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Neck pain is a common symptom in the general population with a self-reported incidence of 213 per 1000 persons. The incidence of neck injuries during competitive sports activities ranged from 0.02 to 21 per 1000 exposures [1]. Cervical internal disc disruption (CIDD) syndrome can be a source of neck pain. CIDD is the presence of internal annular fissure, which can be categorized into inner annular fissure and major tears involving both the inner and outer layers of the annulus without apparent disc herniation.

The CIDD syndrome, commonly known as cervical discogenic pain, is caused by the leakage of nuclear pulposus through the tears, and the irritation of the nociceptors within the annular fissures. It presents as chronic axial neck pain with or without scapular or shoulder pain, which may refer into the upper arm but rarely extends down to the forearm and hand. Some patients reported tingling feelings within the upper limb without objective neurologic deficit. Many patients also experienced occipital headaches. Before establishing this diagnosis, the clinician should first rule out other disorders causing neck pain, such as a cervical facet joint or apparent cervical disc herniation with direct compression of the ipsilateral nerve root. Diagnostic studies, including plain x-ray, magnetic resonance imaging (MRI), cervical provocation discography with postdiscography, computed tomography (CT), assist in affirming the diagnosis.

PLAIN FILM RADIOGRAPHY

If a patient presents with chronic neck pain similar to that caused by CIDD syndrome, anteroposterior, oblique, and lateral view, particularly dynamic motion radiographs of the cervical spine should be considered as the initial workup. X-ray studies are particularly necessary for patients with a history of trauma, inflammatory disease, spine fusion, malignancy, compromised immune system, chronic pain with failed conservative treatment, or being involved in litigation. A review study by the Neck Pain Task Force group recommends that people seeking care for neck pain should be triaged into four groups: grade I neck pain with no signs of major pathology and no or little interference with daily activities; grade II neck pain with no signs of major pathology, but with interference with daily activities; grade III neck pain with neurologic signs of nerve compression; grade IV neck pain with signs

of major pathology. In the emergency room, after blunt trauma to the neck, those patients with a high risk of fracture should be further examined with plain radiography and/or CT scan [2].

It should be recognized that compared with MRI and discogram, plain films of the cervical spine have little value in directly diagnosing discogenic pain but nevertheless they can help physicians rule out other gross trauma, fracture, dislocation, and tumors. Radiographs are used to assess the stability of vertebral alignment, disc space narrowing, and facet joint arthropathy. In patients with neck pain who suffer paraspinal muscle spasms, the cervical spine alignment presents straightened with decreased cervical lordosis. As discogenic pain is more and more commonly seen in young and middle-aged patients, radiographic findings can be normal or with mild disc degeneration [3]. More substantial degenerative changes are seen in older patients. Little correlation exists between symptomatic and asymptomatic individuals and structural changes on roentgenographic examinations [4]. In patients with previous cervical bony trauma or fusion, more attention should be paid to the adjacent disc level for possible internal disc disruption from exacerbated degeneration and/or instability. In patients with normal plain x-ray results but persistent axial neck pain, additional diagnostic imaging should be considered to further evaluate a patient's chief complaint of axial neck pain.

CT, MYELOGRAPHY, AND CT MYELOGRAPHY

Because of its weak delineation of disc morphologic changes, CT alone is rarely used for diagnosing CIDD. However, CT is routinely used immediately following cervical discography to identify the location of annular fissures and leakage of contrast dye. Cervical discography is discussed in detail elsewhere in this textbook (see Chapter 31). Myelography and CT myelography, nowadays are rarely used to evaluate primary axial neck pain and have been widely replaced with MRI, are only used to resolve a suspicion of serious spinal pathology, cancer, infection, myelopathy, or progressive motor deficit.

Ruling out facet joint-originated neck pain can help establish the diagnosis of CIDD syndrome, which is difficult to surmise based solely on CT findings. Findings on CT studies alone are not able to differentiate the pain

caused by internal disc disruption from the pain of facet joint origin (see Chapter 33). Facet joint pain can be diagnosed with controlled, diagnostic, and local anesthetic blocks [5] (see Chapter 34). An immediate relief of neck pain confirms the facet as a pain generator, or a portion of the pain origin. Recent literature supports using cervical medial branch block as a preferred technique [5,6].

