Cervical Zygapophysial Joint Pain Maps

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A B S T R A C T

Objective. To determine the patterns of referred pain in patients with proven cervical zygapophysial joint pain.

Design. The pain drawings were analyzed of patients with neck pain or headache who underwent controlled, diagnostic blocks, to test whether a zygapophysial joint was the source of their pain. The distribution of pain reported by each patient who had a positive response to blocks at a particular segmental level was copied onto a grid map in order to construct a composite map of the pain patterns of that segment. Based on the prevalence of a particular joint being symptomatic and the frequency with which it referred pain to particular areas, maps were constructed to indicate the probability of a particular joint being the source of pain in a given area.

Results. As reported by patients, the location and distribution of pain from particular cervical zygapophysial joints varies considerably; more so than in studies of normal volunteers. Nevertheless, segmental patterns could be identified. Although the pain patterns of adjacent segments overlap, those of remote segments do not. Furthermore, certain guidelines could be derived by which practitioners might distinguish pain from adjacent segments.

Conclusion. Pain maps based on areas in which patients are relieved of pain by controlled blocks provide a more representative guide to the recognition of the segmental origin of cervical zygapophysial joint pain than do maps derived from normal volunteers.

Key Words. Cervical; Zygapophysical; Facet; Pain Map; Neck Pain

Introduction

The zygapophysial joints of the cervical spine are a common source of chronic neck pain. In patients with neck pain attending pain clinics, multiple and independent studies have determined the prevalence of zygapophysial joint pain (mean; 95% confidence interval) to be 54% (40–68%) [1], 49% (33–64%) [2], 36% (27–45%) [3], and 60% (50–70%) [4]. Among drivers injured in high-speed motor vehicle accidents, the prevalence is as high as 74% (65–83%) [5]. No other source or cause of neck pain has been shown to have a prevalence that approaches these figures.

The diagnosis of cervical zygapophysial joint pain ultimately is based on the response to controlled, diagnostic blocks of the medial branches of the cervical dorsal rami that innervate the painful joint or joints [1,2,4,6,7]. Medial branch blocks should completely relieve the patient's pain. When two joints are symptomatic, anesthetizing one joint should relieve the portion of the pain caused by that joint; anesthetizing the other joint should relieve the remaining pain; and anesthetizing both joints should relieve all of the pain [6].

Because medial branch blocks are an invasive procedure, and require radiation exposure, they should not be undertaken indiscriminately. They are not indicated simply because the patient has

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neck pain. Optimally, they should be indicated in patients likely to respond, and at segmental levels likely to be positive.

One approach by which to select patients might be to recognize patterns of pain suggestive of zygapophysial joint pain and its location. To this end, three studies have provided data. Dwyer et al. [8] composed pain maps that indicated where normal volunteers perceived pain when their cervical zygapophysial joints were stimulated with intra-articular injections of contrast medium (Figure 1). Fukui et al. [9] constructed such maps based on where patients reported feeling pain when their joints were stimulated and when individual medial branches were stimulated electrically. Windsor et al. [10] mapped the areas to which sensation, although not pain per se, was evoked when medial branches were stimulated electrically in normal volunteers.

These maps provide a prima facie basis for suspecting cervical zygapophysial joint pain. However, their reliability and validity are not known. Nor do they reflect the extent to which patients might vary in either location or extent of pain stemming from a particular joint.

The present study was undertaken with several objectives: to determine the range of distribution of cervical zygapophysial joint pain; to determine the validity of pain maps for cervical zygapophysial joint pain; to revisit the prevalence of zygapophysial joint pain in patients undergoing diagnostic blocks; and to determine the prevalence of zygapophysial joint pain at particular segments. The
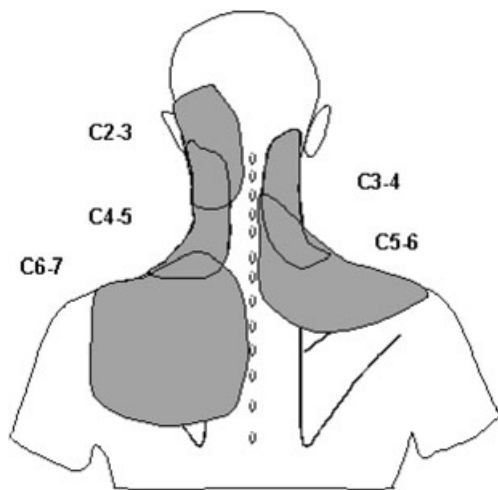

Figure 1 The patterns of referred pain from the cervical zygapophysial joints produced experimentally in normal volunteers (based on Dwyer et al. [8]).

results provide guidelines for the efficient use of medial branch blocks in the pursuit of cervical zygapophysial joint pain.

