Cervicogenic headaches: Radiofrequency neurotomy and the cervical disc and fusion

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ABSTRACT

Objective

Headaches that originate from pathology of the cervical spine, called "cervicogenic headache", have been debated, described, and treated by various researchers. This paper describes the use of radiofrequency neurotomy procedures to relieve cervicogenic headache at several strategic locations. Procedures listed include those to the greater occipital nerve territory, the C2 medial rami, and the cervical discs. Anatomy relevant to the innervation of the disc by way of the sympathetic chain is described and illustrated.

Methods

Radiofrequency neurotomy procedures were performed following either a successful nerve block in either the distribution of the greater occipital nerve or the C2 medial rami, or after provocative cervical discography. Cervical disc and fusion surgery is being correlated to the nerve supply of the discs and ligaments.

Results

The majority of patients suffering from cervicogenic headaches can be totally relieved for a lifetime, especially if the pain is unilateral. A very, very small percentage of these patients cannot be helped. The remaining sufferers have a considerable reduction in the intensity and frequency of pain.

Discussion

Each of the procedures discussed, or a combination of all of them, can alleviate cervicogenic headaches completely, as is our goal.

Introduction

The location of the sinuvertebral nerves to disc material, as well as their possible role in the pathogenesis of cervicogenic pain, has been a neglected field. Until recently it was not realized that the tiny sinu-vertebral nerves in the outermost layer of annulus fibrosis could be responsible for disc-related pain.

This nerve was called the 'meningeal branch', as illustrated in Pernkopf's Atlas (1), originating distally to the ganglion and returning back through the nerve root canal to supply the dura and meninges.

Mendel (2) identified the primary rami originating proximally to the nerve root and ganglion as a sole supply of the sinuvertebral nerve of the disc and adjacent ligaments. It is therefore important to illustrate these nerve structures to understand the rational for different treatment modalities. A new nerve staining method, the acetylcholinesterase whole-mount method studied in human fetuses, and a more sophisticated microdissection enabled these workers to identify 4 to 6 nerve strands ventrally and 2 strands dorsally, interwoven with the nerve root and its ganglion. These strands originate from the sympathetic chain, the rami communicantes, and in the cervical spine from the perivascular nerve plexus of the vertebral artery. Thick and thin sinuvertebral nerves were exposed which ascend, descend and communicate with the opposite side (dichotomizing). Innervation of the facet joints (zygoapophyseal joint) was not found to be exclusively from the sympathetic trunk. Even though the origin was sympathetic, it contained nociceptive, proprioceptive, vaso-motor and vaso-sensory nerve functions.

We have dissected and exposed these tiny nerve strands interwoven with the nerve root and its ganglion by literally 'lifting up' the third cervical nerve in order to illustrate these sympathetic strands in the nerve root canal. We could not illustrate the ascending, descending and cross communicating sinuvertebral nerve structures in a simplified drawing, but the artist Rex Muller was able to illustrate sinu-vertebral nerves sprouting towards the center of the cervical disc in a disrupted, sequestered disc where the nucleus pulposus has disintegrated (Fig. 1).

Freemont (4) has investigated the inner-

vation to the lumbar disc in conjunction with the sympathetic nerve supply from the sympathetic chain, which is located anterior to the disc (Fig. 2). We thus infer from his work that sprouting of sinuvertebral nerves also exists to injured cervical discs (a normal nucleus pulposus has no nerve supply).

These nerve structures may be exposed to inflammatory and algogenic chemicals, such as stromelysin, metalloproteinase, creatine phosphokinase and phospholipase A2, the last enzyme being responsible for the liberation of arachnoidionic acid from the cell membrane. These chemicals constitute the basis for chemical nociception and the tears and fissures in the damaged disc may sensitize these nerve structures for mechanical nociception. The concept of the sympathetically maintained pain from these structures may give answers and hypotheses as discussed by Janig (5). This type of pain does not appear to qualify as a complex regional pain syndrome, but as a sympathetically maintained pain (SMP).

