Cervical Zygapophyseal Joint Pain Patterns I:
A Study in Normal Volunteers

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The pain patterns evoked by stimulation of normal cervical zygapophyseal joints were determined in five volunteers. Under fluoroscopic control, joints at segments C2–3 to C6–7 were stimulated by distending the joint capsule with injections of contrast medium. Each joint produced a clinically distinguishable, characteristic pattern of pain, which enabled the construction of pain charts that putatively could be of value in determining the segmental location of symptomatic joints in patients presenting with cervical zygapophyseal pain. [Key words: neck pain, cervical zygapophyseal joints, referred pain]

NECK PAIN IS a poorly understood symptom, most often ascribed to "disc disease" or "soft-tissue injury." Such diagnoses are based largely on clinical interpretation and reflect the major contemporary viewpoints on the causes of neck pain. To introduce a new concept not only challenges entrenched viewpoints but evokes cynicism that must be assuaged by convincing evidence. In this regard, several authors have proclaimed that the cervical zygapophyseal joints can be a source of neck pain,[2,7,8,13,24,26–28] the principal evidence being the relief of neck pain in some patients after intra-articular blocks of certain cervical zygapophyseal joints or the nerves supplying them. This evidence, however, may be viewed cynically as insufficiently convincing. Studies conducted on patients with pain may be compromised by placebo responses, the presence of disease in multiple structures or multiple segments, and the possibility that anesthetizing part of a painful segment might be sufficient to relieve temporarily all pain from that segment.

To exclude such possibilities, it is necessary to show that the zygapophyseal joints can be a source of pain in the clear-cut absence of disc disease or other possible causes of pain. This can only be done in normal volunteers. Hence, for a given structure to be deemed a possible source of spinal pain two criteria should be satisfied: 1) In normal volunteers, stimulation of the structure should produce pain; and 2) In patients with similar forms of pain, anesthetization of the structure should totally relieve their pain.

In the case of the lumbar zygapophyseal joints, both these criteria have been satisfied. Stimulation of the lower lumbar zygapophyseal joints in normal volunteers produces low-back pain and referred pain—largely in the buttock and thigh, but sometimes as far as the leg.[20,23] Comparable types of pain in patients can be relieved by anesthetizing one or other of the lumbar zygapophyseal joints, usually at the L4–5 or L5–S1 levels.[3–6,9,10,12,15,16,18,19,23] Such results have led to the acceptance of "facet syndrome" as a definite diagnostic entity in the lumbar region.[9,12,22]

In the case of the cervical zygapophyseal joints, only the second criteria has been satisfied. Studies in normal volunteers have not been conducted, and it has not been shown that neck pain can be produced by selective and exclusive stimulation of cervical zygapophyseal joints.

A further issue is that while cervical zygapophyseal joint pain might be diagnosed by blocks of putatively symptomatic joints, these blocks are invasive, and there is a need for a clinical screening test by which patients with probable zygapophyseal pain might be recognized before or without resorting to invasive, diagnostic blocks. One possibility in this regard would be if patients presented with pain patterns characteristics of the symptomatic level, which would indicate the level at which diagnostic blocks should be undertaken. Thus, a further advantage of studies in normal volunteers is the prospect of defining pain patterns characteristic of the segment stimulated.

Studies of the lumbar region indicate that this is not the case for lumbar zygapophyseal joints, for the referred pain patterns from zygapophyseal joints at different segmental levels are indistinguishable because of extensive overlap.[20] However, to conclude that the same applies for the cervical region simply on the basis of extrapolation is not legitimate.

Prompted by the similarity of pain complaints in patients with symptomatic zygapophyseal joints at the same segmental levels, we undertook to determine whether or not pain from a given joint assumed a characteristic distribution, whereupon the pain pattern in a given patient might be used as an accurate cue for diagnosing the symptomatic joint clinically. To avoid problems with placebo responses or anomalous reactions in patients with multiple sources of pain or possible psychologic problems, our study was undertaken in normal volunteers.

METHODS

Injections of contrast medium into the joints were used as the experimental stimulus, for this has been advocated as a provocation test for the diagnosis of cervical zygapophyseal pain syndromes in radiologic practice[7,28]; but before undertaking such injections in normal volunteers, we considered the potential risks. Local anesthetic blocks were also to be used for postexperimental analgesia, and the hazards of these blocks in normal volunteers also had to be considered.