Methods

The study was conducted in a clinic specializing in spinal pain, based in a university teaching hospital, located in Newcastle, Australia, a regional city of some 600,000 inhabitants, located 100 miles north of Sydney. The clinic sees patients referred from general practitioners and specialists, from Newcastle and Sydney, and from rural areas for which Newcastle is the major medical center.

The study sample consisted of all patients seen between January 1999 and October 2003 who completed investigations for cervical zygapophysial joint pain. Each patient completed a map of their pain, with the assistance of a research nurse, using a standardized drawing of the upper trunk, shoulders, and head. Each patient then underwent a diagnostic block at a segmental level selected by the physician who performed the block. If the block was negative, testing was terminated, or initiated at another segmental level that might reasonably have been responsible for the pain. In this manner blocks were continued until all possible levels that might reasonably have been the source of pain proved negative or until a positive response was encountered.

If a positive response was encountered, that level was again tested on a subsequent occasion, once the patient's pain had returned, and no earlier than 1 week later. The response was tested and verified using comparative local anesthetic blocks [6,7,11–13]. Blocks were performed on a double-blind basis such that neither the patient nor the assessing nurse knew the agent used.

A research nurse assessed the responses to blocks. A negative response was defined as no relief of pain. A positive response was defined as either complete relief of all pain, or complete relief in a definable portion of the patient's area of pain, such as complete relief in the upper or lower half of the area, although not in the remaining area [6,13]. Reduction in intensity of pain, but without complete relief in any topographical region, was not accepted as a positive response.

For a particular joint to be classed as symptomatic, the patient had to obtain complete relief of pain whenever that joint was anesthetized, and provided that they obtained short-lasting relief (typically 1–2 hours) when a short-acting agent was used (lignocaine 2%), and long-lasting relief

(typically 2–5 hours or longer) when a long-acting agent (0.5% bupivacaine) was used [6,7,11–13].

At typical cervical levels, the blocks anesthetized the medial branches that innervated the target joint. They were performed under fluoroscopic control, using a lateral approach, with 0.3 mL of local anesthetic being injected onto each nerve [13]. In the case of the third occipital nerve, which innervates the C2–3 zygapophysial joint, three injections of 0.3 mL were used to cover possible variations in the location of that nerve [13,14]. When undertaken, blocks of the lateral atlanto-axial joint (C1–2) were performed using intra-articular injections [15,16].

Patients with multiple symptomatic zygapophysial joints on the same side were identified according to the following protocol [6,13]. Patients with pain at consecutive segmental levels had to obtain complete relief of the upper half of their pain when the upper of two consecutive joints was blocked, complete relief of the lower half of their pain when the lower joint was blocked, and complete relief of all of their pain when both joints were blocked. Patients who had upper neck pain with headache, as well as lower neck pain, had to obtain complete relief of their upper neck pain and headache when an upper joint was blocked, and complete relief of their lower neck pain when a lower joint was blocked. In all instances, the responses at each level had to be corroborated by controlled blocks.

In patients with bilateral pain, each side was investigated separately, on different occasion, following the same protocol used for unilateral pain. Responses for each side were recorded and analyzed separately, unless the diagnostic block relieved contralateral pain.

Each patient's pain map was categorized according to whether all or part of their pain was relieved or not by diagnostic blocks of a particular level, or particular levels if more than one level was tested. The areas of pain relieved or not by diagnostic blocks were copied onto a standardized grid (Figure 2). The grid lines adopted were designed to designate conventional areas of clinical interest (such as upper neck, lower neck, occiput, and forehead). In the course of the study the areas of interest were modified to highlight certain areas that emerged as potentially discriminating (such as the lateral shoulder and medial scapula areas).

Transparencies of the grid pattern were applied to each patient's pain map to record the frequency with which the patient reported pain in particular grid areas. Composite maps were then constructed
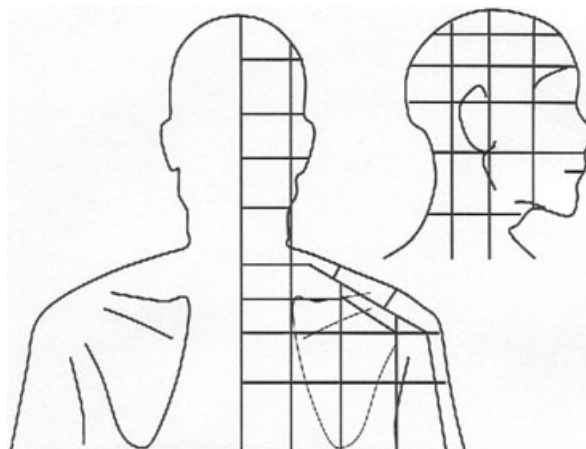

Figure 2 The grid used to map the distribution of pain reported by patients who underwent zygapophysial joint blocks.

to reflect the frequency with which all patients with pain from a particular joint reported relief of pain in particular grid areas. Grid densities were used to calculate the probability with which pain in a particular area might be attributed to a particular joint or not.