Provocative discography

Prior to any treatment to the disc with its sympathetic nerve structures, provocative discography using 1 cc Isovue 300 Iopamil 61% may provide information as to which of the discs are symptomatic and can reproduce the patient's pain. One may also alleviate pain temporarily with an intradiscal injection of a local anesthetic [0.2 cc of 1/4% Marcaine (Bupivacaine HCL)] that also enters the epidural space in an abnormal disc where there are often multiple tears and fissures in the annulus fibrosis.

Discography is essential to assess each of the discs, particularly if we are dealing with intractable cervicogenic headaches which are unilateral and when the pain condition originating from the disc levels at C2/3 and C3/4 is identified. Pain from that level causes pain at the base of the skull, with or without radiating pain to the vertex, or pain radiating from the base of the skull to the forehead, temporal region, around the eyes and retro-orbital region. Pain may also be referred to the upper mid and lower cervical spine and some radiating pain into the trapezius territory. Discography at the levels

Suggested Corrected Nerve Supply to the Cervical Disc and Ligaments

Fig. 1. The radiofrequency lesions to the sinuvertebral nerves exclusively supplied by the sympathetics within the discs and its sympathetic strands and outer layer of adjacent C3 nerve root.

Suggested Corrected Nerve Supply to the Lumbar Disc L5-S1 and Ligaments

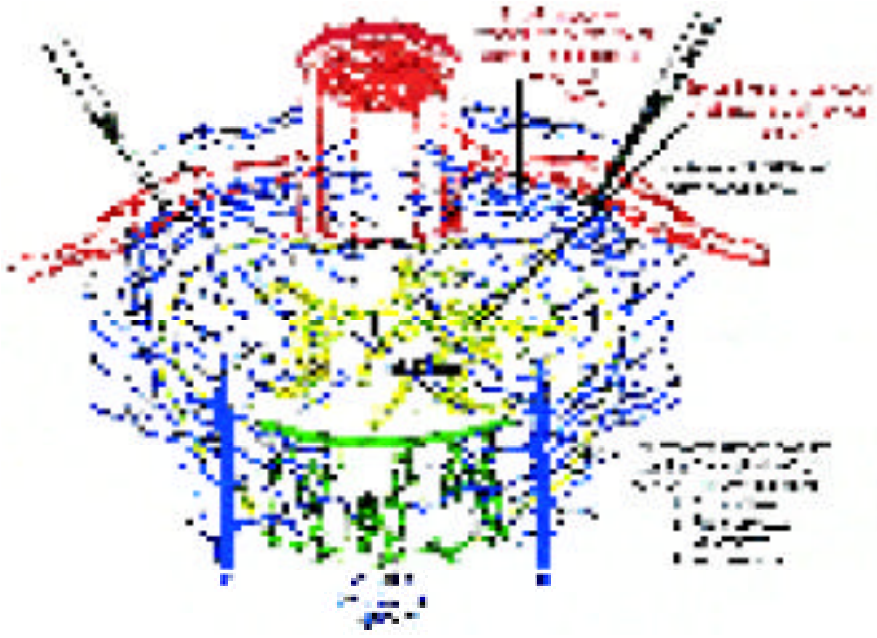

Fig. 2. This illustration also demonstrates a diseased lumbar disc with deeper penetration of nerves from the sympathetic chain.

of C4/5, C5/6 and C6/7 may also cause radiating pain in the shoulder or arm.
If discography reproduces the original pain and visualizes the pathology of the disc, this may enable the appropriate determination of treatment. For instance, discography to the discs, levels C2/3, C3/4 and C4/5, is able to identify which level is responsible for the cervicogenic headaches. Using this diagnostic technique before cervical disc and fusion, we have found an increase in the percentage of the relief from cervicogenic headaches from 52% to 86%. In previous communications we found that using this technique we were able to relieve neck/shoulder/arm pain in 92% and obtain complete relief in 52% of those with cervicogenic headaches (6).
CT scans are not helpful in my experience unless they are done immediately at the discogram for each level separately where the C-arm is combined with the scanner, because the contrast material disappears rapidly out of the epidural space.