The only theoretical risks of cervical zygapophyseal injections are allergic reactions to the material injected, rupture of the joint capsule, penetration of the needle into the epidural or subarachnoid space, and the injection of contrast medium into these spaces.

Allergic reactions to contrast medium and local anesthetic are rare and were considered negligible, but nonetheless the experiments were undertaken in a comprehensive hospital with full resuscitation facilities available. Although capsular ruptures have been reported during lumbar zygapophyseal joint injections,[5,16] no deleterious effects ascribable to this phenomenon have been reported. Nevertheless, in our experiments it was intended to prevent this phenomenon by monitoring closely the injection of contrast medium into the joints using image-intensifier fluoroscopy.

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Epidural or subarachnoid injections of contrast medium should not be a risk with cervical zygapophyseal joint injections if these are performed skillfully and carefully. The vertebral canal can be entered only if the needle is over-zealously or irresponsibly inserted. In this regard, our volunteers, both implicitly and explicitly, had faith in our operator (CA). Nevertheless, even if needles are accurately placed in a zygapophyseal joint, it is conceivable that contrast medium might inadvertently enter the epidural space by somehow leaking medially out of the joint. However, in this event, only a fraction of the volume injected into the joint would enter the epidural space, and provided the volume injected into the joint is small (less than 1 ml), any leakage should be minimal. Moreover, the agent we elected to use (iothalamate meglumine; Conray, Mallinckrodt, St. Louis, MO) is one that, in other circumstances, has been safely used for epidurography.[25] For these reasons we thought that the risk of deleterious effects of any such leakage was negligible.

There was no intention to inject local anesthetic into the zygapophyseal joints. Local anesthetic was to be used only for postprocedural analgesia by blocking the medial branches of the dorsal rami that supplied the target joint. Such blocks are performed over the posterolateral aspect of the vertebral column and are not attended by risks other than allergic reactions.

To ensure accurate needle placement into the target joints or onto the target nerves, fluoroscopic screening was to be used. This necessitated exposure of the volunteer to radiation, but the dosage involved using an image-intensifier was considered to be well within tolerable limits.

Four asymptomatic normal volunteers with no history of cervical disorders participated in the study. They were consenting physicians who were aware of the significance of the study, the potential hazards of the procedure used, and the measures taken to avoid these hazards. A fifth volunteer was a consenting physician with a history of neck pain who underwent stimulation of his symptomatic level, but also volunteered to have two asymptomatic levels studied. Throughout the experiments the volunteers remained masked as to the segmental level of the joint stimulated at any one time.

The cervical zygapophyseal joints were stimulated under image-intensifier, fluoroscopic control using injections of contrast medium. A lateral approach was used to enter the target joint. With the subject lying on his side, the target joint was identified by lateral screening of the neck. A 25-gauge, 90-mm needle was introduced through the skin overlying the joint and the posterolateral neck muscles until it struck the superior or inferior articular process of the target joint. To distinguish the silhouette of the cavity of the target joint from that of the contralateral joint at the same level, the subject was rolled slightly. When the subject is moved in this way the image of the target joint moves in the direction in which the subject is rolled and coincides with the movement of the inserted needle.

Having identified the target joint, the needle was readjusted onto the lateral margin of its cavity and was advanced slowly until it was felt to pierce the joint capsule. Up to 1 ml of constrast medium then was slowly injected, and its entry was monitored on the image-intensifier. Provided the contrast medium remained within the joint cavity, the injection was continued until pain was elicited, at which point further injection was ceased. Arthrograms then were taken to document and confirm the accurate and selective injection of the joint, and the needle was withdrawn.

Once the joint had been injected, the subject was examined for tenderness in the cervical and shoulder regions. The distribution of the evoked pain and any tenderness was marked on the skin, and the delimited area was recorded on a body diagram. Additionally, the subject recorded the level of pain perceived on a visual analog scale.

On completion of the examination and recording, the medial branches of the dorsal rami that supply the target joint were blocked with 0.5 ml of 0.5% bupivacaine to provide postprocedural analgesia. These blocks were performed using a lateral approach with the nerves being blocked where they crossed the lateral aspect of their respective articular pillars. After these blocks, the subject was reexamined to determine the presence or absence of the previously recorded area of pain or tenderness.

