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Referred pain distribution of the cervical zygapophyseal joints and cervical dorsal rami

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Summary The purpose of this study was to determine the distribution of referred pain from the cervical zygapophyseal joints (C0/1 to C7/Th1) and the cervical dorsal rami (C3 to C7). The subjects were 61 patients who had occipital, neck, and shoulder pain of suspected zygapophyseal origin in whom pain was reproduced by injection of contrast medium into the joints or by electrical stimulation of the dorsal rami. Under fluoroscopic control, the zygapophyseal joints from C0/1 to C7/Th1 were stimulated by the injection of contrast medium and while electrical stimulation of the cervical zygapophyseal dorsal rami at segments C3 to C7 was performed during facet denervation. If injection or electrical stimulation reproduced the patient's usual pain, the distribution of referred pain was determined and the sites of referred pain were divided into 10 areas. A total of 181 joints and 62 segments were studied. Each joint and dorsal ramus produced referred pain with a characteristic distribution. The main distribution of referred pain was as follows. Pain in the occipital region was referred from C2/3 and C3, while pain in the upper posterolateral cervical region was referred from C0/1, C1/2, and C2/3. Pain in the upper posterior cervical region was referred from C2/3, C3/4, and C3, that in the middle posterior cervical region from C3/4, C4/5, and C4, and that in the lower posterior cervical region from C4/5, C5/6, C4, and C5. In addition, pain in the suprascapular region was referred from C4/5, C5/6, and C4, that in the superior angle of the scapula from C6/7, C6, and C7, and that in the mid-scapular region from C7/Th1 and C7.

Key words: Zygapophyseal pain; Cervical zygapophyseal joint; Referred pain; Dorsal rami; Radiofrequency facet denervation; Neck pain

Introduction

Various structures in the cervical spine, such as the zygapophyseal joints, intervertebral discs, root ganglia, muscles, and ligaments, are capable of causing headache, neck pain, and shoulder pain (Bogduk and Aprill 1993).

Recently, many studies have focused on the zygapophyseal joints as a significant cause of back pain. Bogduk and Marsland (1988) reported that cervical medial branch block and zygapophyseal joint block relieved pain completely in 17 out of 24 patients with chronic neck pain. The cervical zygapophyseal joints have also been reported to be a significant source of cervicogenic headache (Edmeads 1988; Busch and Wilson 1989; Bovim et al. 1992). Thus, the zygapophyseal joints are increasingly being recognized as a significant source of cervicogenic headache, neck pain, and shoulder pain (Edmeads 1988; Aprill and Bogduk 1992; Bovim et al. 1992).

Zygapophyseal joint block and arthrography have been used as both diagnostic and therapeutic procedures. Reproduction of pain by distension of the joint after the intraarticular administration of contrast medium and relief of pain by zygapophyseal joint block have been used as the diagnostic criteria up until now (IASP Task Force on Taxonomy 1994). When zygapophyseal joint block does not yield long-term improvement, radiofrequency denervation is commonly performed as a safe method of achieving long-lasting pain relief (Sluijter and Koestsveld-Baart 1980; Uerrest and Stolker 1991). Zygapophyseal joint arthrography has previously been utilized by some authors to determine the distribution of referred pain (Dwyer et al. 1990; Dreyfuss et al. 1994). Bogduk and Marsland (1988) reported that neck pain with headache arose from the C2/3 joint and neck pain with shoulder pain was derived from the C5/6 joint after performing diagnostic cervical medial branch block and zygapophyseal joint block in 24 consecutive neck pain patients. Dwyer et al. have described the

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distribution of referred pain for the C2/3 to C6/7 joints, while Dreyfuss et al. reported the patterns of referred pain from C0/1 and C1/2 in five normal volunteers. In the present study, we determined the distribution of pain arising from the cervical zygapophyseal joints from C0/1 to C7/Th1 in a large number of patients with suspected zygapophyseal joint pain. In addition, to confirm the validity and reliability of the referred pain maps for each zygapophyseal joint, the pain patterns evoked by electrical stimulation of the cervical zygapophyseal dorsal rami from C3 to C7 were studied during cervical facet denervation.

C2/3 is innervated by the third occipital nerve with a small inconstant contribution from a communicating branch of the great occipital nerves, while each zygapophyseal joint below C2/3 is innervated by the medial branches of the cervical dorsal rami above and below its location (Bogduk 1982; Bogduk and Marsland 1988).