MAGNETIC RESONANCE IMAGING

MRI is extensively used to evaluate cervical disc morphology, the contour of the outer annulus, disc degeneration, and canal stenotic changes. It has been established previously that MRI is very useful for the diagnosis of lumbar and cervical disc herniation [7–11]. With respect to cervical discogenic pain, after other causes of neck pain have been ruled out, it is difficult to pinpoint the painful disc based solely on disc morphology on MRI [11–13]. Zheng and colleagues [11] investigated the value of MRI and discography for evaluating cervical discogenic pain. The authors retrospectively reviewed the surgical outcome of 55 patients (involving a total of 161 disc levels), who had been clinically diagnosed with cervical discogenic pain for at least 6 months and underwent an anterior cervical discectomy and fusion using the Simmons Keystone technique and who were available for a follow-up of a minimum of 2 years. All of the patients had a preoperative MRI scan, discography, and a postdiscography CT scan. In evaluating the MRI images of the cervical spine, the sagittal T2 spin echo images were used to evaluate the disc nuclear signal intensity and the status of posterior annulus as described by Horton and Parfenchuck, with some modifications [7,11,12]. The nuclear signal intensity on MRI reflects the hydration of nuclear pulposus of the disc, which can be described as white, speckled, or dark. A white disc has a hyperintense, homogenous signal; a speckled disc has a heterogenic pattern with areas of hypointense changes with two or more areas of hyperintense signal; a dark disc has a homogenous and hypointense signal. The integrity of the posterior annulus can be classified as flat, bulging, torn, or herniated. A flat posterior annulus is

straight or minimally convex; a bulging annulus is a gradually convex annulus that slightly encroaches on the thecal sac in any sagittal image; a torn annulus has a discontinuity in the signal of posterior annulus; a small herniation is a disc injury in which the outer annular fibers are intact and there is a small amount of spinal canal encroachment, either focal or more circumferential on lateral view or axial view (Figure 30.1) [7,11,12].

Nuclear Signal Intensity and Neck Pain

The signal pattern of disc nucleus depends on the water content of the disc. The changes in hydration state result in different nuclear signals on MRI and usually correlate with nuclear deterioration [14,15]. The relationship between CIDD and discs with a hypointense signal or dark discs on MRI is not entirely clear [11,12]. It has been reported that the dark nuclear pattern and torn annulus have a high correlation with a positive lumbar discography [7,16]. However, the correlation is not definitive but rather suggestive if dark and torn annular patterns were seen together at one level [7]. Some physicians simply assume that the dark cervical discs are pathologic and therefore symptomatic [12]. Parfenchuck and Janssen [12] concluded that a dark or torn disc on cervical MRI may not need cervical discography because these discs are invariably the source of neck pain, but they also admitted their study was limited by the small number of dark discs included in their study. The result of Zheng's study strongly suggests that the dark cervical disc is not always symptomatic. Only 63% of the dark discs in chronic neck pain patients were positive on discography (see Chapter 31), and they accounted for almost half (49%) of the symptomatic levels in the study group [11]. This study provides valuable information to the clinician beyond cervical MRI in evaluating chronic discogenic neck pain. In the lumbar spine, the white bulging and white flat discs were found to have a 90% chance of having no pain with discography [7]. A previous study classified white cervical disc on MRI as normal. However, results of the study also showed 63% of the discs with positive discography [12]. In Zheng's study, although the authors categorized speckled



Figure 30.1 (A) Showing the white at C6-7, speckled at C4-5, C5-6, and dark at C2-3 C3-4 of signal intensity on MRI. Flat disc at C6-7 C7-T1, and bulging disc at C3-4, C4-5 C5-6, as well. (B) Showing torn disc on C3-4 and C4-5. (C) Showing small disc herniation.

and flat, white and bulging, and white and flat discs as probably not being pain generators, the results showed that some of these discs are the source of neck pain determined by discography. Therefore, to gain acceptable clinical results, the authors suggested not depending solely on the morphology of the disc on MRI for the selection of surgery level.

Annular Contour and Neck Pain

The status of the posterior annulus is another important aspect for evaluating the morphology of the disc on MRI. Most of the published literatures about discogenic pain are the studies of MRI and discography on the lumbar spine. Previous studies of the lumbar spine defined three categories for evaluating the posterior annulus: torn, bulging, or flat [7]. In Zheng's [11] study, the authors added into the categories a small-herniated disc where the outer annular fibers were intact and only a small amount of focal or more circumferential spinal canal encroachment was seen. The reason for adding this subtype is that the cervical spine is different from the lumbar spine [12,13,17]. The authors tried to determine whether the small-herniated disc was always a source of pain. Their results showed that positive discography was found in 59% of the small-herniated discs and torn discs, 35% of bulging discs, and 29% of flat discs, respectively. Dark and small-herniated pattern was the most commonly operated on, and 67% of the discs with this pattern had a positive discography. In decreasing order of frequency, the discs with dark and torn, speckled and small herniated, and speckle and torn patterns were also painful.