Methods of treatment

Radiofrequency to the cervical disc C2/3 and C3/4

The location of the radiofrequency-induced (RF) lesions depends upon the cervicogenic headache with unilateral symptomatology. The approximate sizes of the lesions are 2 mm to 4 mm in diameter and 4 mm in length, and 6 to 8 lesions are made.
When performing the radiofrequency procedure, only one direction is possible. After making a number of lesions at or near the center of the disc, the needle is advanced to the outer layer of the posterior lateral quadrant. In recent cases we have been advancing the RF needle through the outer layer of the annulus fibrosis entering the nerve root canal, making up to 3 or 4 RF lesions to interrupt the interwoven network of 4 to 6 strands of the sympathetic nerve structures ventral and 2 of the strands dorsal to the nerve root and some of the nociceptive C-fiber activity within the C3 nerve root.
In a desiccated or disrupted disc the sinuvertebral nerve grows and sprouts not only into the inner one-third of the annulus fibrosis, but extends to the disrupted nucleus pulposus in lumbar regions (4), suggesting by inference the importance of the pathogenesis of neck pain and cervicogenic headaches, because these elongated nerve structures can also be stretched, squeezed, pulled, compression, pinched or twisted.
If this procedure has to be repeated, after at least one month of complete relief of cervicogenic headaches, additional lesions are made by changing the direction of the pathway of the RF needle by a few degrees (Fig. 3). The same procedure can be done bilaterally, but during the same sitting. In the diagram we retained the previous drawing showing the distribution of the so-called primary rami originating from the nerve root (2); however recent research by Groen (3) calls into question the existence of the primary rami.
The same procedure can be performed at the disc level at C3/4 except that the needle is not advanced into the nerve root canal because of the important motor function of the C4 nerve root. Six to eight lesions are made at 80°C for 3 minutes at a time, producing lesions 2 to 3 mm in diameter and 4 mm in length. Figure 3 illustrates the primary rami (2) and the sympathetic nerve supply (3), as well as the sprouting of the sinuvertebral nerves to the center of the disrupted and desiccated disc (4). The RF needle position is shown with the lesions outlined in red, extending into the C2/3 nerve root canal

Suggested Corrected Nerve Supply to the Cervical Intervertebral Disc and Ligaments

