Diagnostic value of C2-3 instantaneous axes of rotation in patients with headache of cervical origin

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Cephalalgia


Previous investigators have suggested that patients suffering headache stemming from the C2-3 segment of the cervical spine can be identified by detecting an abnormal axis of rotation of that segment. The present study tested this hypothesis by correlating the location of the instantaneous axis of rotation (IAR) of the C2-3 segment with diagnostic blocks of the C2-3 zygapophysial joint in a sample of patients with headache. We found no significant correlation between the location of the axis and the response to diagnostic blocks. Previous false-positive assertions appear to be due to insufficient attention to the precision and reproducibility of the techniques used to determine IARs.

Cervical spine, headache, instantaneous axis of rotation, whiplash

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The taxonomy of the International Headache Society (IHS) recognizes that some forms of headache can be attributed to pain referred from the cervical spine (1), and there is ample evidence of the neuroanatomical and physiological basis for such pain referral to the head (2-4). However, the objective diagnosis of headaches of cervical origin remains vexatious and controversial. The clinical criteria outlined by the International Headache Society are not particularly compelling and are not universally accepted as indicating a unique form of headache. Objective, confirmatory tests are either lacking or not commonly available.

Amongst the causes of headache of cervical origin are disorders of the upper cervical synovial joints (3) and, in particular, the C2-3 zygapophysial joint (5). A previous descriptive study (4) and a recent, controlled study (6) have shown that headaches stemming from the C2-3 zygapophysial joint can be diagnosed using diagnostic blocks of the third occipital nerve which innervates this joint. Diagnostic blocks, however, are not a particularly palatable means of investigating headache, not just because they are invasive, but also because they require special facilities and expert skills. For these reasons, some investigators have pursued non-invasive techniques for the diagnosis of cervical headaches.

Clinical examination and plain radiography have not been found to be diagnostic of headaches of cervical origin (7). However, one study has suggested that such headaches might be diagnosable using functional radiography (8). In particular, the discriminating feature would appear to be the location of the instantaneous axes of rotation (IARs) of upper cervical motion segments.

The IAR is a mathematical summary of the kinematics of a vertebra as it moves in an arcuate motion from flexion to extension; essentially, it is the point around which the vertebra appears to move. The IAR may be determined by applying basic geometry to lateral plain radiographs, one in full flexion and one in full extension (9-11).

Mayer and associates (8) combined diagnostic blocks with IARs in an attempt to elucidate a relationship between the source of cervical pain and IARs. Their study proposed a link between cervical headache and abnormally located IARs at the C2-3 segmental level. This is an attractive notion because it suggests that functional radiography might be a suitable means of replacing diagnostic blocks as an objective test of cervical headache.

The present study was undertaken to explore the validity and utility of this notion. A particular form of headache was studied, namely headache stemming from the C2-3 zygapophysial joint. This form of headache was addressed because it has been found to be a common complaint following neck injury (6), one whose segmental source could be specified, and for which an IAR could be determined. The principle espoused by Mayer and associates invited the hypothesis that headaches stemming from C2-3 would be indicated by an abnormally located IAR at that segment. This hypothesis was expressly tested in the present study.

Methods

The patients for the present study were seen during the period April, 1991, to November, 1992, at the
Cervical Spine Research Unit (CSRU) of the Mater Misericordiae Hospital, in Newcastle. The Unit is a tertiary referral centre specializing in the investigation of neck pain following whiplash injury. Criteria for admission to the Unit were that patients suffered neck pain for more than 3 months, with or without headache, following and attributed to a motor vehicle accident. Patients presented either with neck pain as their sole complaint, with neck pain but headache as their major complaint, or with neck pain as their predominant complaint but with some or occasional headache.

The sample of patients studied comprised 82 patients in whom functional radiographs of the cervical spine had been obtained and who had completed investigations using double-blind controlled blocks to the extent that headaches stemming from the C2-3 zygapophysial joint had been either confirmed or expressly refuted. The patients were aged 40 ± 10 years (mean ± SD) and exhibited a male:female ratio of 3:5. Ethics approval had been granted by the University and Area Health Service Ethics Committees to perform double-blind, controlled investigations on these patients.