Relationship Between MRI and Cervical Discography

The knowledge of cervical disc disruption, classification, and discogram are mostly extrapolated from lumbar disc disruption and discogram [7]. Although cervical disc disruption and lumbar disc disruption share some common characteristics, because of the unique anatomy of the cervical vertebra and intervertebral disc, substantial differences exist between cervical and lumbar disc disruption and clinical implication [8,13].

Because of its ability to determine whether or not a patient has discogenic neck pain and to identify which intervertebral disc is responsible for the persistent pain, cervical discography has been the most useful diagnostic tool to directly evaluate internal disc disruption. Discography represents a functional diagnostic test because the patient's subjective response is integral in the outcome of the test. On the other hand, visual anatomic imaging can demonstrate whether or not there is an internal disc disruption and can match the result of the internal disc disruption testing with the symptomatology, for example, a disc has moderate tears and causes pain, and another disc has severe disc leaking in all directions but does not cause provoked concordant pain [14].

In general, disc disruption is proportional to the degeneration of the disc [7]. Cervical trauma can also cause or exacerbate this process. DePalma and Slipman

[18] categorized the nucleogram into four categories: lobular, irregular, fissured, and ruptured (Figure 30.2).

Previous studies have proven that the presence of internal disc disruption does not always cause discogenic pain in the neck [11,13]. Internal disc disruption is more commonly seen in degenerated discs [13]. However, asymptomatic internal fissures have been seen by discography in asymptomatic individuals with normal MRI appearance of cervical discs [13]. Moreover, even in symptomatic patients, some discs with fissuring do not cause pain although some discs with fissuring do cause discogenic pain by provocative discography [11,13]. On the other hand, Schellhas et al. [13] prospectively correlated MRI imaging and discography in 10 asymptomatic subjects and 10 patients with chronic axial pain. The authors found that various degrees of annular disruption were common in both symptomatic and asymptomatic patients. The ruptures were usually posterior-lateral and full-thickness tears and leaks into the epidural space occurred in about 50% of the discs. Annular tears were identified during discography in 23 of the 24 discs judged normal based on MRI scans. Parfenchuck and Janssen's [12] study also showed that leakage illustrated either on discography or on CT discography did not correlate with whether or not a cervical disc is painful. Fissures in the annulus in the uncovertebral region occur commonly in cervical discs [8,13]. Leakage of contrast medium through such fissures results in discographic patterns that, in the lumbar region, would be considered abnormal. In the cervical region, these patterns, however, must be considered as the presence of disc degeneration rather than a pain generator in the absence of painful response during discography [8,13].

Parfenchuck and Janssen indicated MRI correlates reasonably well with provocation discography. They



Figure 30.2 Schematic illustration of lobular (A), irregular (B), fissured (C), and ruptured (D) nucleograms. Courtesy of DePalma MJ, Slipman CW. Technique and indication of cervical discography. In: Freeman MK, Morrison WB, Harwood MI, eds. *Minimally Invasive Musculoskeletal Pain Medicine*. New York: Informa Healthcare, 2007:235–247.

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suggested that cervical discs abnormal on MRI are likely to be painful whereas discs normal on MRI are not likely to be painful. However, they admitted that this correlation is not absolute [12]. The diagnosis of the possible symptomatic disc level was based on the abnormal morphology of the T2 MRI scans. In Zheng and colleague's study, with respect to the disc signal, a dark disc was the most significant. A speckled disc and white disc were of less significance. With regard to the posterior annulus, a small-herniated or torn annulus was considered the most significant. The bulging annulus and flat annulus were of less significance, again in that order. Thus, the discs that were thought to be probably symptomatic were the dark and herniated, dark and torn, dark and bulging, speckled and herniated, speckled and torn, and white and herniated discs. The discs that were thought to be possibly symptomatic were the dark and flat, speckled and bulging, and white and torn discs. The speckled and flat, white and bulging, and white and flat discs were considered probably not as pain generators [11]. These possibilities of discogenic pain were finally tested using cervical discography. Parfenchuck and Janssen [12] studied the association between abnormality on MRI and pain response on discography in 101 disc levels using discography, and they concluded that MRI has sensitivity of 73%, a false-negative rate of 27%, specificity of 67%, and a false-positive rate of 33% for detecting a painful disc. With more patients and more types of disc levels being tested, Zheng and colleagues studied 55 patients in 161 disc levels, the overall MRI findings in 103 of the 161 (64%) injected levels correlated completely with the results of discography. With the sensitivity of 73.4% and the false-negative rate of 26.6%, MRI resulted in only a specificity of 49% and a false-positive rate of 51% for discriminating the painful cervical disc from asymptomatic levels [11].