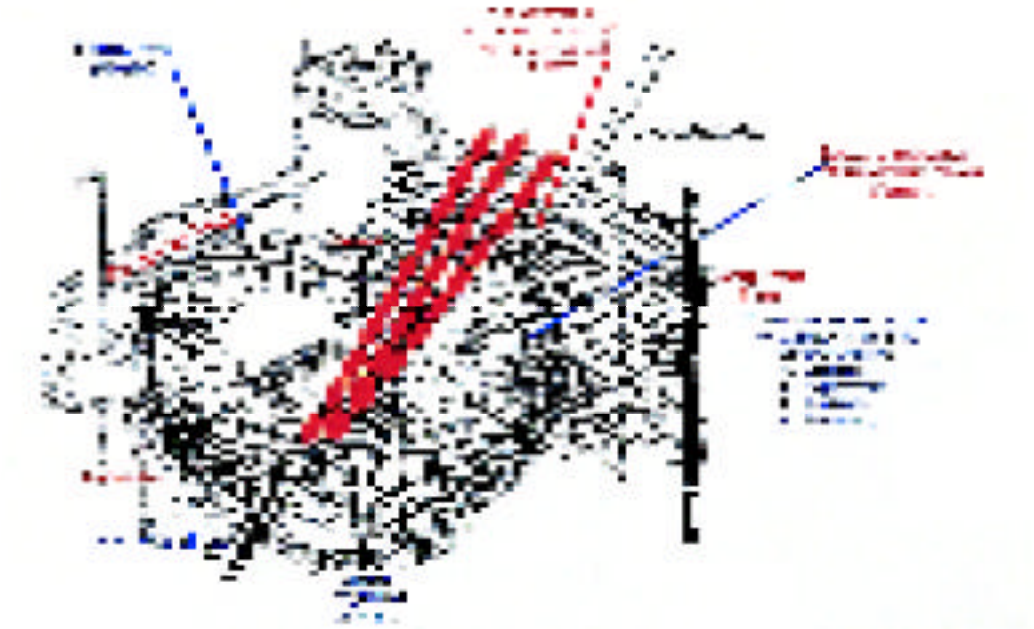

Fig. 3. Nerve supply to the intervertebral disc, left side shows the distribution of the primary rami (Mandel) as the sole nerve supply to the disc is incorrect. The right side demonstrates innervation of the disc solely by sympathetic strands from the sympathetic chain, rami communicantes and perivascular plexus. If this procedure has to be repeated, additional lesions are made by changing the direction of the pathway of the RF needle by a few degress, unilaterally or bilaterally.

prior to making RF lesions between the uncinate processes, incorrectly called the "joints" of Luschka. Notice that there are three needle pathways demonstrating that double or triple lesions may be performed in order to provide maximum benefit. We cannot denaturate the entire sympathetic nerve supply to the disc, as this is technically impossible. If relief lasts for several months, additional lesions can be made by changing the direction of the RF needle a few degrees to obtain a new pathway, as outlined in Figure 3. In this drawing we preserved the previously drawn nerve supply to the discs from the primary rami of the nerve root which is now incorrect.

Unlike Sluijter (7), we found that more than one lesion in the disc is necessary for the reduction or relief of cervicogenic headaches at the level of either C2/3 or C3/4. (It should be kept in mind that the cervical discs of C4/5, C5/6 and C6/7 could also be responsible for the cervicogenic headaches.)

Before advancing the needle to the C3 nerve root, electrical stimulation is applied. Many patients experience a tingling sensation at the head/neck junction, upper to mid-cervical region, and the superior border of the trapezius. Once the needle is advanced to the nerve root canal there is usually a slightly greater degree of minimal muscle contraction of the trapezius, causing the head to turn ipsilaterally and is related to the monopolar stimulation.

Results of RF to the cervical disc C2/3 and C3/4

The RF lesions to these structures resulted in complete relief of cervicogenic headaches in a limited number of patients for a few months. Rarely did the relief last up to 6 months unless the lesion was extended into the C2/3 nerve root canal with denaturation of up to 8 strands of the sympathetic nerve structures.

A detailed analysis of 24 cases of patients undergoing radiofrequency of the C2-3 and C3-4 discs for cervicogenic headache has previously been described. Four patients had the RF procedure at C2-3, three at C3-4, two at both levels, and all 9 patients reported complete relief for 2 to 6 months from the date of the procedure. Three had 70% relief, 5 had 50% relief and 3 had a 30% decrease of cervicogenic headache pain. Four had no results. Six of the 24 patients required cervical disc and fusion surgery at the same levels where the radiofrequency was done. The 20 cases where we made lesions within the nerve root canal had a follow-up of 9 months but we have not statistically analyzed these cases because of the short follow-up duration.

The side effects to these lesions in the C2/3 nerve root canal were temporary hypanalgesia, or hypesthesia of the ear lobe ipsilaterally either in the upper or lower ear lobe with the exception of the external auditory meatus, tragus, concha and the inner portion of the anthelix basically involving the helix lobule. A very slight unsteadiness without nystagmus or ataxia was observed for 1 to 2 weeks in only 2 patients, most likely related to temporary dysfunction of some of the cervical musculature. We perform all radiofrequency procedures using Owl and Radionic systems and their accessories.