The accuracy, validity, and reliability of the joint pain distribution maps was confirmed by comparing the pattern of referred pain on C2/3 joint injection to that generated by stimulation of the C3 dorsal rami, while the maps for the cervical zygapophyseal joints below C2/3 were compared to the results of stimulation of the dorsal rami above and below each joint.

Materials and methods

The subjects were 61 patients who underwent cervical zygapophyseal joint injection and radiofrequency facet denervation at the pain clinic of either the Kantou Teishin Hospital, the Jikei University Hospital, or the Hannnan Central Hospital between March 1994 and January 1996. The patients complained of occipital, neck, and shoulder pain, had well localized paravertebral tenderness over the zygapophyseal joints, and were suspected to have zygapophyseal joint pain.

The site of injection was chosen to correspond to any focal paraspinal tenderness.

Under image intensifier control, the symptomatic joints at C0/1 and C1/C2 were entered via a lateral approach, while the joints from C2/3 to C7/Th1 were entered via a posterior oblique approach (Dory 1983; Dussault and Nicolet 1985; Wedel and Wilson 1985). For the posterior oblique approach, the patient was placed on the fluoroscopy table in the prone oblique position with the thorax resting on two pillows. The neck was flexed and the head was turned 60–90° away from the side of injection so as to obtain a prone oblique view. The C-arm was angled in a cephalad to caudal manner until the joint cavity was maximally visualized. Under fluoroscopic guidance, a 22 gauge needle was advanced into the target joint and a small quantity of contrast medium (iohexohl; Omnipaque) was injected. The accuracy of placement was confirmed by arthrography of the joint and injection was continued under constant imaging until pain occurred or the intra-articular pressure increased and further contrast medium could not be safely injected without potentially rupturing the capsule. Then, a mixture of 0.5–1 ml of local anesthetic (1% mepivacaine) and 1 mg of dexsamethazone was injected into the zygapophyseal joint space as a therapeutic procedure.

Patients whose pain was reproduced by the injection of contrast medium and relieved temporarily by zygapophyseal joint block were selected for facet denervation.

Under fluoroscopic control, facet denervation of the dorsal rami above and below the symptomatic joint was performed when stimulation reproduced the patient's pain. A radiofrequency generator (Radionics Model RFG-34f) was used to supply current through a 22 gauge needle electrode (Sluyter-Meta-Kit; 100 mm long with a 4 mm exposed tip) for coagulation of the dorsal rami. The procedure was performed with the patient lying on the fluoroscopy table in the oblique position and with the affected side raised by 20°.

The target area for facet denervation was the waist of the vertebral articular pillar where the medial branch of the cervical dorsal ramus shows a constant relationship to the bone.

Precise needle placement was verified with electrical stimulation at 2, 5, 20, and 50 Hz to identify the exact position of the dorsal ramus. With stimulation at 2 and 5 Hz, attempts were made to elicit a tingling sensation or paraspinal muscle contraction in the neck at an intensity of less than 1 V. With sensory stimulation of 20 and 50 Hz, attempts were made to cause paraesthesia and to elicit exact or similar reproduction of the patient's usual pain at an intensity of less than 1 V. If the patient felt stimulation at a threshold under 1.0 V, this was accepted as confirmation that the needle tip was close to the nerve. Otherwise, the electrode was repositioned. After checking the position by injection of a small amount of contrast medium, the medial branch was anesthetized with 0.3 ml of 2% mepivacaine and a radiofrequency lesion was made at 90°C over 90–180 s.

During injection and facet denervation, each patient was asked whether their usual pain was reproduced. When the patient's pain was reproduced by capsular distension during arthrography and electrical stimulation, the patient was asked to describe the distribution of the induced pain. In order to simplify the comparison of pain distributions, the sites of referred pain were classified into the following 10 regions: (1) occipital region, (2) upper posterolateral cervical region (posterior auricle towards the mastoid process), (3) upper posterior cervical region, (4) middle posterior cervical region, (5) lower posterior cervical region, (6) suprascapular region, (7) superior angle of the scapula, (8) mid-scapular region, (9) shoulder joint, and (10) upper arm (Fig. 1). The subjects were restricted to patients whose usual pain was reproduced by intraarticular injection or by electrical stimulation of the dorsal rami.

