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Clinical Studies

Provocative cervical discography symptom mapping

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Abstract

Background context

In a small prospective study assessing 10 symptomatic and 10 asymptomatic subjects, Schellhas et al. compared cervical discography to magnetic resonance imaging. Within that study he reported on the distribution of pain for the C3–C4 to C6–C7 levels. Four years later, Grubb and Ellis reported retrospective data from his 12-year experience using cervical discography from C2–C3 to C7–T1 in 173 patients. To date, no large prospective study defining pain referral patterns for each cervical disc has been performed.

Purpose

To conduct a prospective visual and statistical descriptive study of pain provocation of a cohort of subjects undergoing cervical discography.

Study design/setting

Prospective multicenter descriptive study.

Methods

Pain referral maps were generated for each disc level from patients undergoing cervical discography with at least two levels assessed. If concordant pain was reproduced in a morphologically abnormal disc, the subject immediately completed a pain diagram. An independent observer interviewed the subject and recorded the location of provoked symptoms. Visual data were compiled using a body sector bit map, which consisted of 48 clinically relevant body regions. Visual maps with graduated color codes and frequencies of symptom location at each cervical disc level were generated.

Results

A total of 101 symptom provocation maps were recorded during cervical discography on 41 subjects. There were10 at C2–C3, 19 at C3–C4, 27 at C4–C5, 27 at C5–C6, 16 at C6–C7 and 2 at C7–T1. Predominantly unilateral symptoms were provoked just as often as bilateral symptoms. The C2–C3 disc referred pain to the neck, subocciput and face. The C3–C4 disc referred pain to the neck, subocciput, trapezius, anterior neck, face, shoulder, interscapular and limb. The C4–C5 disc referred pain to the neck, shoulder, interscapular, trapezius, extremity, face, chest and subocciput. The C5–C6 disc referred pain to the neck, trapezius, interscapular, suboccipital, anterior neck, chest and face. The C6–C7 disc referred pain to the neck, interscapular, trapezius, shoulder, extremity and subocciput. At C7–T1 we produced neck and interscapular pain. Visual maps with graduated color codes and frequencies of symptom location at each cervical disc level were generated.

Conclusions

In conclusion, these results confirm the observations of prior investigators that cervical internal disc disruption can elicit axial and peripheral symptoms. The particular patterns of pain generation allow the discographer to preprocedurally anticipate disc levels to assess. With these data, the number of disc punctures that are required can be limited rather than routinely assessing all cervical discs.

Keywords: Internal disc disruption syndrome; Neck pain; Discography; Fusion surgery

Article Outline

Introduction

During the past century, multiple events have transpired culminating in the theory that cervical discs may refer pain peripherally. In 1935, Mixter and Barr [1] suggested that the lumbar intervertebral disc may be symptomatic without compressing a nerve root. In 1947, Inman and Saunders [2] proposed sclerotomal referral as the mechanism by which the intervertebral disc may cause pain. In 1948, Lindblom [3] described a procedure to puncture lumbar discs in patients with low back pain and lower extremity pain in order to help localize the level of symptomatic discs. The following year, Hirsch [4] used lumbar disc puncture in an attempt to identify the level of any painful discs. Subsequently, Cloward [5] and Smith and Nichols [6] working independently developed a technique to allow direct injection of cervical discs. These authors claimed that injection into the involved disc served two purposes: to visualize the morphology of the internal structure of the disc and to reproduce the patient's complaints [7], [7] and [8]. They believed that the pain perceived was more diagnostic than the morphology of the disc. Smith and Cloward acted on these beliefs by using cervical discography as the diagnostic test in selecting the level at which disc excision and fusion should be performed [9].

Crock [10], Fernstrom [11], and Goldner et al. [12] have all described pain syndromes emanating from the lumbar intervertebral disc. There are a plethora of studies supporting the notion that the lumbar disc itself, without mechanically compressing any neural structures, can refer pain to the lower extremities [3], [4], [13], [14], [15], [16], [17], [18], [19], [20] and [21]. In 1995, Schwarzer et al. [21] reported referral pain to the buttock, groin, thigh, calf and foot in patients with lumbar internal disc disruption (IDD) as demonstrated by provocation discography. Two years later, Ohnmeiss et al. [13], using pain diagrams to demonstrate the location and character of lower extremity symptoms associated with Grade 2 versus Grade 3 annular tears, also demonstrated that lumbar discs refer pain sclerotomally to the buttocks, thighs and legs. In 1999, Ohnmeiss et al. [22] again reported lower extremity pain referral in patients with symptomatic, internally disrupted discs as demonstrated by postdiscography computed tomography.