A similar approach was used to determine the distribution of pain among patients who were not relieved by blocks of zygapophysial joints at particular levels. The incidence of particular patterns of pain, such as band-like or linear patterns vs broad areas or spots, bilateral symmetrical pain vs bilateral asymmetrical pain, were compared for patients with and without symptomatic zygapophysial joints.

Once maps for individual segments had been completed a second iteration was undertaken. Maps were constructed to reflect the probability of a particular joint being responsible or not for pain in a particular area or pattern. The probabilities were calculated as the product of the relative prevalence with which a particular segment was symptomatic, and the frequency with which it referred pain to a particular area.

Results

A total of 194 patients seen between January 1999 and October 2003 were identified who met the inclusion criteria. Their demographic data are shown in Table 1. All had neck pain that had been present for longer than 6 months. A total of 347 diagnostic blocks were performed on these patients, 163 on the left side and 184 on the right. One hundred and eighty-six blocks (54%) revealed

symptomatic levels. One hundred and thirty-four patients (69%) had at least one symptomatic level.

Whereas patients with bilateral and asymmetric pain tended to have less likelihood of a symptomatic level being detected, this difference was not statistically significant. Only one patient reported bilateral relief from a single level block.

The most commonly symptomatic level was C2–3 (36%), followed by C5–6 (35%), and then C6–7 (17%) (Figure 3). Joints at C3–4, C4–5, and C1–2 were each symptomatic in less than 5% of cases. Of the patients with zygapophysial joint pain, 52% had only 1 symptomatic joint. In the remainder, multiple symptomatic joints occurred in various combinations (Figure 3). These included: both joints at the same segment (e.g., C2–3 or C5–6), consecutive joints on the same side (e.g., C5–6, C6–7), displaced joints on the same side (C5–6 and C2–3), and other combinations of these patterns. Rarely were C3–4 and C4–5 symptomatic alone. Most often they were symptomatic together with an adjacent joint.

Patients differed in the manner in which they depicted their pain graphically. Some indicated areas, but others drew linear patterns, or spots (Figure 4). Comparison of how patients depicted their pain revealed no significant systematic differences between those who had a symptomatic z-joint and those who did not.

For no segment did patients consistently perceive pain across an entire area said to be characteristic of that segment in normal volunteers. Rather, patients reported pain variously in one or more grid areas that, when summed, generated maps of areas into which pain from a particular segment could be referred. Consequently, the frequency with which the sample of patients reported pain in particular grid areas varied considerably, and tended to be distributed widely across many grid areas. In only some grid areas did a majority of patients consistently report pain.

C1–2 (Figure 5)

On the posterior view, pain from C1–2 most often occurred in the suboccipital region. From there it could extend cephalad to the occiput and vertex, or caudad into the neck. On the profile view, pain from C1–2 frequently occurred over the vertex and in the upper forehead. Often it encompassed the region of the ear and the orbit. Conversely, it rarely occurred in the temporoparietal region and supraorbital forehead.

C2–3 (Figure 6)

On the posterior view, pain from C2–3 resembled that of C1–2. It occurred anywhere within a band from the occiput to the vertex. In contrast to the pain of C1–2, that of C2–3 was not particularly focused on the suboccipital or occipital region. Instead, more often it extended over the lateral occiput toward the mastoid region and above. On the profile view, the pain of C2–3 most often occurred in an area extending from the occiput, across the parietal and upper temporal regions, to end in the forehead or in the orbit. In this regard, the typical forehead pain of C2–3 was lower than that of C1–2, and focused on the supraorbital forehead. Unlike pain from C1–2, that of C2–3 did not encompass the ear.

C3–4 (Figure 7)

Few patients had pain exclusively from this level. Therefore, a characteristic pattern could not be established firmly. When it occurred, pain from this level could occur anywhere over the suboccipital and occipital regions, or cranially in the vertex or forehead, or caudally along the posterolateral neck.

C4–5 (Figure 8)

When it occurred, pain from C4–5 tended to be focal: centered over the lower posterior quadrant of the neck. It could spread laterally into the uppermost and proximal region of the shoulder girdle, and upwards to the suboccipital region. No patient with pain from C4–5 reported pain in the head.