A total of 61 patients were studied (181 joints and 62 dorsal rami). There were 10 C0/1 joints, 10 C1/2 joints, 14 C2/3 joints, 21 C3/4 joints, 46 C4/5 joints, 46 C5/6 joints, 27 C6/7 joints, and 7 C7/Th1 joints, as well as 8 C3 rami, 11 C4 rami, 21 C5 rami, 15 C6 rami, and 7 C7 rami. The patients were aged from 25 to 81 years, with a mean age of 51.1 years. There were no significant complications arising from the procedure.

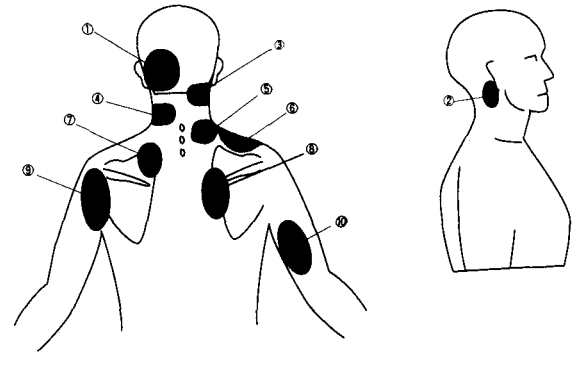

Fig. 1. Referred pain distributions: (1) () occipital region; (2) upper posterolateral cervical region; (3) upper posterior cervical region; (4) middle posterior cervical region; (5) lower posterior cervical region; (6) suprascapular region; (7) superior angle of the scapula; (8) midscapular region; (9) shoulder joint; (10) upper arm.

TABLE I

REFERRED PAIN DISTRIBUTIONS FOR THE ZYGAPOPHYSEAL JOINTS FROM C0/1 TO C7/TH1 AND THE DORSAL RAMI FROM C3 TO C7

	1	2	3	4	5	6	7	8	9	10
C0/1 ($N = 10$)	3 (30)	10 (100)	–	–	–	–	–	–	–	–
C1/2 ($N = 10$)	2 (20)	10 (100)	–	–	–	–	–	–	–	–
C2/3 ($N = 14$)	7 (50)	7 (50)	9 (64)	2 (14)	–	–	–	–	–	–
C3/4 ($N = 21$)	8 (38)	–	16 (76)	11 (52)	–	–	–	–	–	–
C4/5 ($N = 46$)	–	–	1 (2)	25 (54)	35 (76)	20 (43)	1 (2)	–	1 (2)	–
C5/6 ($N = 46$)	–	–	2 (4)	7 (15)	21 (46)	23 (50)	16 (35)	2 (4)	5 (11)	2 (4)
C6/7 ($N = 27$)	–	–	–	1 (4)	9 (33)	3 (11)	13 (48)	11 (41)	4 (15)	1 (4)
C7/Th1 ($N = 7$)	–	–	–	–	–	1 (14)	2 (28)	6 (86)	2 (28)	1 (14)
C3 ($N = 8$)	4 (50)	2 (25)	8 (100)	2 (33)	–	–	–	–	–	–
C4 ($N = 11$)	–	–	1 (9)	5 (45)	6 (55)	6 (55)	–	1 (9)	1 (9)	–
C5 ($N = 21$)	–	–	–	3 (14)	11 (52)	6 (29)	7 (33)	–	4 (19)	–
C6 ($N = 15$)	–	–	–	–	3 (20)	5 (33)	7 (47)	5 (33)	4 (27)	2 (13)
C7 ($N = 7$)	–	–	–	–	2 (29)	1 (14)	5 (71)	5 (71)	2 (29)	–

1 = occipital region; 2 = middle posterior cervical region; 3 = upper posterior cervical region; 4 = middle posterior cervical region; 5 = lower posterior cervical region; 6 = suprascapular region; 7 = superior angle of the scapula; 8 = midscapular region; 9 = shoulder joint; 10 = upper arm. Data in parentheses are percentages.

Results

The distribution of referred pain for each zygapophyseal joint and dorsal ramus is shown in Table I. The main specific referred pain distribution from each joint and dorsal ramus were as follows.

C0/1 joint ($n = 10$): occipital region (30%) and upper posterolateral cervical region (100%).

C1/2 joint ($n = 10$): occipital region (20%) and upper posterolateral cervical region (100%).