In the first volunteer, joints at all levels from C2–3 to C6–7 were stimulated. A different joint was stimulated on a separate occasion at intervals of at least 1 week. In the remaining volunteers, one or three joints were stimulated depending on the availability of the volunteer and his tolerance of the procedure. The joints selected for stimulation were chosen to supplement the observations in the first volunteer such that, for the whole series of experiments, observations in at least two different volunteers were made for each segmental level.

RESULTS

No complications occurred during the experiments and no volunteers suffered any ill effects after the procedure. On all but one occasion the target joint was adequately and selectively injected as determined from the arthrogram. The one exception occurred in the first volunteer when an injection failed to enter the C2–3 joint cavity and appeared to spread between the fibers of the semispinalis capitis muscle that overlay the joint. This joint was successfully injected on a subsequent occasion. In no experiment did the contrast medium appear to leak out of the joint cavity into the epidural space. All arthrograms demonstrated a regular margin consistent with the joint capsule having been distended but remaining intact (Figure 1).

A total of 11 joints were injected (Table 1), and pain was produced in nine of these experiments. Included among these positive responses was one observation in the physician with neck pain whose symptoms were reproduced by injection of his previously diagnosed symptomatic joint. On two occasions pain was not produced. In one, the contrast medium was observed to dissipate into the space of Okada.[24] In the other, no pain was produced but tenderness was evoked in a zone comparable to that in which referred pain occurred in other volunteers.

When it occurred, pain was reported by the volunteers when about 1 ml of contrast medium had entered the joint, at which point the capsule appeared to be distended. The distributions of pain and tenderness reported by the volunteers are depicted in Figures 2 and 3. The pain was felt deeply and was aching in quality. The mean reported intensity was about "2.1" on a 10-cm visual analog scale.

In the first volunteer, joints at different segmental levels gave rise to distinctly different pain patterns. Although the areas overlapped, their central foci and rostrocaudal extents appeared characteristic. As joints from above downward were stimulated, the evoked areas of pain were centered over progressively more caudal levels, and pain from the lower cervical joints extended laterally into the shoulder girdle.

The pain patterns for C5–6 and C6–7 (which encompassed the shoulder girdle) were clearly different from those of C2–3 and C3–4 (which covered the upper cervical region). The C2–3 pattern was distinguished from that of C3–4 by its extension into the head. The C5–6 pattern covered the top of the scapula and shoulder above the level of the spine of the scapula and was distinguishable from that of C6–7, which extended more caudally to the inferior angle of the scapula. The C3–4 and C4–5 areas were distinguishable by the more rostral extent of

Table 1. Segments Stimulated and Pain Response

	Segments stimulated and response (VAS)				
Subject	*C2-3*	*C3-4*	*C4-5*	*C5-6*	*C6-7*
AD	1	3	3	2	2
BR	1	—	—	(3)*	0†
BD	—	0†	—	—	—
NB	—	—	4	—	—
JT	—	—	—	5	—

*Symptomatic joint.
†No pain, but tenderness in referred area.
‡Contrast medium escaped into Okada's space.