C5–6 (Figure 9)

Pain from C5–6 typically centered over the junction of the base of the neck and the top of the

Table 1 Demographic and clinical features of patients with neck pain who responded or not to cervical zygapophysial joint blocks

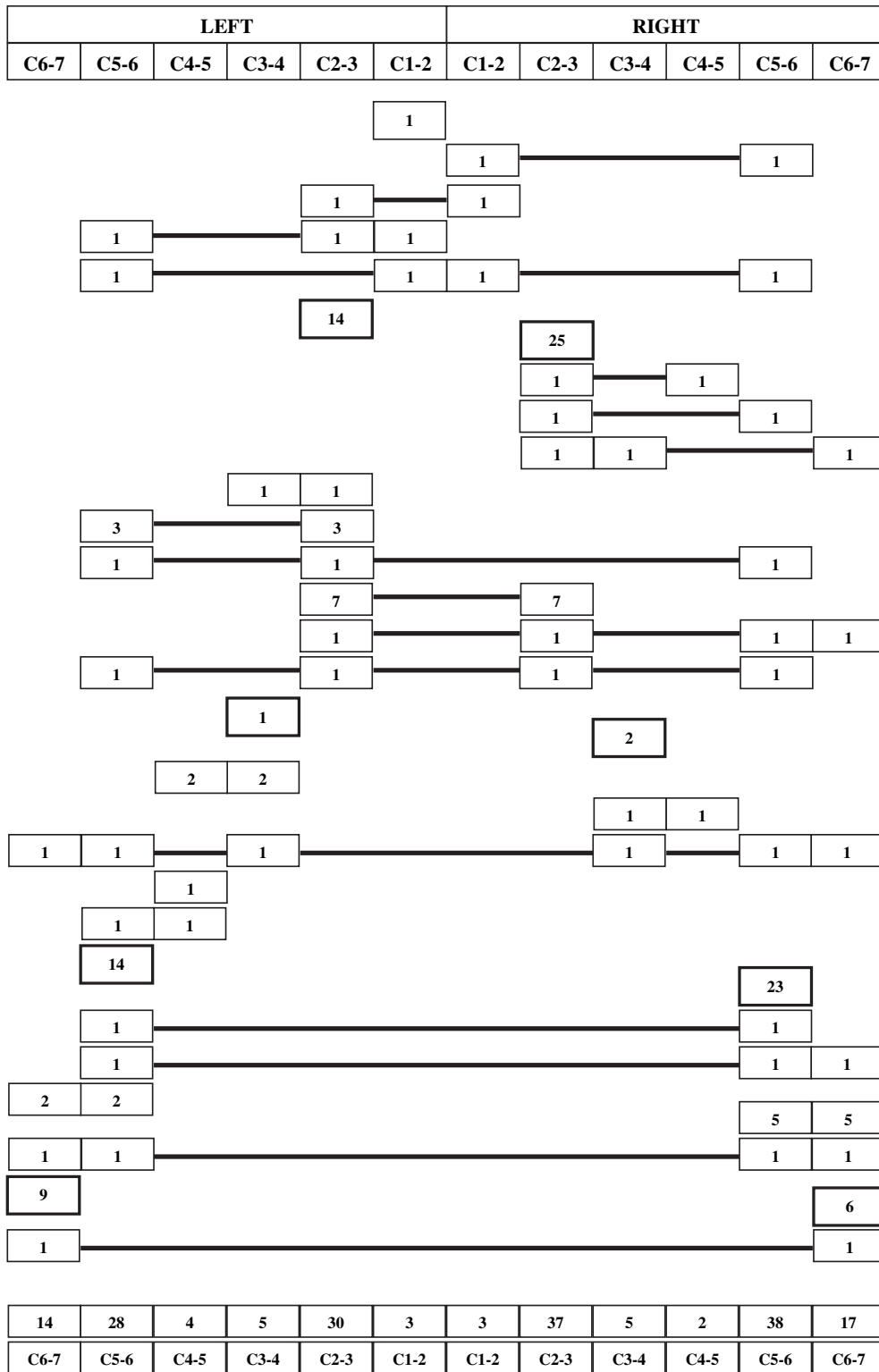| Feature	
Gender	
Male	108
Female	86
Age (years)	
Mean	49
SD	14
Range	19–84
Visual analog pain score (0–100)	
Mean	62
SD	15
Range	40–100
Motor vehicle accident	99
Litigation	148