Clinically, these patients satisfied all but one of the IHS criteria (1) for headaches stemming from the cervical spine. They had pain in the occipital region radiating variably to the forehead, orbit, temple or vertex, aggravated by neck flexion or rotation, associated with resistance to passive motion and tenderness of the posterior neck muscles. They did not have demonstrable radiographic abnormalities such as tumours or rheumatoid arthritis. They did not satisfy the criterion of movement abnormality. This feature, indeed, was the object of the present study. By and large the patients had a unilateral headache or predominantly unilateral headache (one side consistently worse than the other; no side-shift), and the pain was constant, present for more than 75% of their waking hours. Otherwise, the clinical features of these patients and the features of C2-3 headache have been detailed elsewhere (6).

All patients in the sample population underwent diagnostic blocks of their cervical zygapophysial joints using blocks of the medial branches of the dorsal rami that supplied the target joint (12-14). In the case of the C2-3 zygapophysial joint, the third occipital nerve was blocked (4, 6). For joints below C2-3 each of the two medial branches that supplied the target joint were simultaneously blocked. For patients whose dominant symptom was headache, blocks were initiated at the C2-3 level. For patients whose dominant complaint was neck pain, blocks were initiated at levels suggested by referred pain maps for cervical zygapophysial joint pain (5, 15). If a block failed to relieve the patient's pain, further blocks were undertaken on subsequent occasions at adjacent levels until a positive response was obtained or until all joints that might reasonably be the source of pain had been excluded. For patients with unilateral headache or headache predominantly on one side the blocks were performed on that side. For patients with bilateral headaches, blocks were performed systematically one side at a time, on separate occasions.

All blocks were performed under double-blind controlled conditions using comparative local anaesthetic blocks (13). Each patient was randomly allocated to receive either a short-acting local anaesthetic (lignocaine 2%) or a long-acting anaesthetic (bupivacaine 0.5%) on the occasion of their first block. If they obtained complete pain relief they returned for a repeat block on a subsequent occasion using the reciprocal agent.

For the last 68 patients who entered the programme, injections of normal saline were performed as an additional control to eliminate any ambiguity about patients who exhibited prolonged responses to either of the anaesthetic agents and to identify any possible placebo responses (13).

A positive response was entertained only if the patients obtained complete relief of their pain on both occasions that local anaesthetics were used, but provided that the duration of pain relief was longer with bupivacaine than with lignocaine, and provided that they obtained no relief if and when saline was used. A response was deemed ambiguous if the patients had a positive response to saline or if they obtained longer relief with lignocaine than with bupivacaine. In patients with bilateral headache a positive response was entered if blocks on either side abolished the headache at least on that side.

All patients underwent lateral radiographs in full active flexion and full active extension; passive over-pressure was not applied. IARs were determined using a previously validated and calibrated technique (10). In brief, it involved obtaining tracings of the flexion and extension radiographs; tracings of corresponding motion segments were superimposed to reveal the relative motion of the upper vertebra; identical points on that vertebra were connected by intervals whose perpendicular bisectors intersected at the IAR (Fig. 1); the location of the IAR was plotted with respect to X, Y coordinates constructed on the lower vertebra of the motion segment and its coordinates were normalized and expressed as proportions of the height and width of that vertebra. An IAR was classified as normal or abnormal depending on whether it fell within or outside the normal range as determined previously using the same techniques as in the present study (16, 17).

Motion segments with ranges of movement of less than five degrees were rejected from the study because it has been reported that, in such instances, technical errors increase markedly (18).
To determine the correlation between headache stemming from C2-3 and the location of IARs for this motion segment, a 2 x 2 contingency table was constructed. Additional correlations were pursued between the location of IARs at C2-3 and the presence or absence of headache, irrespective of its source. A chi-squared test was used to test for significance of association.

**Results**

In 28 patients, IARs could not be determined. Twenty-three patients exhibited less than 5 degrees of motion at C2-3; in two instances, the films were lost by the patients, subsequent to their release by the hospital; in one case the patient forgot to keep radiographic appointments due to complications related to a previous head injury and in two cases rotation of the cervical spine out of the sagittal plane resulted in a poor vertebral image. However, IARs were determined in the remaining 54 patients. These patients exhibited 8.5 ± 2.5 degrees (mean ± SD) of sagittal rotation at C2-3.