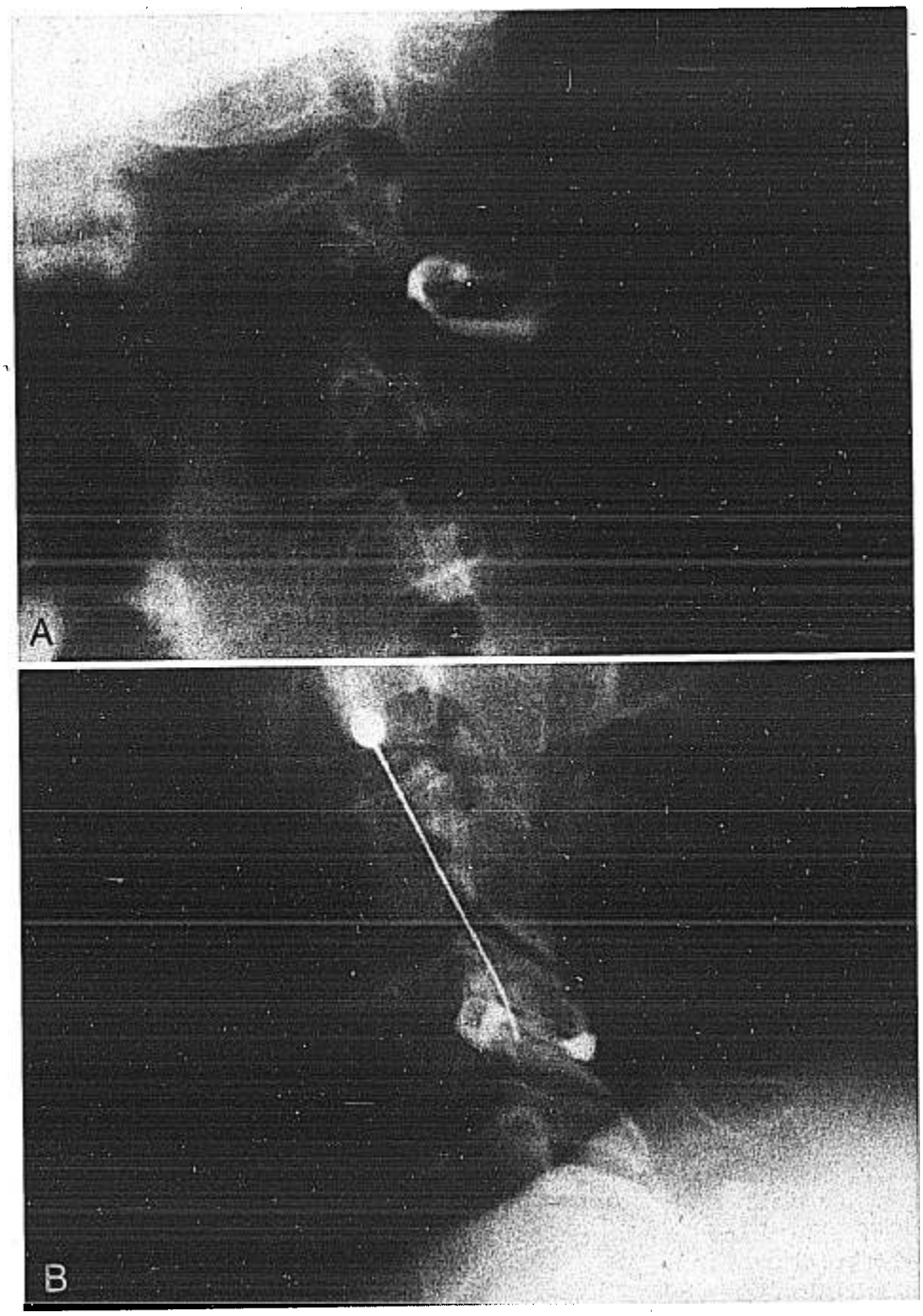

Fig 1. An arthrogram taken during stimulation of the C4–5 zygapophyseal joint in the first volunteer, to show how the injection was restricted to the target joint. **A**, AP view; **B**, lateral view.

the former and the more caudal extent of the latter. The C3–4 pattern appeared to cover an area that was co-extensive with the underlying levator scapulae muscle, while the C4–5 pattern concentrated over the angle formed by the top of the shoulder and the side of the neck. The C4–5 area differed from that of C5–6 in that, while the former extended onto the suprascapular region from above, the latter clearly spread laterally toward the shoulder.

For logistic reasons, observations in the other volunteers were restricted to only one or three segments in each subject, but the patterns exhibited by these subjects were remarkably similar to those of the first subject when joints at similar levels were stimulated (Figure 3).

The analgesic blocks of the medial branches of the dorsal rami succeeded in promptly relieving the experimentally induced pain on all occasions. Examination of the subjects following these blocks revealed an unexpected phenomenon. All demonstrated a slight hypesthesia over an area that coincided with the previously recorded area of invoked pain and tenderness. This sensation was not an absolute cutaneous anesthesia but a slightly decreased sensitivity to light touch with a slight hyperesthetic sensation around the borders of the area. The difference from normal cutaneous sensitivity was clearly perceived, and the boundary of the region of altered sensation was clearly and consistently delineated by the subjects. Objectivity in this regard was maintained, for the zones of cutaneous sensory changes were all on the back of the neck and shoulder and the subjects were all examined from behind. The altered sensitivity persisted for the duration of action of the local anesthetic used for the nerve blocks.