The existence of referral pain patterns from somatic structures in the cervical spine has been demonstrated. In 1990, Dwyer et al. [23] diagrammed the pain patterns evoked by stimulation of normal cervical zygapophyseal joints. They demonstrated that distension of the synovial capsules of the cervical zygapophyseal joints can refer pain beyond the immediate vicinity of the stimulated joint and may be referred peripherally to the ipsilateral shoulder and/or periscapular region. They stated that "our results therefore imply that as in the lumbar region, a physiologic mechanism exists whereby pain stemming from the zygapophyseal joint can be referred into the related limb or limb girdle." In 1996, Schellhas et al. [24] reported in a prospective study, the purpose of which was to assess the correlation of magnetic resonance imaging (MRI) and cervical discography, that patients perceive pain peripherally during cervical discography.

Currently, it is assumed that the cervical disc disruption can refer pain to the upper extremities. This theory is based on previously referenced papers by Dwyer et al. [23] demonstrating pain referral from the cervical zygapophyseal joints, Schwarzer et al. [21] and Ohnmeiss et al. [13] demonstrating lumbar disc disruption referral to the lower extremities and Schellhas et al. [24] reporting sensory perception peripherally on provocation cervical discography. To our knowledge, there is no large prospective study evaluating referral patterns of pain elicited during cervical discography.

Materials and methods

After institutional review board approval, methodology and data collection proceeded in a similar manner at three spine centers. Consecutive patients who during routine clinical care were deemed to require cervical discography to ascertain whether surgical intervention was a viable alternative and, if affirmative, at which level(s) it should be performed were queried as to whether they would participate in this study. If they agreed, proper research consent forms were signed. The logistics, risks and benefits of the procedure were explained to each patient before its performance. Each patient was cleaned and draped in sterile fashion. At no time was any form of sedation used. A 23-gauge, 3.5-inch spinal needle was introduced into the cervical disc using an anterolateral approach. The internal carotid was palpated and then displaced laterally, while the esophagus and trachea were moved medially (toward the contralateral side) before insertion of the needle. During incremental advancement of the needle, the location of the needle tip and the orientation of the needle in the sagittal, coronal and axial planes were assessed using sequential fluoroscopic imaging. Nuclear needle placement was confirmed in the anteroposterior and lateral views before the introduction of contrast. Each disc was then injected with omnipaque until filling of the disc was visualized or resistance was appreciated. Injection of contrast was aborted when the patient verbally indicated that he or she was perceiving pain. The patient was then questioned about whether the perceived sensation was pain or pressure, the location of these symptoms, the perceived symptom intensity level and relationship to the presenting complaints. If a concordant or partially concordant pain response with a minimum visual analog scale rating of 60/100 was produced in a morphologically fissured or ruptured disc, then the patient completed a pain diagram (Fig. 1). For purposes of clarity, a few definitions are described. Concordant pain was defined as pain that completely and exactly covered the area where the patient usually experienced symptoms, the quality of the pain was identical and the pain intensity level was a minimum of 60 out of 100 on the visual analog scale. Partial concordant pain was defined as all of the aforementioned criteria for concordant pain, except that only a portion of the usual area of typical pain was reproduced. Concordant pain denoted pain provoked in an area that was not a region in which the patient usually experienced pain regardless of intensity or quality. Upon completion of this form, a physician not performing the procedure immediately obtained a history focused on describing the character, intensity and location of pain perceived during the disc injection. The questioner then completed a pain diagram based on the information elicited. If there was any discrepancy observed during the comparison of the two drawings, this was resolved during an additional interview session between the independent observer and the patient. All information concerning pain intensity, location, quality and relationship to the usual pain experienced was recorded immediately after the disc in question was stimulated and before the assessment of the next disc. This process was followed until all of the discs to be evaluated were analyzed. Inclusion criteria for the study were a fissured or ruptured disc as demonstrated during discography and postdiscography computed tomography (CT) with a concordant or partially concordant pain response and a completed pain diagram. The completed pain diagrams were scanned into a digital bitmap image with 46 defined body regions (see Fig. 2). If a disc created discordant pain or was nonpainful, there were no data recorded for that disc level. In each instance discography was performed at a minimum of two levels: a single concordant level and a single adjacent asymptomatic level. As many as six disc levels could be assessed depending on the information garnered during the discogram. No data were recorded regarding how many disc levels were performed on each patient.