C2/3 joint ($n = 14$): upper posterior cervical region (64%), occipital region (50%), and upper posterolateral cervical region (50%).

C3/4 joint ($n = 21$): upper posterior cervical region (76%), middle posterior cervical region (52%), and occipital region (38%).

C4/5 joint ($n = 46$): lower posterior cervical region (76%), middle posterior cervical region (54%), and suprascapular region (43%).

C5/6 joint ($n = 46$): suprascapular region (50%), lower posterior cervical region (46%), superior angle of the scapula (35%), middle posterior cervical region (15%), and shoulder joint (11%).

C6/7 joint ($n = 27$): superior angle of the scapula (48%), mid-scapular region (41%), lower posterior cervical region (33%), shoulder joint (15%), and suprascapular region (11%).

C7/Th1 joint ($n = 7$): mid-scapular region (86%) and superior angle of the scapula (28%).

C3 ramus ($n = 8$): upper posterior cervical region (100%), occipital region (50%), middle posterior cervical region (33%), and upper posterolateral cervical region (25%).

C4 ramus ($n = 11$): lower posterior cervical region (55%), suprascapular region (55%), and middle posterior cervical region (45%).

C5 ramus ($n = 21$): lower posterior cervical region (52%), superior angle of the scapula (33%), suprascapular region (29%), and shoulder joint (19%).

C6 ramus ($n = 15$): superior angle of the scapula (47%), suprascapular region (33%), mid-scapular region (33%), shoulder joint (27%), and lower posterior cervical region (20%).

C7 ramus ($n = 7$): mid-scapular region (71%), superior angle of the scapula (71%), shoulder joint (29%), lower posterior cervical region (29%), and suprascapular region (14%).

The main joints and dorsal rami responsible for referred pain at each site were as follows: occipital region, C2/3 and C3; upper posterolateral cervical region, C0/1, C1/2 and C2/3; upper posterior cervical region, C2/3, C3/4 and C3; middle posterior cervical region, C3/4, C4/5 and C4; lower posterior cervical region, C4/5, C5/6, C4 and C5; suprascapular region, C4/5, C5/6 and C4; superior angle of the scapula, C6/7, C6 and C7; mid-scapular region, C6/7, C7/Th1 and C7 (Fig. 2).

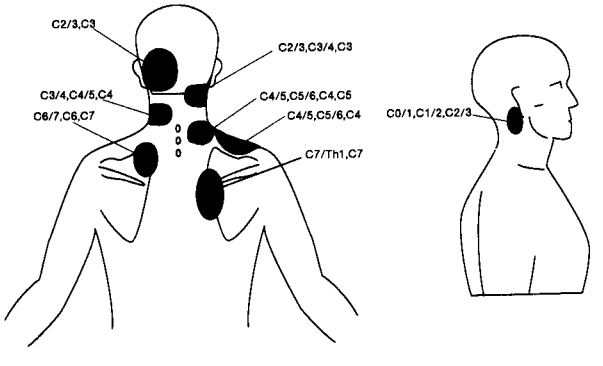

Fig. 2. Main referred pain distributions for the zygapophyseal joints from C0/1 to C7/Th1 and the dorsal rami C3 to C7.

Discussion

Aprill and Bogduk (1992) reported that zygapophyseal joint block relieved pain and arthrography reproduced pain in 82 (64%) out of 128 patients with chronic neck pain. In addition, double-blind controlled studies have shown that up to 60% of neck pain after whiplash injury stems from the zygapophyseal joints (Barnsley et al. 1994a, 1995).

The zygapophyseal joints are richly supplied with nerve fibers that may mediate pain (Ashmed et al. 1993), and these joints are increasingly being recognized as a common source of significant occipital, neck, and shoulder pain in addition to the intervertebral discs (Cloward 1959).

The clinical features are pain associated with well-localized paraspinal tenderness over the zygapophyseal joints, increased pain on extension, increased pain on rotation of the spine, and the absence of neurologic signs or root tension signs (Jackson and Spurling tests). However, these findings are not specific enough to be of diagnostic value. A zygapophyseal joint can be deemed symptomatic if provocation by injection of contrast medium exactly reproduces the patient's pain and if anesthetizing the joint promptly relieves the pain (Barnsley et al. 1993; IASP Task Force on Taxonomy 1994). If the patient receives excellent but short-term relief by joint blocks (Barnsley et al. 1994b), radiofrequency denervation can be used as a long-term treatment for zygapophyseal joint pain. The technique is quite simple and it can be easily done safely on an outpatient basis (Uerrest and Stolker 1991).