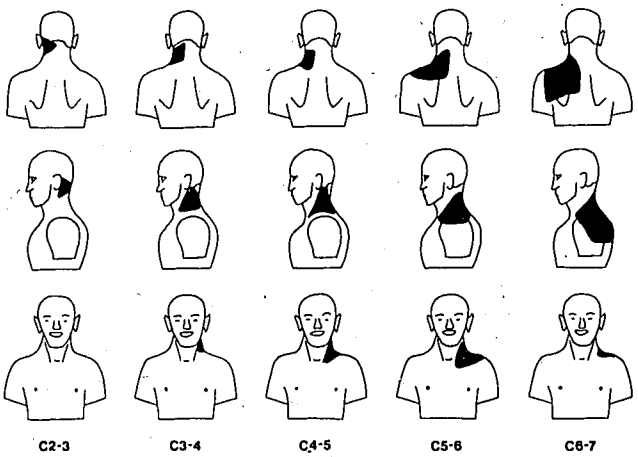

Fig 2. Patterns of pain evoked in the first volunteer by stimulating the zygapophyseal joints at segments C2–3 to C6–7.

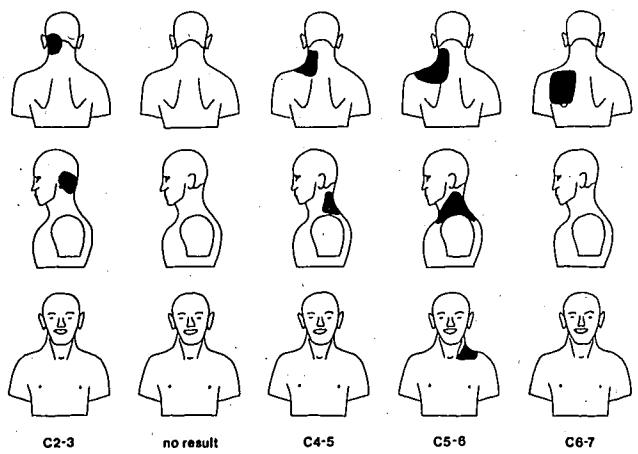

Fig 3. Patterns of pain evoked in further volunteers by stimulating joints at segments C2–3 to C6–7.

DISCUSSION

A large number of volunteers would have been preferable in this study so that a greater measure of individual variation could have been obtained. However, injections in the neck appear threatening even among physicians, let alone among lay persons. For this reason, our volunteer population was restricted to persons who not only were capable of being fully informed of potential hazards, but also were sufficiently versed in the procedures undertaken to appreciate their safety and the measures taken to ensure their safety. Consequently, the pool of potential volunteers available to us was very small.

Nonetheless, the results in the first volunteer suggested that joins at different segmental levels gave rise to distinctly different patterns of pain. Furthermore, when joints at the same levels were successfully stimulated in other volunteers, pain occurred in correspondingly similar regions. This concordance suggested that the pain patterns from cervical zygapophyseal joints follow constant patterns and that the patterns seen in the first volunteer are characteristic.

The validity of this assertion is enhanced when the pain patterns observed in normal volunteers are compared with those reported in studies of symptomatic patients. The C3–4 and C5–6 patterns in the present study are virtually identical to those found in a recent study of patients whose pain was relieved by medial branch blocks and intra-articular blocks of the corresponding joint.[2] Similar comparisons cannot be made for the C4–5 and C6–7 levels, for the patterns of pain in patients with disease at these levels have not been reported to date. The C2–3 area observed in the present study resembles the distribution of pain reported by patients with headaches stemming from the C2–3 zygapophyseal joint.[1] The distribution in volunteers and patients is identical over the posterior region of the head. The one difference is that patients have reported a more extensive rostral extension of their pain to encompass the forehead. We suggest that this more extensive referral probably reflects a greater intensity of pain in patients.

From experimental studies in the lumbar region, it is known that the referral of pain from the zygapophyseal joints into the lower limb is proportional to the intensity of the stimulus.[21,23] In our experiments, the stimulus used was relatively mild. The joints were distended only until the subjects felt pain. To avoid rupturing the capsule, no attempt was made to increase the intensity of pain. Thus, the stimuli used in the present study would have to be considered minimal. This is corroborated by the relatively low scores reported by the volunteers on the visual analog scale.

Moreover, the studies on the lumbar zygapophyseal joint employed hypertonic saline, which is a persistent chemical irritant. In our experiments, pain was coincident with capsular distension and we believe that phasic capsular tension, rather than sustained chemical irritation, was the principal cause of pain. Controlled and restrained capsular distension is probably less noxious a stimulus than hypertonic saline and in these terms, the absence of more extensive referral of pain in our experiments is understandable.