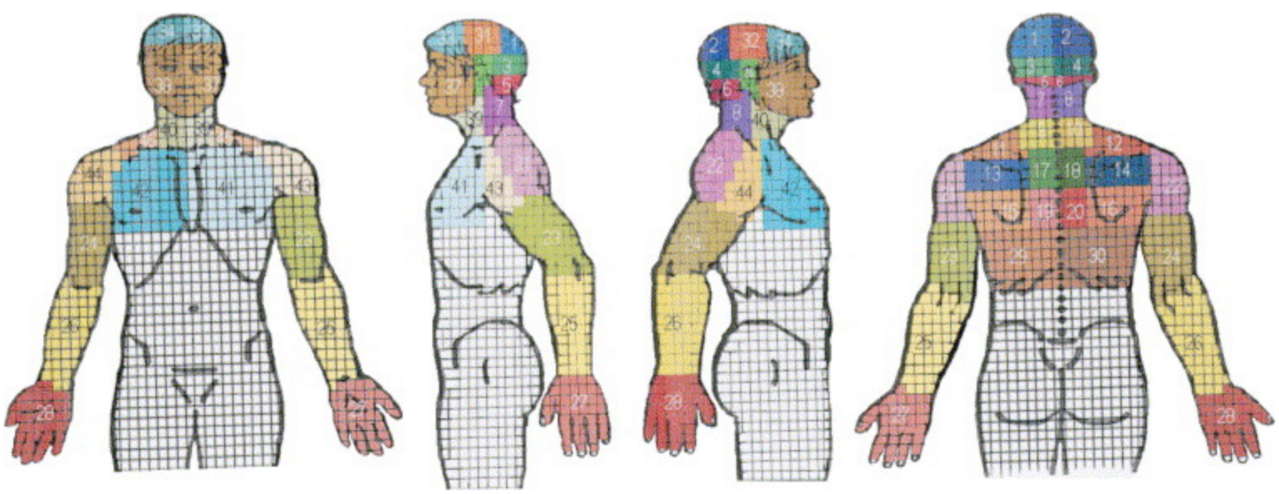

Fig. 1. Body region pain diagram.

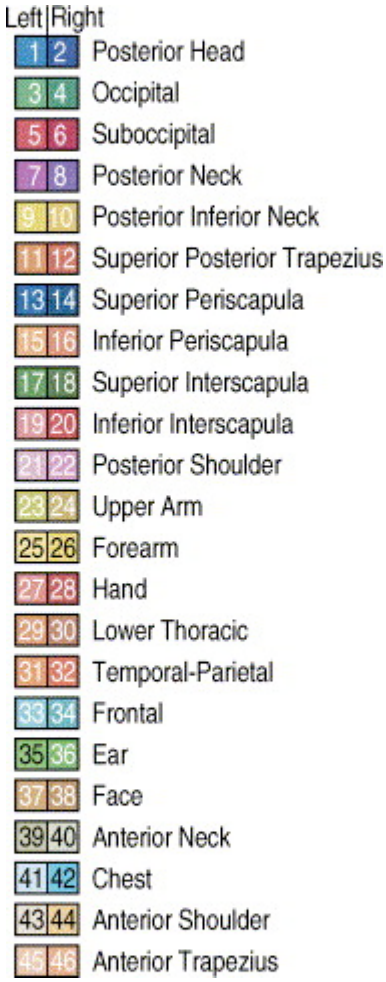

Fig. 2. Numerical coordinates of body regions.

Results

A total of 101 symptom provocation maps were recorded during cervical discography on 41 subjects. The 101 maps comprised 10 at C2–C3, 19 at C3–C4, 27 at C4–C5, 27 at C5–C6, 16 at C6–C7 and 2 at C7–T1. Predominantly unilateral symptoms were provoked just as often as bilateral symptoms. The C2–C3 through C7–T1 discs could produce posterior or inferior posterior neck pain. Head and/or face symptoms were produced by the C2–C3 through C6–C7 discs. Trapezius and shoulder symptoms were produced by the C3–C4 through C6–C7 discs. Extremity symptoms were produced by the C3–C4 through C6–C7 discs. Anterior chest wall symptoms were produced by the C4–C5 and C5–C6 discs. Interscapular pain was produced at the C3–C4 through C7–T1 levels. C7–T1 exclusively produced midline pain extending from the posterior cervical spine to the mid-thoracic distribution.

These data are represented in Table 1 and in bitmap image form in Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7 and Fig. 8.

Table 1.