Figure 3 The prevalence of joints symptomatic at particular segments, alone, bilaterally, or in various combinations, in 194 patients, of whom 134 had at least one symptomatic joint. Single boxes indicate a single symptomatic joint on either side. Contiguous boxes indicate symptomatic joints at consecutive segments on the same side. Bars linking boxes indicate symptomatic joints at displaced segments or bilaterally in the same patient. The numbers in the boxes indicate the number of patients who exhibited the particular distribution of symptomatic joints indicated by the boxes. The total number of joints symptomatic at particular segments, on each side, irrespective of combinations, is shown at the bottom of the figure.
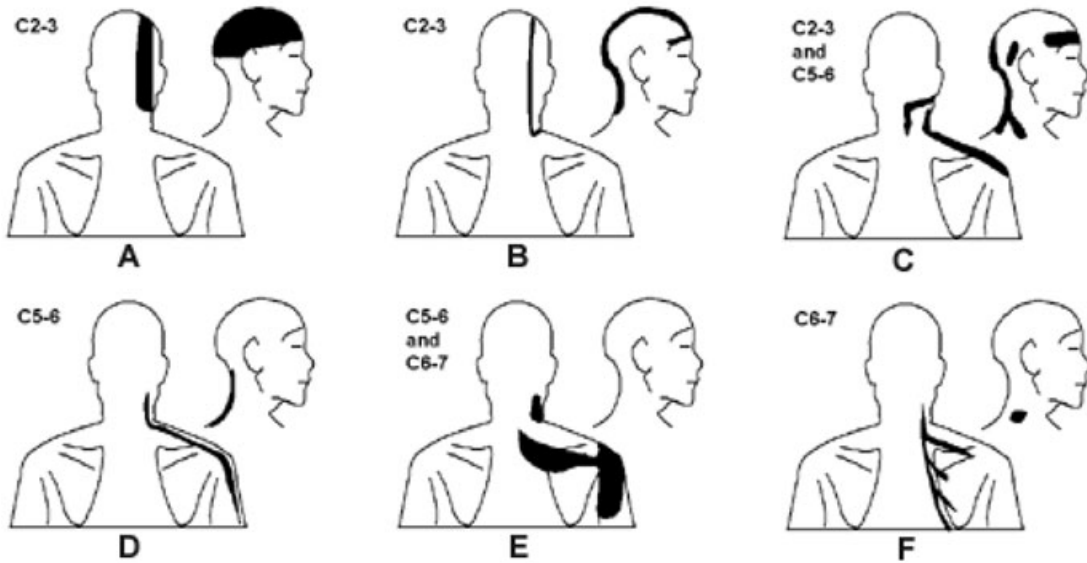
Figure 4 Examples of how patients drew the location of distribution of their neck pain or headache.

shoulder girdle. From there it could extend cranially toward the suboccipital region, and laterally across the outer margin of the shoulder girdle and arm. Less often, it could flow inferiorly over the scapular region, or into the posterior arm. No patient with C5–6 pain reported pain in the head.

C6–7 (Figure 10)
Pain from C6–7 shared a similar focus with that of C5–6 at the junction of the neck and shoulder girdle, but differed in its direction of spread. Typically it spread inferiorly and medially into or around the central or medial aspect of the scapula.

Reciprocally, unlike pain from C5–6, that of C6–7 tended not to spread into the lateral arm. In no patient did C6–7 pain refer into the head.

Specificity
The pain patterns of individual segments had some features in common with those of other segments, but also other features that were distinctive or distinguishing. For example, the patterns of C4–5, C5–6, and C6–7 did not involve the head. Reciprocally, the pain of C1–2 and C2–3 occurred predominantly in the head. Although it could spread caudally into the neck, pain from these latter segments did not occur primarily in the
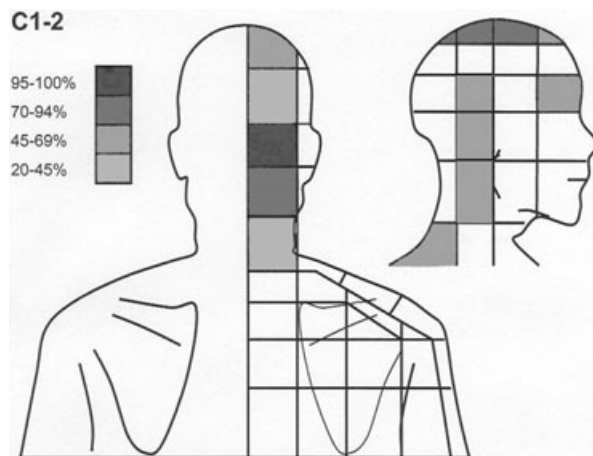

Figure 5 The frequency with which patients with pain stemming from C1–2 reported pain in various grid areas.
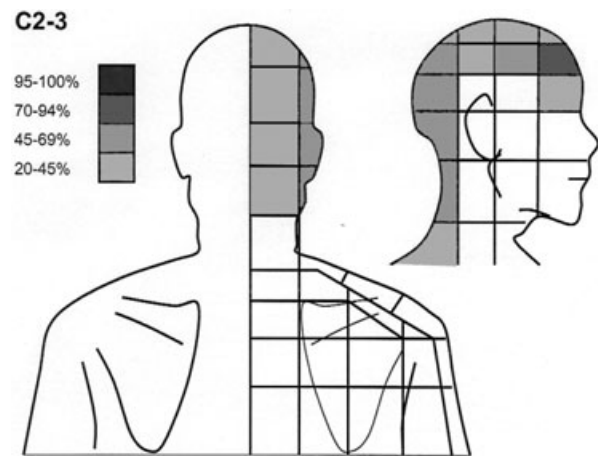

