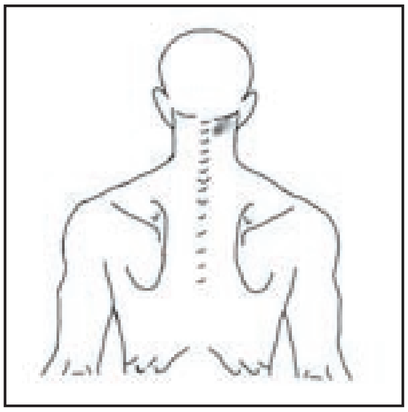


Fig. 2A. A composite drawing of the referral zones of all subjects derived from the minimal threshold stimulation of their right third occipital nerve.

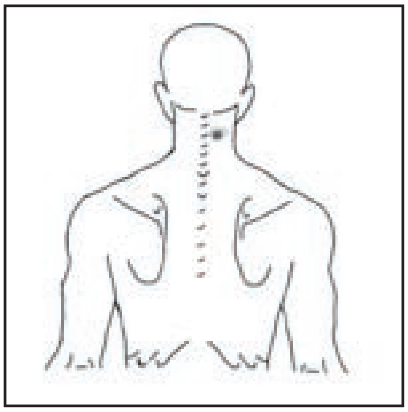


Fig. 2B. A composite drawing of the referral zones of all subjects derived from the minimal threshold stimulation of their right C3 medial branch.

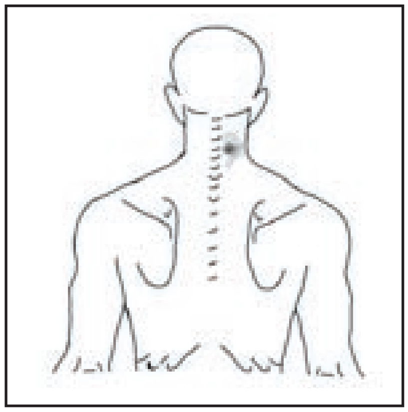


Fig. 2C. A composite drawing of the referral zones of all subjects derived from the minimal threshold stimulation of their right C4 medial branch.

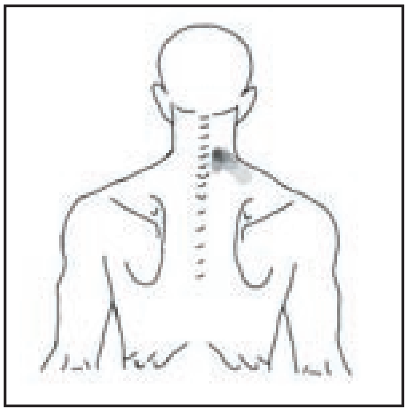


Fig. 2D. Is composite drawing of the referral zones of all subjects derived from the minimal threshold stimulation of their right C5 medial branch.

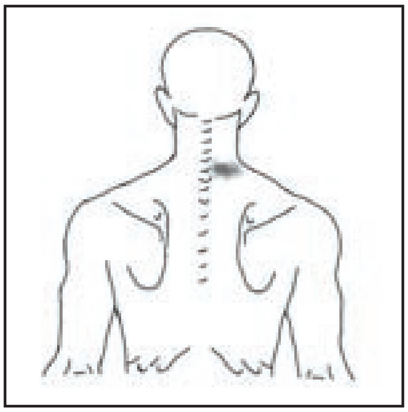


Fig. 2E. Is a composite drawing of the referral zones of all subjects derived from the minimal threshold stimulation of their right C6 medial branch.

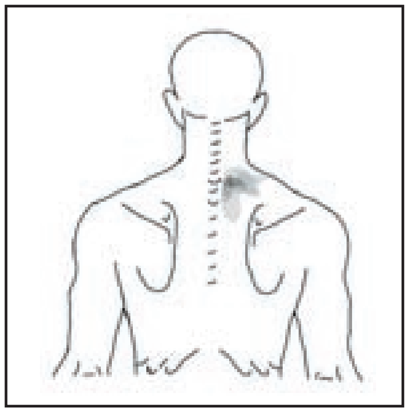


Fig. 2F. A composite drawing of the referral zones of all subjects derived from the minimal threshold stimulation of their right C7 medial branch.

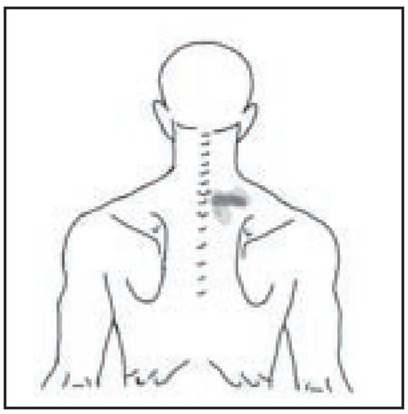


Fig. 2G. A composite drawing of the referral zones of all subjects derived from the minimal threshold stimulation of their right C8 medial branch.