Distribution frequency of evoked pain by cervical disc level

Disc number Body region	**Numerical coordinates by body region (see Fig. 2)**	**C2–3 N=10**	**C3–4 N=19**	**C4–5 N=27**	**C5–6 N=27**	**C6–7 N=16**	**C7–T1 N=2**
Posterior head	1						
	2	0	0	0	0	0	0
Occipital	3						
	4	1	1	2	2	1	0
Suboccipital	5						
	6	6	5	6	6	1	0
Posterior neck	7						
	8	9	17	23	20	9	0
Posterior inferior neck	9						
	10	2	15	23	17	13	1
Superior posterior trapezius	11						
	12	0	9	17	12	7	0
Superior periscapula	13						
	14	0	4	11	11	9	0
Inferior periscapula	15						
	16	0	1	6	5	5	0
Superior interscapula	17						
	18	0	1	9	11	12	1
Inferior	19						

Disc number Body region	Numerical coordinates by body region (see Fig. 2)	C2–3 N=10	C3–4 N=19	C4–5 N=27	C5–6 N=27	C6–7 N=16	C7–T1 N=2
interscapula							
	20	0	1	4	3	6	1
Posterior shoulder	21						
	22	1	5	11	12	7	0
Upper arm	23						
	24	0	3	8	4	4	0
Forearm	25						
	26	0	2	1	2	2	0
Hand	27						
	28	0	2	0	0	1	0
Lower thoracic	29						
	30	0	1	3	1	2	0
Temporal-parietal	31						
	32	0	0	2	0	0	0
Frontal	33						
	34	0	0	1	1	0	0
Ear	35						
	36	0	0	1	1	0	0
Face	37						
	38	1	1	4	3	0	0
Anterior neck	39						
	40	2	4	4	4	2	0
Chest	41						
	42	0	0	4	5	2	0

Disc number Body region	**Numerical coordinates by body region (see Fig. 2)**	**C2–3 N=10**	**C3–4 N=19**	**C4–5 N=27**	**C5–6 N=27**	**C6–7 N=16**	**C7–T1 N=2**
Anterior shoulder	43						
	44	0	2	6	7	3	0
Anterior trapezius	45						
	46	0	1	5	6	3	0
Lumbar	47						
	48	0	0	0	0	1	0

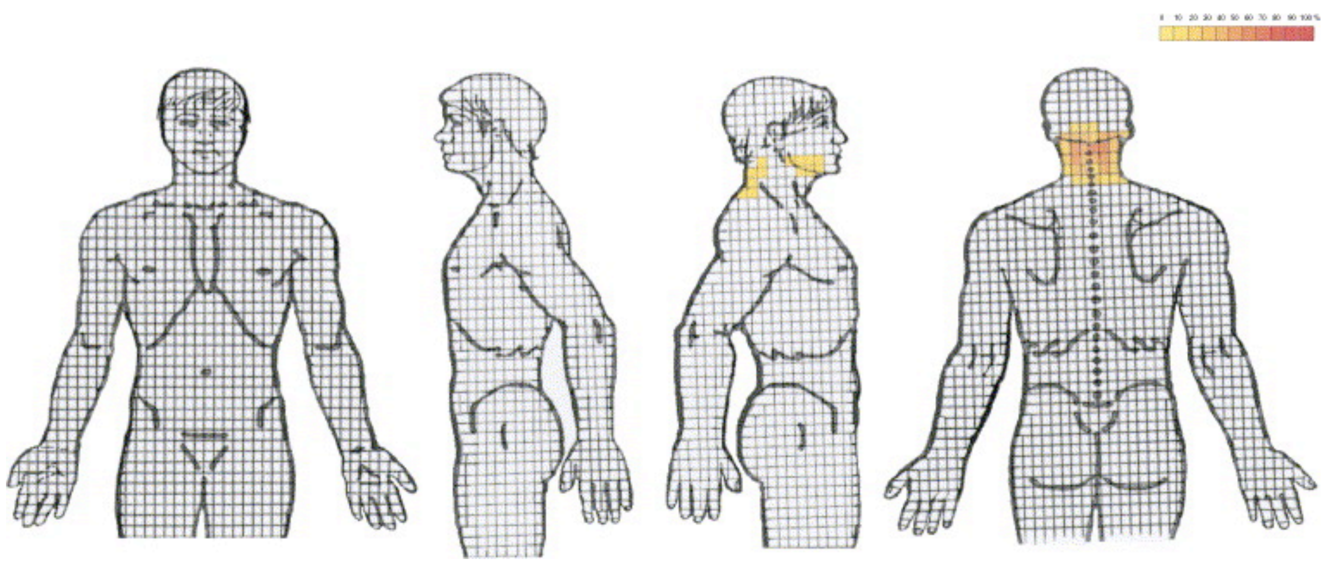

Fig. 3. C2–C3 discogram pain referral map.