Cervical disc and fusion surgery

During the cervical discectomy and fusion procedure, a number of sympathetic end fibers of the sinuvertebral nerves that have sprouted into the central portion are removed. The importance of this procedure is to remove all of the disc tissue adjacent to the nerve root, unroofing the nerve root canal, avoiding injury to the sympathetic strands interwoven with the nerve root and ganglion, and separating the sinu-vertebral nerves from sympathetic strands that remain untouched. By removing some anterior and all posterior disc elements, one interrupts sympathetic nerve structures that are ascending, descending and crossing contra-laterally. The lateral, anterior and mid-portion of the disc remains intact with its sympathetic network and helps to maintain stability.

In some cases the posterior longitudinal ligament is absent because over the years it has been eroded and the disc with its sinuvertebral nerves is directly in contact with the dura and nerve root sleeve. If the posterior longitudinal ligament is intact, it does not extend over or protect the nerve roots. Instead it covers basically two-thirds of the posterior central portion of the spinal canal with its disc. Therefore, if one is performing a surgical procedure where the posterior longitudinal ligament is still present, one must remove it or use bipolar coagulation to destroy as many sympathetic fibers with their proprioceptive, nociceptive, vasomotor and vaso-sensory function as possible. By keeping the ligament intact, one may increase the stability of the spine. If consolidation occurs it will reduce and alleviate the pain from mechanically squeezed sympathetics in the remaining disc, adjacent ligaments and facet joints. We re-emphasize that these nerves to the joints have not been confirmed to be exclusively supplied by the sympathetics.

We have performed over 700 cervical disc and fusion surgeries for neck/shoulder, neck/shoulder/arm pain and cervicogenic headaches. When an additional second or third disc is removed we have found the relief of neck/shoulder/arm pain to be up to approximately 92%, and in 86% the complete relief of cervicogenic headaches was obtained.

Radiofrequency denaturation of the C2 medial rami

RF to the C2 medial rami, its sympathetics and unmyelinated nerve structures to the obliquus capitis inferior, rectus capitis major, semi-spinalis and atlantic muscle groups was first performed by Rogal (8) and Francis (9). We found that about 50 lesions are needed to denaturate the unmyelinated nerves of the interspinal muscle between C1/2 and C2/3. Indications for this procedure include a trial nerve block with relief of cervicogenic headache lasting from 6 hours to several days (Fig. 4).

One hundred patients with the diagnosis of cervicogenic headache were chosen for this procedure. Thirty percent were male and 70% were female, with an age range of 27-84 years. A total of 110 procedures were performed. Forty-nine patients had one C2 rami radiofrequency procedure performed. Twenty-five patients had the procedure performed more than once. The number of lesions ranged from 18 to 52 during a single procedure, unilaterally.

Pain relief ranged from 100% in 43 patients, to greater than 90% in 7 patients,

greater than 80% in 5 patients, and greater than 70% in 7 patients, while 11 patients had pain relief ranging from 25% to 60%. Twenty-one patients had no relief of pain.

Radiofrequency to the greater and tertiary occipital nerve territory

RF lesions were made to the terminal sensory, sympathetic and unmyelinated nerve structures of the relevant muscle attachments; semispinalis capitis, rectus capitis posterior major, rectus capitis posterior minor, and obliquus superior as outlined in the figure. This procedure accomplished complete relief of cervicogenic headaches in over 80% of 750 patients observed for over 30 years. Despite the fact that we have made up to 50 unilateral radiofrequency lesions, no permanent sensory deficit in the distribution of the greater occipital nerve was found. Success was defined by lack of recurrence for 6 months.