Sixty-three patients underwent double-blind controlled blockade of the third occipital nerve. Of these, 37 had a positive response and 26 had a negative response. A further 19 were not investigated at the C2-3 segment because this joint was not implicated in their pain; either their pain was relieved when segments below C2-3 were anaesthetized, or they exhibited unreliable responses to diagnostic blocks.

Results of IAR determinations at the C2-3 level were compared with the results of diagnostic blocks of this segment (Table 1). No association was found to exist between IARs and pain stemming from the C2-3 segment \( p = 0.7 \). Similarly, there was no significant association between abnormal IAR location and the presence of headache as either a major or secondary complaint (Tables 2 and 3).

<table>
<thead>
<tr>
<th>Table 1. Contingency table comparing the results of zygapophysial joint blocks with the status of IARs at the C2-3 motion segment.</th>
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<tr>
<td><strong>Zygapophysial Joint Blocks at C2-3</strong></td>
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<tr>
<td>Abnormal IARs</td>
</tr>
<tr>
<td>IARs</td>
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<tr>
<td>Normal</td>
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<td>( \chi^2 = 0.15; \text{df}=1; p = 0.7 )</td>
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<th>Table 2. Contingency table comparing the presence or absence of headache with the status of the IAR at the C2-3 motion segment.</th>
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<tr>
<td><strong>Zygapophysial Joint Blocks at C2-3</strong></td>
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<td>Normal</td>
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<td>( \chi^2 = 0.04; \text{df}=1; p = 0.9 )</td>
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Table 3. Contingency table comparing the presence of headache as either an incidental or a major complaint with the status of the IAR at the C2-3 motion segment.

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<tr>
<th>Headache Major Complain</th>
<th>Incidental</th>
<th>Abnormal IARs</th>
<th>Normal IARs</th>
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<tbody>
<tr>
<td>Abnormal</td>
<td>8</td>
<td>14</td>
<td></td>
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<tr>
<td>Normal</td>
<td>19</td>
<td>13</td>
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$X^2 = 1.9; df = 1; p = 0.2$

Discussion

Headache was a common complaint amongst the 68 patients who completed the study. Only 9 denied any headache; for 35 patients headache was their major complaint; for 24, headache was only incidental to their neck pain.

In nearly one-third of these patients IARs were abnormal at C2-3. However, there was no positive association between an abnormal IAR and whether or not a patient complained of headache, whether or not headache was a major complaint, or whether or not their headache stemmed from the C2-3 zygapophysial joints. This lack of association is in contrast to the observation reported by Mayer and associates (8), which we submit stems from the difference in rigour between the two studies.

In the present study, diagnostic blocks were performed under stringent double-blind controlled conditions so as to minimize false-positive responses. IARs were determined meticulously using validated techniques of known accuracy and compared to normative data obtained previously using the same techniques.

In contrast, the study of Meyer and associates (8) did not employ controlled diagnostic blocks and did not specify the accuracy of the techniques used to determine IARs or the reliability of the normative data against which they were compared. The implication of that study was that the IARs could be readily determined. This is not the case. The determination of IARs is fraught with difficulty (9, 10). Difficulties arise in accurately identifying vertebral margins, tracing them, registering traces and geometrically determining the IAR. Interobserver errors potentially occur at each step.

The normative data used in the present study were collected meticulously from a substantial number of patients ($n = 40$) (17) with careful attention to interobserver errors, their source and magnitude, which have been detailed elsewhere (9, 10, 16, 17). The techniques used have been shown to provide better interobserver agreement than traditional methods (10). These same techniques were used to study the radiographs of the symptomatic patients in the present study.

Although, prima facie, the results of the present study refute the notion of Mayer et al. (8), this could be due to a type I error. A large proportion of patients could not be included in the analysis because they exhibited low ranges of motion and IARs could not be determined; yet many of the patients had positive diagnostic blocks at C2-3. Thus a relationship between headache and IARs could exist but was not detected in the present study for technical reasons.

If IARs are to be pursued as an index of headache or any form of neck pain technical limitations would need to be overcome. One suggestion is that patients should be examined fluoroscopically first to ensure that adequate motion occurs at the segment in question before plain films are taken. Films taken directly opposite that segment of interest would also ensure optimal images of the vertebrae and reduce technical errors. However, unless and until such measures are taken doubts must remain about the reliability and utility of biomechanical tests as a tool for the investigation of headache.

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References