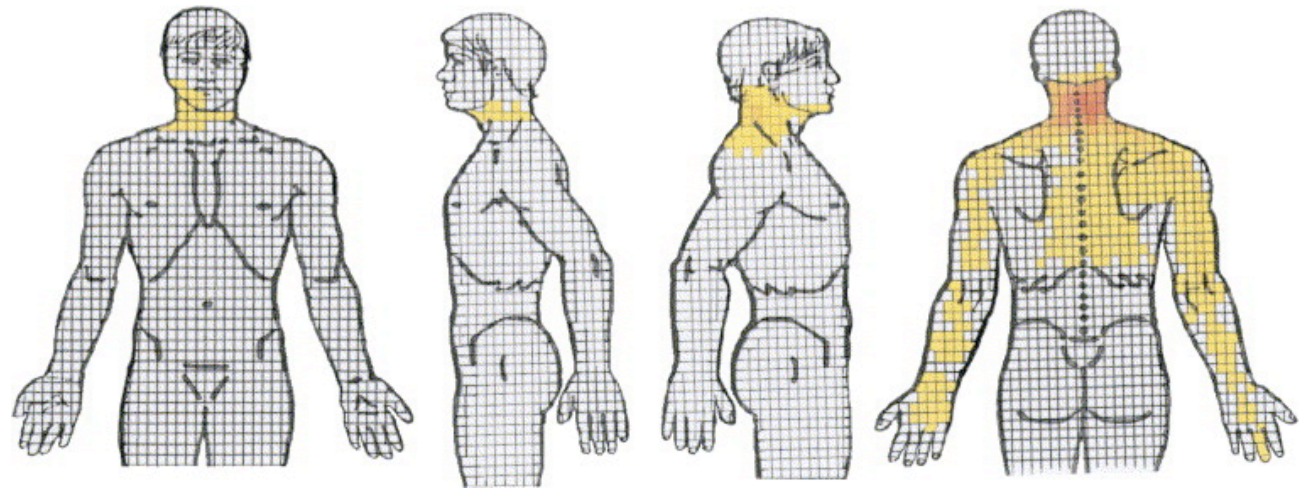

Fig. 4. C3–C4 discogram pain referral map.

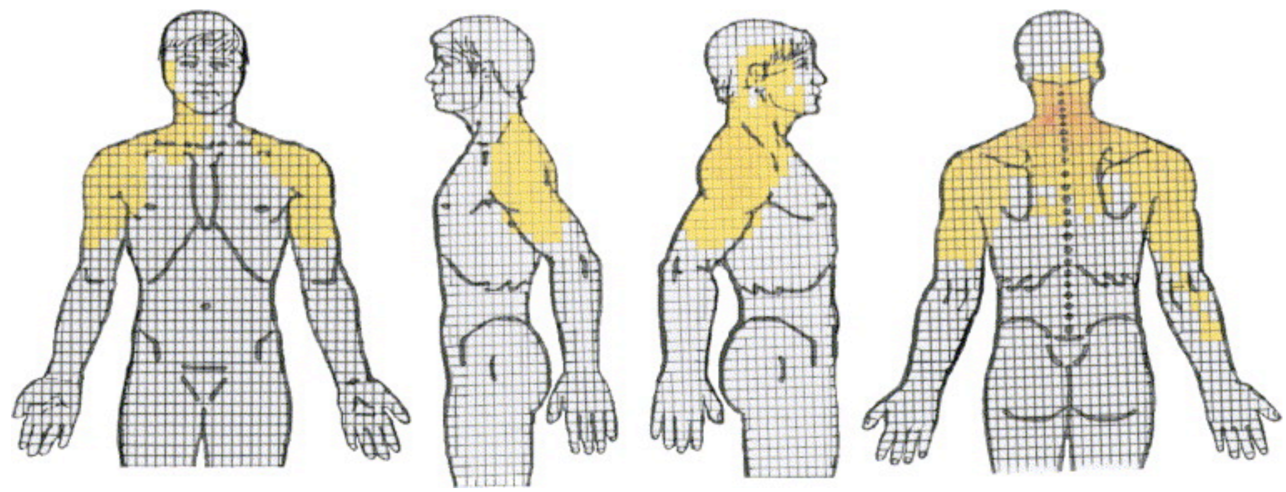

Fig. 5. C4–C5 discogram pain referral map.