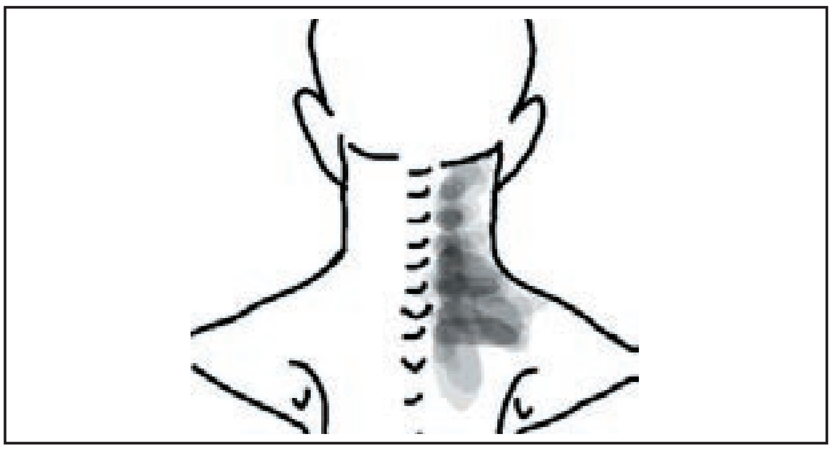


Fig. 3. A composite drawing of the referral patterns of all subjects derived from the minimal threshold stimulation of their right third occipital nerve and C3-C8 medial branches.

ter sized and shaped paresthesia immediately over or lateral to the C3-4 joint. In addition to this pattern, one individual reported paresthesia radiating caudally from the point of stimulation approximately 5 cm (Figs. 2B and 2C). Stimulation of the C5 medial branch caused a 3-4 cm circular or oval region of paresthesia immediately lateral and caudal to the C5-C6 joint. In addition, two subjects reported a 2 x 5 cm region of paresthesia extending caudally from the point of maximal stimulus. One other subject also reported a 2 x 5 cm oval region of stimulus originating at the point of maximal stimulus and radiating obliquely toward the right shoulder (Fig. 2D). In five subjects, stimulation of the C6 medial branch caused a more or less circular region of stimulus that was 2-4 cm in diameter approximately 5 cm lateral to the midline at the C5-6 level and one subject reported a 2 cm circular region of stimulus immediately lateral to midline at the C5-6 level. In addition, one subject reported a 1 x 4 cm oval region of stimulus extending in a caudal direction with the point of maximal tenderness immediately lateral to the C5-6 facet joint and two subjects noted a 2 x 5 cm oval region of stimulus extending in horizontally and laterally away from the C5-6 facet joint (Fig. 2E). In stimulating the C7 medial branch, four subjects noted a circular region of stimulus lateral to the C6-7 facet joint ranging in size from 2-4 cm in diameter, three subjects noted an obliquely oriented paresthesia pattern directed toward the superomedial angle of the right scapula, one subject noted a vertically oriented paresthesia pattern extending caudally from the C6-7 facet joint in the facetal line, and one subject noted a horizontally and laterally directed paresthesia pattern extending from the C6-7 facet joint (Fig. 2F). In stimulating the C8 medial branch four subjects noted a horizontally arranged paresthesia pattern extending laterally from the C7 level, two subjects noted obliquely oriented paresthesia patterns emanating from the C7 level and extending toward the right interscapular region, and one subject reported a circular 3 cm region of stimulus approximately 5 cm lateral to the right C6-7 facet joint (Fig. 2G). In all cases of distally referred stimulation, the point of maximum stimulus was closest to the spine and dissipated the further it went from the spine. If the stimulus was increased the size of the stimulation footprint increased (Fig. 3). If the referred stimulation was non-circular and extended from the spine, then a stronger stimulus would cause it to extend further from the spine. In no case did the stimulus extend along a radicular or dermatomal pattern.

Discussion

Several researchers have identified various etiologies of referred pain of spinal etiology. This report has demonstrated that the medial branch of the cervical posterior primary rami and the third occipital nerve, when stimulated individually has a separate and distinct referral pattern from the referral patterns previously published. Entrapment of the medial branch has been identified in the lumbar spine (72, 114, 115) and may occur in the cervical spine. Injury to the medial branch may occur from systemic metabolic conditions such as diabetes (116). Since the cervical facet joint is innervated by the medial branch above and below (77), it seems appropriate that the referral pattern arising from stimulation of the facet joint and each of its medial branches individually would be different. Since the signal arising from stimulation of a facet joint must travel along each of its two medial branches, pass through their respective dorsal root ganglia, and travel to their respective receptive fields on the dorsa horn via the second order neuron, it seems reasonable that the receptive field for the facet joint should be larger than that of the medial branch alone. Indeed, we found the area of perceived stimulation of the medial branch and third occipital nerve to be substantially smaller than that induced by stimulation of the facet joint. Under unusual circumstances of chronic or severe pain, patients may experience "wind up" thus causing the region of referred pain to be enlarged when compared to normal subjects (117). This phenomenon must be taken into account when considering this data during the treatment of pain patients.

Conclusion

All 64 referral patterns were meticulously mapped and well controlled. All of the subjects' referral patterns agreed well with one another except for some minor variation in orientation. In general, all referral patterns were isolated to a small region lateral to the point of stimulation. Orientation of the referral pattern varied slightly in 40% of subjects in the lower cervical spine but not enough to discount injury or irritation of the medial branch as a possible etiology of a focal cervical pain syndrome.

These referral maps differ from those reported for the cervical facet joints and may have different clinical implications. These referral maps may provide the clinician with additional insight when evaluating a patient with suboccipital, cervical, or shoulder girdle pain.

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