An incidental observation in our study concerns the peculiar hypesthesia reported by the volunteers following cervical medial branch blocks. The areas of hypesthesia did not coincide with known dermatomal patterns. They occurred over the posterior neck and shoulder,

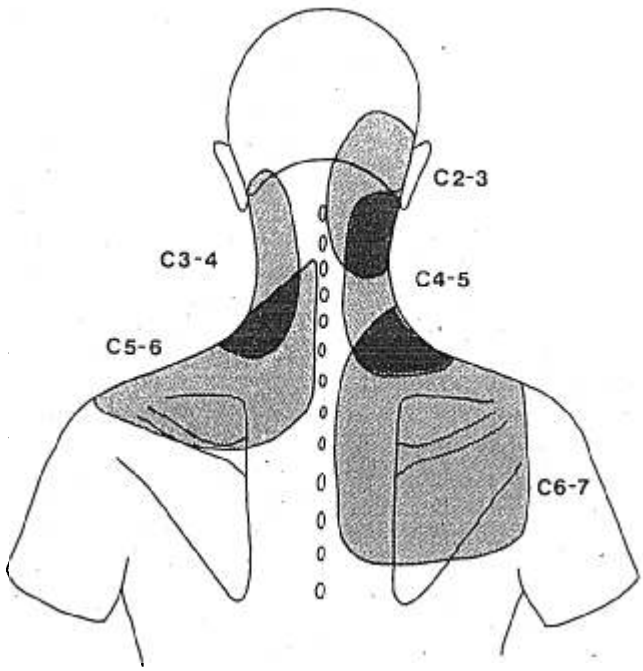

Fig 4. A composite map of the results in all volunteers depicting the putative characteristic distribution of pain from zygapophyseal joints at segments C2–3 to C6–7.

whereas the corresponding dermatomes lie over the anterior neck, forearm, and hand. Nor did the areas correspond to the known cutaneous distribution of the dorsal rami of the nerves blocked.

The hypesthesia was distributed precisely over the previously painful area. In a sense, it seemed to represent a negative image, or "phantom" of the area of evoked pain when this pain was abruptly relieved by the nerve blocks. The sensation could be described as "referred hypesthesia." Qualitatively, this phenomenon is similar to the "referred hypesthesia" and "referred hyperalgesia" reported incidentally in some experiments on referred pain induced by injection of hypertonic saline into interspinous ligaments.[11,14,17]

Because of the lack of association with dermatomal patterns, the mechanism of this phenomenon is unlikely to be due to peripheral or segmental processes and is possibly a hitherto unexplored process in the parietal lobe or thalamus. However, it is not our intention to explore its physiology; rather, we highlight this phenomenon as an indication that, in normal volunteers, physiologic mechanisms seem to be present that can induce seemingly bizarre neurologic features. Such phenomena in patients might, in some circles, be interpreted as "nonorganic" signs. None of our volunteers had histories of psychologic disturbances, hysterical conversion, or compensation neurosis, and we cannot attribute their "strange" reports to such conditions. We suggest that similar reports in patients should be interpreted with caution.

The cardinal demonstration of our study is that the cervical zygapophyseal joints can be sources of neck pain. The pain extends beyond the immediate vicinity of the stimulated joint and so must include an element of referred pain. Our results therefore imply that as in the lumbar region, a physiological mechanism must exist whereby pain stemming from a zygapophyseal joint can be referred into the related limb or limb girdle.

Our results also suggest that cervical zygapophyseal pain is distributed in a pattern characteristic of its segmental origin. By combining the pain areas described by the five subjects at various segments, we have constructed what we perceive to be the cardinal areas of pain characteristic of each segment (Figure 4). We believe that our observations constitute sufficient prima facie grounds to suggest that patients presenting with pain similar to that induced experimentally in our volunteers warrant investigation of their zygapophyseal joints as the putative source of their pain, and that the maps constructed in our study could be used to determine which joints should be investigated with diagnostic blocks. The strength of this conclusion, however, is limited by the small numbers of patients that we were able to study. Consequently, the validity and reliability of the maps constructed in the present study could be questioned. However, either of two approaches could be used to test their reliability.

A larger number of volunteers could be studied to determine the variability of pain patterns, but ethically and logistically this could be a daunting task. Conversely, their reliability could be tested, as it were, by "trial of fire." If the maps constructed in the present study are a valid guide to the segmental location of symptomatic zygapophyseal joints, their use in a clinical setting should succeed in determining the symptomatic level in patients presenting with putative zygapophyseal joint pain. This latter approach has been explored and the results of the related study are reported in a later paper.

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