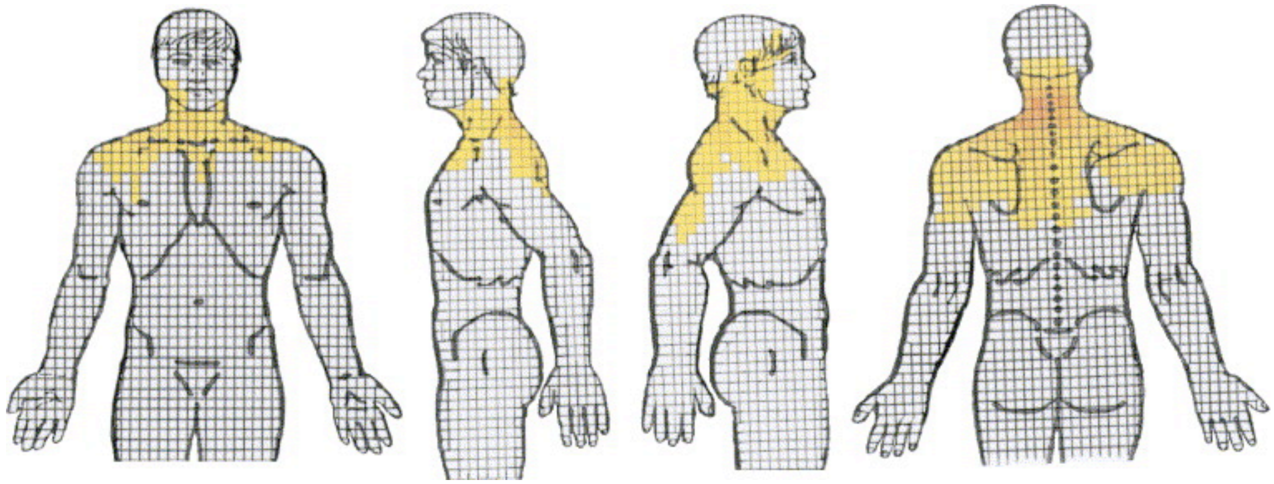

Fig. 6. C5–C6 discogram pain referral map.

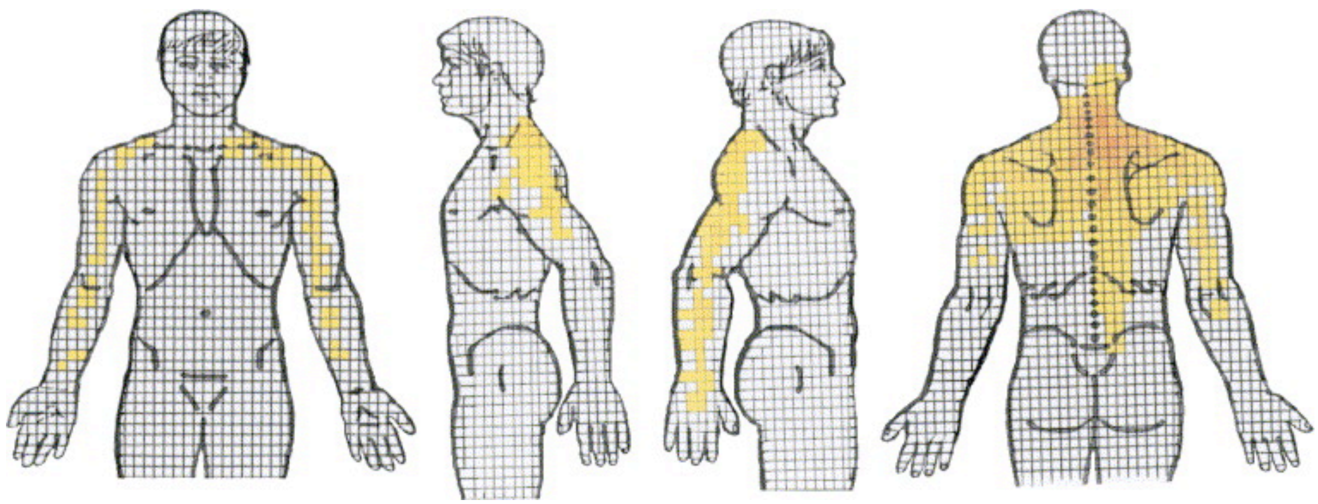

Fig. 7. C6–C7 discogram pain referral map.