Dreyfuss et al. (1994) showed that the atlanto-occipital (C0-C1) and atlanto-axial (C1-C2) zygapophyseal joints could be potential sources of occipital and upper cervical pain by injecting contrast medium in five normal volunteers. In addition, Dwyer et al. (1990) showed that the zygapophyseal joints from C2-C3 to C6-C7 could be potential sources of neck pain and referred pain to the head and shoulder girdle by injecting contrast medium in five normal volunteers. Aprill et al. (1990) confirmed the accuracy of the pain chart of Dwyer et al. (1990) by performing anesthesia of the medial branches of the dorsal rami above and below the symptomatic joint in patients with zygapophyseal pain. Although the results of Dwyer and Dreyfuss have been widely accepted, their provocative joint injection studies involved only five subjects and thus were of limited value for creating reliable pain distribution maps. In the present study, the referred pain distribution of each zygapophyseal joint from C0/1 to C7/Th1 was established in a large number of patients with suspected zygapophyseal joint pain.

The main distribution of referred pain from each joint was as follows: C0/1, upper posterolateral cervical region; C1/2, upper posterolateral cervical region; C2/3, upper posterior cervical region, occipital region, and upper posterolateral cervical region; C3/4, upper posterior cervical region and middle posterior cervical region; C4/5, middle posterior cervical region, lower posterior cervical region, and suprascapular region; C5/6, lower posterior cervical region and suprascapular region; C6/7, superior angle of the scapula and midscapular region; C7/Th1, superior angle of scapula and midscapular region. The main distribution of referred pain determined on electrical stimulation of the dorsal rami was as follows: C3, occipital region and upper posterior cervical region; C4, middle posterior cervical region, lower posterior cervical region, and suprascapular region; C5, lower posterior cervical region; C6, superior angle of the scapula; C7, midscapular region and superior angle of the scapula.

The referred pain distribution for C2/3 was almost identical to that for the C3 ramus and the distribution for the joints below C2/3 was similar to the composite distribution of the dorsal rami above and below each joint. Thus, the accuracy of the referred pain distribution for each joint obtained by injection of contrast medium was confirmed by the pain charts for each dorsal ramus and the validity of the maps was confirmed. The referred pain distribution from the C0/1, C1/2, and C2/3 joints was comparatively restricted, but we found several variations of referred pain from the joints below C2/3. The zygapophyseal joints below C2/3 are innervated by the medial branches of the cervical dorsal rami from above and below the joint and this may be a cause of the variations in the referred pain pattern. Anatomic studies have shown that the C2/3 joint is innervated by the third occipital nerve with a small inconstant contribution from a communicating branch of the great occipital nerve, while the C0/1 and C1/2 joints are occasionally innervated by the ventral rami of C1 and C2 (Bogduk 1982; Bogduk and Marsland 1986). This might explain the restricted referred pain distribution from these joints. Referral of pain to the shoulder joint region from the C4/5 to C7/Th1 zygapophyseal joints was found as a new variation. Stimulation of the dorsal rami from C4 to C7 also produced pain over the shoulder joint, so the pain distribution of the dorsal rami confirmed the accuracy of the charts for these zygapophyseal joints.

In previous investigations, referred pain from the zygapophyseal joint has been studied by injection of contrast medium (Dwyer et al. 1990). However, the referred pain distribution obtained by electrical stimulation of the dorsal rami innervating the zygapophyseal joints has not been reported previously. The referred pain distribution for the zygapophyseal joints and dorsal rami constructed in the present study may provide a useful guide for determining which joint to investigate first and which nerve to treat first in patients with suspected cervical zygapophyseal joint pain who are undergoing zygapophyseal joint block or facet denervation.

Patients with neck pain due to disc disease, bone disease, and nerve root compression are largely recognized by conventional diagnostic methods and undergo established treatment. However, cervical zygapophyseal joint disorders are poorly understood or even not considered in conventional practice (Bogduk and Marsland 1988). Our referred

pain distribution maps of the zygapophyseal joints from C0/1 to C7/Th1 and the dorsal rami from C3 to C7 should provide helpful information about the localization of head, neck, and shoulder pain stemming from the zygapophyseal joints.

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