SUMMARY

The CIDD syndrome presents as axial neck pain. The diagnosis of CIDD relies on ruling out other possible causes of pain via medical history and physical examination, diagnostic imaging, and x-ray-guided diagnostic injections. MRI shows the morphology of a disc, whereas discography demonstrates the pathophysiology of the probable pain generator. MRI can be used to help identify the possible painful discs but, unfortunately, it still has high false-negative and false-positive rates. Dark and small-herniated discs have a high chance of being the pain generators but are not always symptomatic. MRI is recommended to be used as a screening test to identify the levels of the possible painful discs, whereas discography can be used as an adjunctive confirmatory test. Discography can protect the levels from unnecessary interventional procedures or fusion or disc replacement surgery. The combination of clinical symptoms, MRI, and discography provides the

most information for decision making and can improve the management of cervical axial pain.

REFERENCES

1. Hogg-Johnson S, van der Velde G, Carroll LJ, et al.; Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. The burden and determinants of neck pain in the general population: results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. *Spine*. 2008;33(4 suppl):S39–S51.
2. Guzman J, Haldeman S, Carroll LJ, et al.; Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. Clinical practice implications of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders: from concepts and findings to recommendations. *Spine*. 2008;33(4 suppl):S199–S213.
3. Okada E, Matsumoto M, Ichihara D, et al. Aging of the cervical spine in healthy volunteers: a 10-year longitudinal magnetic resonance imaging study. *Spine*. 2009;34(7):706–712.
4. Gore DR, Sepic SB, Gardner GM. Roentgenographic findings of the cervical spine in asymptomatic people. *Spine*. 1986;11(6):521–524.
5. Manchikanti L, Damron K, Cash K, et al. Therapeutic cervical medial branch blocks in managing chronic neck pain: a preliminary report of a randomized, double-blind, controlled trial: clinical trial. *Spine*. 2008;33(17):1813–1820.
6. Falco FJ, Erhart S, Wargo BW, et al. Systematic review of diagnostic utility and therapeutic effectiveness of cervical facet joint interventions. *Pain Physician*. 2009;12(2):323–344.
7. Horton WC, Daftari TK. Which disc as visualized by magnetic resonance imaging is actually a source of pain? A correlation between magnetic resonance imaging and discography. *Spine*. 1992;17(6 suppl):S164–S171.
8. Gibson MJ, Buckley J, Mawhinney R, Mulholland RC, Worthington BS. Magnetic resonance imaging and discography in the diagnosis of disc degeneration. A comparative study of 50 discs. *J Bone Joint Surg Br*. 1986;68(3):369–373.
9. Aprill C, Bogduk N. High-intensity zone: a diagnostic sign of painful lumbar disc on magnetic resonance imaging. *Br J Radiol*. 1992;65(773):361–369.
10. Schneiderman G, Flannigan B, Kingston S, Thomas J, Dillin WH, Watkins RG. Magnetic resonance imaging in the diagnosis of disc degeneration: correlation with discography. *Spine*. 1987;12(3):276–281.
11. Zheng Y, Liew SM, Simmons ED. Value of magnetic resonance imaging and discography in determining the level of cervical discectomy and fusion. *Spine*. 2004;29(19):2140–2145; discussion 2146.
12. Parfenchuck TA, Janssen ME. A correlation of cervical magnetic resonance imaging and discography/computed tomographic discograms. *Spine*. 1994;19(24):2819–2825.
13. Schellhas KP, Smith MD, Gundry CR, Pollei SR. Cervical discogenic pain. Prospective correlation of magnetic resonance imaging and discography in asymptomatic subjects and pain sufferers. *Spine*. 1996;21(3):300–311; discussion 311.
14. Modic MT, Masaryk T, Paushter D. MRI of the spine. *Radiol Clin North Am*. 1986;24:A229–A245.
15. Buirski G, Silberstein M. The symptomatic lumbar disc in patients with low-back pain. Magnetic resonance imaging appearances in both a symptomatic and control population. *Spine*. 1993;18(13):1808–1811.
16. Bernard TN Jr. Lumbar discography followed by computed tomography. Refining the diagnosis of low-back pain. *Spine*. 1990;15(7):690–707.
17. Bogduk N, Windsor M, Inglis A. The innervation of the cervical intervertebral discs. *Spine*. 1988;13(1):2–8.
18. DePalma MJ, Slipman CW. Technique and indication of cervical discography. In: Freeman MK, Morrison WB, Harwood MI, eds. *Minimally Invasive Musculoskeletal Pain Medicine*. New York: Informa Healthcare; 2007:235–247.

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AQ 2: Please confirm whether the reference “DePalma and Slipman, 2007” given here should be added in the reference list. Please provide Figure 30.2