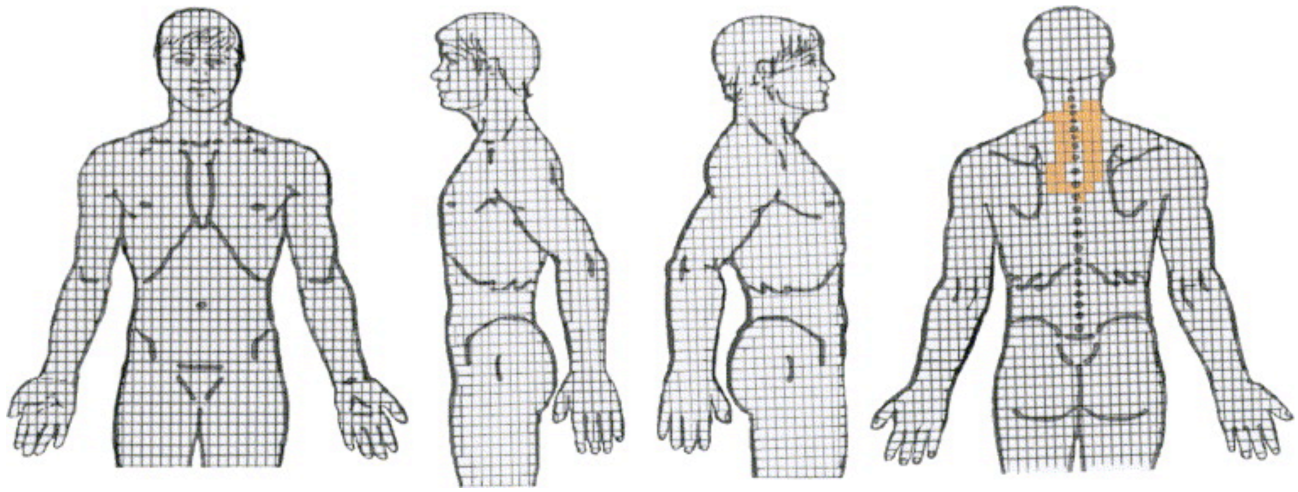

Fig. 8. C7–T1 discogram pain referral map.

Discussion

Our study confirms the observations made by Ohnmeiss et al. [13] and [22] of the lumbar spine and those of Schellhas et al. [24] and Grubb and Kelly [25] of the cervical spine that intervertebral discs can refer pain to distal axial and extremity regions. The culmination of the aforementioned work and our prospective study establishes this clinical observation as fact.

Although our work agreed with some observations made in previous work, there are some significant differences. Schellhas et al. [24] in 1996 reported the results of their prospective study investigating the C3–C4 through C6–C7 intervertebral discs in 10 asymptomatic and 10 symptomatic subjects. Our data demonstrated similar referral patterns with the exception that we did not reproduce anterior chest wall symptoms at the C6–C7 disc. Similar to Schellhas et al., we did reproduce anterior chest wall symptoms at C4–C5 and C5–C6. Both studies produced head and face symptoms at C3–C4 and C4–C5. Our study additionally produced face symptoms at C5–C6, whereas Schellhas's study did not. Grubb in 2000 reported on his experience with 173 cervical discograms from the C2–C3 through C7–T1 levels. Unlike Grub and Ellis, at the C2–C3 level we did not produce frontal, anterior neck or ear symptoms. At C3–C4 we did not produce frontal symptoms, which Grubb and Ellis did. At C4–C5 we produced head, face and extremity pain whereas Grubb and Ellis did not. At C5–C6 we produced head, face and anterior neck pain whereas Grubb did not. At C6–C7 we did not produce any anterior neck or chest wall pain, whereas Grubb and Ellis and Schellhas et al. did. At C7–T1, Grubb and Ellis produced symptoms into the arm and elbow, whereas in our two subjects we did not elicit these symptoms.

It is not surprising that our results were not identical to those reported by Schellhas et al. or Grubb because we use different methodologies. Although Schellhas et al. invoked a prospective method, they assessed only 10 symptomatic individuals, whereas we looked at 41. Although Grubb reported on a much larger sample size, the study was conducted in a retrospective manner.

One of the special benefits of using a prospective analysis is that the explicit information one is looking for can be meticulously accumulated. We suspect that the Grubb trial may have suffered from the simple fact that some information was not obtained at the time of discography. It is easy to imagine that the investigator was looking to identify concordant pain but not pay as close attention to some of the peripheral symptoms, such as chest wall pain, posterior cervical pain or even prefrontal pain. Indeed, in our own trial we had to conduct thorough and lengthy questioning that is not routine during a typical discogram. Normally, our focus is on reproducing the cervical pain, and we are much less interested in the secondary peripheral symptoms. Yet, for this study these referred symptoms are an essential element in the development of the pain distribution maps. It was for this explicit reason that we used independent investigators at each site to acquire the information regarding the location of symptoms. Additionally, we demanded that there be a unanimous decision about the data retrieved. During the process, we witnessed the periodic confusion patients can have and how an investigator can misinterpret the verbal information provided by a subject undergoing discography. It is certainly reasonable to assume that the data we obtained were retrieved through the most accurate process available. It also reasonable to assume that the retrospective Grubb and Ellis study did not obtain similarly accurate data because of the methodology they employed.