Figure 6 The frequency with which patients with pain stemming from C2–3 reported pain in various grid areas.
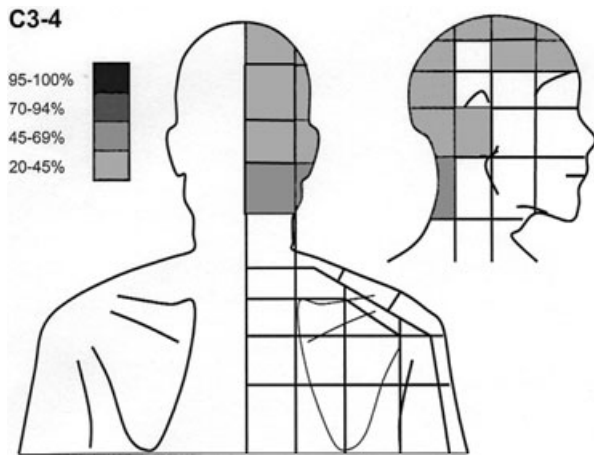
C3-4

95-100%
70-94%
45-69%
20-45%

Figure 7 The frequency with which patients with pain stemming from C3–4 reported pain in various grid areas.
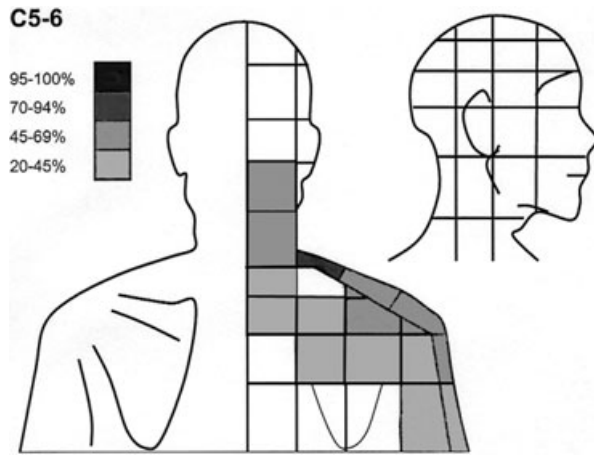
C5-6

95-100%
70-94%
45-69%
20-45%

Figure 9 The frequency with which patients with pain stemming from C5–6 reported pain in various grid areas.

neck. These distinctions allow zygapophysial joint pain to be divided into upper cervical and lower cervical distributions.

In the upper cervical distribution, C1–2, C2–3, and C3–4 all can produce pain in the occipital and suboccipital regions, which can be referred to the parietal and temporal regions. The location or distribution of pain does not allow a particular segment to be identified as the source of pain. In all regions, C2–3 is the most likely source, because this is the most commonly symptomatic joint (Figure 11). However, certain features increase or decrease the probability of C2–3 being the source.

Pain in the occipital area is most likely to arise from C2–3, followed by C1–2, and then C3–4 (Figure 11). The probability of a source at C2–3 increases if the pain occurs in the lateral occiput

and retroauricular area, or spreads to these areas from the occiput. An origin from C2–3 is most likely if the pain traverses the temporal area into the supraorbital area. If the pain occurs in the vertex, C2–3 remains the most likely source, but with less probability. The probability of a C1–2 origin increases (Figure 11). Conversely, pain that spreads from the occiput into the neck is unlikely to arise from C1–2. Such pain most likely arises from C2–3, but can arise from C3–4 (Figure 11).

In the lower cervical distribution, pain in the lower posterior quadrant of the neck can arise from any of the segments C4–5, C5–6, or C6–7, but C5–6 and C6–7 are the more likely sources because of their greater prevalence (Figure 12). Spread of lower cervical pain up the side of the neck into the occiput is virtually pathognomic of
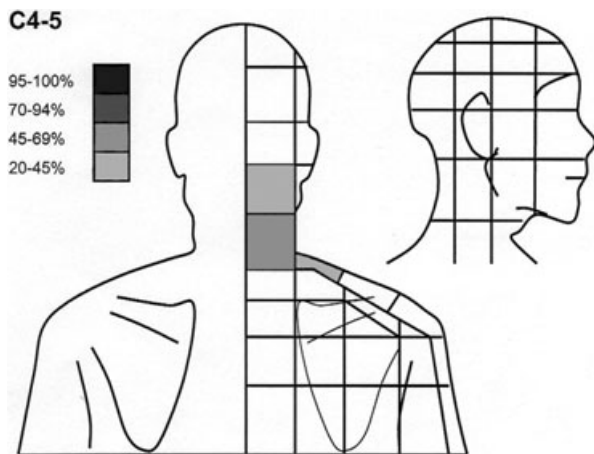
C4-5

95-100%
70-94%
45-69%
20-45%

Figure 8 The frequency with which patients with pain stemming from C4–5 reported pain in various grid areas.