In one case a 16-year-old female suffered from constant unilateral headaches for 4 years after an accident while playing volleyball. This patient was severely limited in activities of daily living, being confined to bed in a dark room with an ice pack on her head around the clock. Numerous nerve blocks to the nerve structures of the facet joints from C1 to C5 including nerve blocks to the C2 nerve root were of no benefit. Numerous so-called occipital nerve blocks were done with temporary relief for 2 days. A nerve block to the medial rami of C2 with its unmyelinated nerve structures was of no benefit. Fifty-three radiofrequency lesions made to the greater and tertiary occipital nerve territory and unmyelinated nerve structures relieved all of her pain.

Indication for the RF neurotomy procedure (Fig. 5) in the occipital nerve territory requires lack of prior response to other procedures, as well as relief from a suboccipital nerve block of 10 cc of º% Marcaine mixed with 80mg of Depomedrol fanning out in six different directions over the occiput unilaterally.

Discussion

We stress the importance of trying conservative measures and traditional blocks prior to using this technology. Only in

RF Neurotomy procedure to the Medial Rami and Unmyelinated Nerve Structures at the C2 Spinous Process

Fig. 4. Muscles attached at the C2 spinous process are the semispinalis, greater posterior rectus, inferior oblique and interspinal muscles that are located between the C1/2 and C2/3 spinous processes.

Cervicogenic Headache: Radiofrequency Neurotomy Procedure

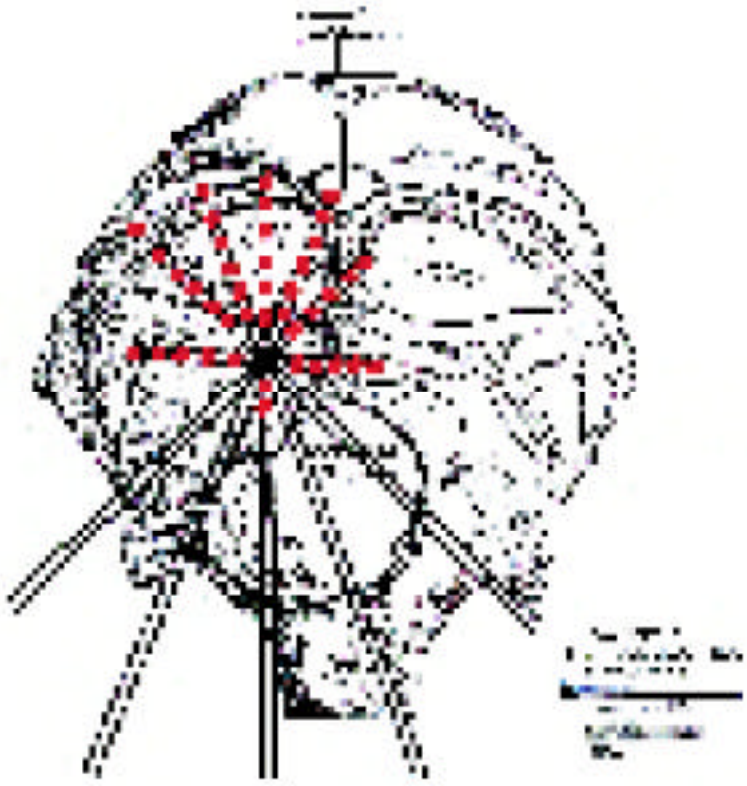

Fig. 5. Schematic drawing of the positions of the thermoelectrodes in 7 different directions in relation to the occipital bone on the left side and this demonstrates the relationship of the muscles shown on the right side. Radiofrequency lesions are made along the tract within the pathway of the thermoelectrode represented by the red dots. Additional lesions are made by withdrawing the needle 5 mm at a time. The average number of lesions is around 50 without severing the function of the greater occipital nerve.

cases of refractory pain are these measures to be employed. We prefer a graduated approach, moving from one method to the next as outlined above.

We also cannot sufficiently stress the need for a careful history and examination to distinguish between tension headaches and unilateral and bilateral cervicogenic disorders. A statistical analysis of all of these cases is being prepared, especially where we have controls where limited RF lesions made within the disc can be compared with lesions within the nerve root canal.

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