One of the most important characteristics revealed in the Grub and Ellis study and observed by us in this study is the how general location of symptoms relates to the disc level investigated. They state that C2–C3 and C3–C4 will generate symptoms in similar locations, whereas C4–C5 and C5–C6 refer symptoms that are similar but comparatively lower than C2–C3 and C3–C4. C6–C7 and C7–T1 trigger painful symptoms even lower than the C4–C5 and C5–C6 pairing. When symptoms are provoked from C3–C4, it is typical that stimulation of lower discs, when symptomatic, will generate symptoms that are more caudal than the higher disc. Combining the data accumulated by Schellhas et al., Grubb and Ellis and this investigation culminates in useful guidelines for the performance of cervical discography. These parameters can be employed preprocedurally such that the correct number of disc levels will be assessed. In each instance the most superior and inferior discs must be investigated. If both are positive, then the discogram can be terminated, provided it is being performed specifically for surgical intervention for primary neck pain. If only one is positive, then the adjacent disc, which has not been reported to produce that symptom complex, must be tested along with the other discs known to provoke that particular symptom complex. The clinically useful cervical symptom complexes and the disc levels that have been shown to evoke them are:

• Cervical and facial pain

• C2–C3 through C5–C6

• Cervical & head pain

• C2–C3 through C6–C7

• Cervical and anterior chest wall pain

• C4–C5, C5–C6, C6–C7

• Cervical and extremity pain

• C3–C4 through C6–C7 (C7–T1).

At this juncture it is not possible to definitively state whether the C7–T1 level elicits extremity symptoms. We did not find that occurrence; however, we conducted only two C7–T1 disc stimulations. Grubb et al. reported that extremity complaints were evoked; however, their patients had been given light sedation (5 to 10 mg of intravascular valium). This may very well have impacted the accuracy of the data collected.

The breakdown of symptom location and its relation to a particular disc level and the understanding that the stimulation of a single disc can be used as a reference for the subsequent disc assessments allows for the judicious implementation of cervical discography. For example, a patient describes mid-neck and anterior chest wall pain. In this instance the C4–C5 to C6–C7 discs will need to be assessed. If the patient describes no pain at C4–C5, concordant neck pain and anterior chest wall pain at C5–C6 and no pain at C6–C7, then no further testing would be required. It would be expected that the C2–C3 and C3–C4 would provoke only pain that is higher than C5–C6, whereas C7–T1 would trigger lower symptoms. If the scenario were altered such that the patient states the pain was positive at C4–C5 (neck and anterior chest wall) and negative at C5–C6, then C3–C4 should be assessed and we would not view C6–C7. If C3–C4 were negative, we would conclude the study. In one more variation of this case, if C4–C5 produced partial concordant neck pain, but there were some higher axial pain that was not elicited and C5–C6 were negative, then we would be obligated to understand the role of C2–C3 and C3–C4 in this instance. In essence, the knowledge of where particular disc levels trigger peripheral symptoms, paying close attention to the location of provoked pain with the initial symptomatic disc and relating this to the patient's symptoms, allows the interventional spine physician to fine tune the discogram. Given these observations, we suggest that performing cervical discography on each disc level C2–C3 through C7–T1 is unwarranted and will only increase the probability that a side effect or complication will occur by virtue of sheer mathematics: the more disc levels assessed, the greater the likelihood a complication will occur.

Because of the descriptive nature of this study, statistical analysis cannot be performed. It is entirely possible that if we had included a larger number of subjects, different results may have been attained. If we had done so, we may have observed some of the pain patterns reported by Grubb and Ellis that we did not obtain in this study. We attempted to minimize the impact of this potential problem by incorporating Grubb and Ellis' results in our final recommendations. For example, we did not obtain anterior chest wall pain with stimulation of C6–C7, whereas Grubb and Ellis did. Yet we incorporated those observations into our suggestion that a patient with neck and anterior chest wall pain may require discography at the C4–C5 to C6–C7 levels.

In conclusion, these results confirm the observations of prior investigators that cervical internal disc disruption can elicit axial and peripheral symptoms. The particular patterns of pain generation for each intervertebral disc allow the discographer to preprocedurally anticipate the optimal intervertebral discs to assess. With these data, the number of disc punctures that are required can be limited; it is unnecessary to stimulate all cervical discs, and thus patients experience less discomfort and are subjected to less procedural risk.

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