C6-7
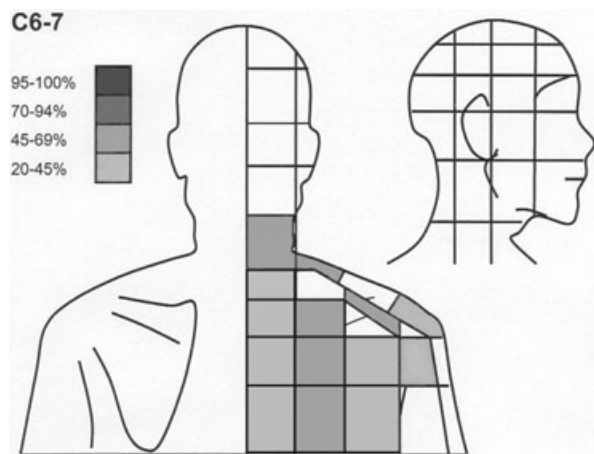
95-100%
70-94%
45-69%
20-45%

Figure 10 The frequency with which patients with pain stemming from C6–7 reported pain in various grid areas.
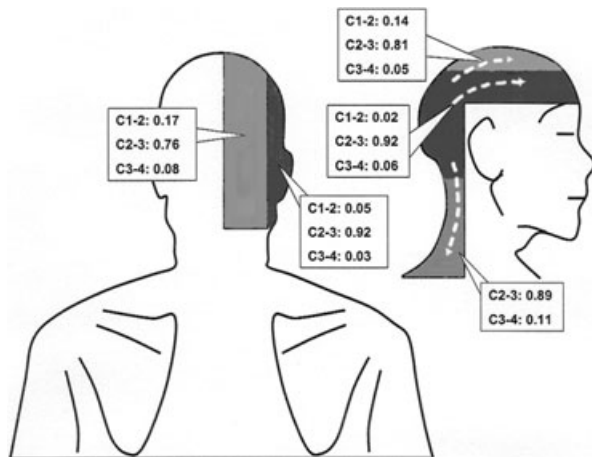
Figure 11 The probability of joints at the segments indicated being the source of pain in the areas depicted.

a C5–6 source. Such spread was not associated with a source at C4–5 or C6–7. If pain occurs in the lateral shoulder and arm, or if it spreads to these regions, the probability of a C5–6 origin increases; and the further the spread the more likely is the source to be C5–6 (Figure 12). Pain over the upper, medial angle of the scapula is essentially equally likely to arise from C5–6 or C6–7; but the more it extends inferiorly or over the scapula, the more likely C6–7 becomes the origin (Figure 12).

Discussion

The prevalence data in the present study are consistent with previously published reports [1–5], and reinforce how common cervical zygapophysial joint pain is. Sixty-nine percent of all patients had
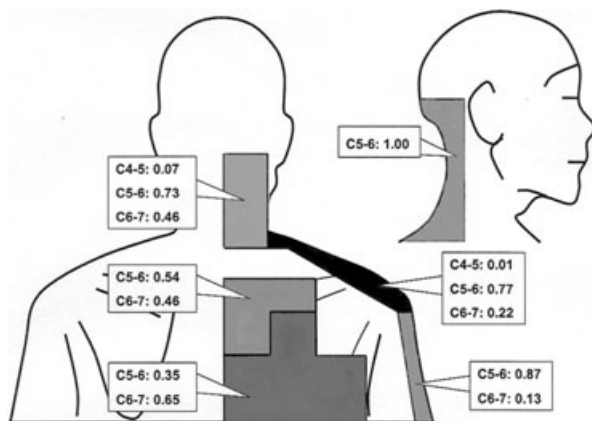

Figure 12 The probability of joints at the segments indicated being the source of pain in the areas depicted.

at least one symptomatic zygapophysial joint, and 54% of all blocks were positive. The present sample is also the largest described to date, and shows the prevalence of pain from individual segments and combinations of segments (Figure 3). Either alone or in combinations, the C2–3 and C5–6 zygapophysial joints are most commonly symptomatic.

In previous studies, pain maps were based on patterns of pain evoked by experimental stimuli, such as distending a joint or electrical stimulation of its nerve supply [8,9]. These stimuli were artificial and necessarily limited in magnitude, in order not to injure the patient. In contrast, the present study determined the patterns of naturally occurring pain that was relieved by controlled blocks.

Also, the segmental maps of previous studies were idealized (Figure 1). The maps depicted rounded areas, and implied that patients would report pain in similarly circumscribed areas. This may be the case for normal volunteers, but the present study showed that patients do not report their pain in neat patterns. They indicate spots, lines, and patches, as well as or instead of areas. Consequently, the pain maps of patients do not necessarily resemble the maps produced by normal volunteers. Patients vary considerably more than volunteers in how and where they perceive pain from a particular segment.

Nevertheless, the general segmental patterns revealed in the present study are consonant with those previously reported. Pain from C1–2 and C2–3 tends to arise in the suboccipital region. That of C3–4 encompasses the posterolateral neck, overlying levator scapulae. Pain from C4–5 is nestled into the angle between the neck and the shoulder girdle. Pain from C5–6 and C6–7 occurs over the lower neck and spreads into the upper limb girdle. In these respects, the present maps agree with those developed in normal volunteers.

Where the present maps depart from those of previous studies is the extent and variability of referral. Normal volunteers reported pain only in the suboccipital region and occipital regions when C1–2 [17] or C2–3 [8] were stimulated. Patients experience pain in these regions but also extensively into the parietal, temporal, and frontal regions. Similarly, normal volunteers experienced pain in the lower cervical region and proximal shoulder girdle when C5–6 and C6–7 were stimulated [8], but in patients with pain from these joints the pain can extend inferiorly over the scapula and into the arm. Presumably, this difference

can be attributed to patients suffering more intense pain, or pain for longer, than that evoked by temporary, experimental stimuli in normal volunteers.

Thus, while confirming the general, segmental nature of referred pain from the cervical zygapophysial joints, the present study provides data that are more clinically material. Practitioners should not expect ideal patterns of referral from the cervical zygapophysial joints. Nevertheless, they should be able to discern recognizable patterns.

Pain in the head invites consideration of C1–2, C2–3, or C3–4 as the source. However, practitioners do not need to try to discern C3–4 patterns in the first instance. On epidemiological grounds, this joint is unlikely to be symptomatic in isolation. For patients with headache, C2–3 is more likely to be the source. Therefore, that segment should be investigated first. C3–4 will emerge as symptomatic subsequently, either if lower pain persists after blocking C2–3 relieves the patient's headache, or if blocking C2–3 fails to relieve headache but subsequently blocking C3–4 does relieve it.

The distinction between C1–2 and C2–3 is more contentious. On epidemiological grounds, C2–3 is far more commonly positive, and is more likely to be the source if pain is referred to the forehead. Pain in the vertex is common in patients with C1–2 pain, but occurs also from C2–3. Thus, although the likelihood of a C1–2 source increases if the patient has pain in the vertex, its probability is still dwarfed by the prevalence of C2–3 pain. Meanwhile, although pain referred to the ear is not regularly a feature of pain from C1–2, it was not encountered in patients with pain from C2–3. Therefore, pain in the ear should raise suspicion of a C1–2 source.

In this regard, however, the present data may be biased. C1–2 blocks were not commonly performed early in the history of the clinic, on the grounds that no options for treatment were available at that time. They were added to the protocol only in recent years, following the advent of C1–2 fusion as an option for treatment. Consequently, the actual prevalence of C1–2 pain encountered in this study may be an underestimate. Future studies might raise the prevalence of C1–2 pain and increase, beyond that of C2–3, the probability of C1–2 being the source of pain in particular areas of the head, such as the vertex.

Pain in the lower neck, not involving the head, invites consideration of C4–5, C5–6, and C6–7. However, practitioners are spared the need to identify C4–5 patterns. Pain from this joint does not differ from the cervical distribution of pain from C5–6, but C5–6 pain is far more common. Therefore, blocks should be undertaken first at C5–6. C4–5 will emerge as a source either if C5–6 blocks fail to relieve pain, or if pain persists above a region of distinct relief after a C5–6 block.

The distinction between C5–6 and C6–7 lies in the general direction to which pain spreads. A lateral spread to the arm favors C5–6. An inferior spread to the medial scapula favors C6–7. If blocks of the first joint chosen fail to relieve pain, the complimentary joint should be investigated next.

An important caveat concerning the use of pain maps is that areas of pain are not diagnostic of a particular source. They reflect the innervation of the source. It has been shown that patterns of referred pain from the cervical intervertebral discs closely resemble those of the zygapophysial joints of the same segment [18]. Thus, pain patterns do not necessarily imply zygapophysial joints as the source. However, given a particular pain pattern, a zygapophysial joint becomes the foremost source because zygapophysial joint pain is more common than cervical discogenic pain.

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