Dorsal root entry zone lesions for post-amputation pain

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Chronic pain following an amputation may involve the stump, the phantom limb, or both. Operations such as rhizotomy, cordotomy, stump revision, and dorsal column stimulation have been unsuccessful in treating this condition. This study evaluates the effectiveness of dorsal root entry zone (DREZ) coagulation for this pain problem. The authors studied 22 patients with amputations due to trauma, gangrene, or cancer. All developed post-amputation pain, underwent a DREZ procedure, and were followed from 6 months to 4 years after surgery. Overall, only eight (36%) of these 22 patients had pain relief. However, good results were obtained in six (67%) of nine patients with phantom pain alone, and in five (83%) of six patients with traumatic amputations associated with root avulsion. Poor results were obtained in patients with both phantom and stump pain, or stump pain alone. The DREZ procedure has a limited, but definite, place in the treatment of post-amputation pain.

KEY WORDS • phantom pain • amputation • pain • dorsal root entry zone lesion

Chronic pain after an amputation is one of the most difficult problems for a neurosurgeon to treat. This pain involves the phantom limb and/or the stump, and is refractory to most methods of treatment. Its incidence following amputation is unknown. Henderson and Smyth identified post-amputation pain in only 6% of a large group of World War I amputees; however, Carlen, et al., reported an incidence of transient or chronic pain in 67% of amputees in an Israeli series. Review of the literature reveals numerous approaches to this pain problem. Sherman, et al., identified 68 treatment methods which had been used in the United States, most of which were unsuccessful. White and Sweet discussed 11 surgical approaches, of which only anterolateral cordotomy gave a reasonable percentage of long-term relief. A recent book edited by Siegfried and Zimmerman reemphasized the lack of effective therapy.

This series includes 22 patients with post-amputation pain who underwent a DREZ operation. The patients were interviewed 6 months to 4 years after their operations in order to determine the degree of pain relief, and it was found that the overall results were poor: only eight (36%) of the 22 patients had significant prolonged relief. However, excellent results were obtained in patients with only phantom pain, or with pain associated with root avulsion.

Procedures involving the dorsal root entry zone (DREZ) offer some hope of pain relief to select groups of patients suffering from post-amputation pain. These individuals can be identified preoperatively with careful clinical assessment and myelography. Less suitable candidates may also be identified and offered an alternative form of therapy.

Clinical Material and Methods

We reviewed the records of 28 patients who received a DREZ procedure to relieve post-amputation pain. We excluded patients who could not be contacted for an interview, or had undergone an amputation to relieve the chronic pain of brachial plexus avulsion. A detailed description of each amputation was obtained. It was determined whether the amputation was due to trauma, cancer, or gangrene. The site of amputation was determined, as was the time between amputation and the DREZ operation.

Each patient was questioned regarding the presence of stump or phantom pain. The time of onset of the pain after amputation was determined, as was the character and intensity of the pain, and the conditions which made it better or worse. Patients were asked if they had phantom sensation and, if present, whether the phantom hand or foot had “telescoped” to the corresponding shoulder or hip. All prior medical and surgical treatments were recorded, as well as their results. All patients underwent physical examination and roentgenological
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evaluation. The dermatomes involved with the chronic pain, and the nerve roots which correlated to these dermatomes, were carefully noted.

The surgical technique of the DREZ operation has been published elsewhere. At surgery, the appropriate dorsal nerve roots were treated with DREZ coagulation. Early in the series, we used a probe with a 0.5-mm diameter and 2-mm spinal cord penetration. Lesions were made with 35 to 65 mA for 10 to 15 seconds, with a spacing of 1 to 2 mm. Later in the series, a 0.25-mm probe was used to create lesions at a temperature of 75°C to 80°C for 15 to 20 seconds. The appearance of the spinal cord, nerve roots, and meninges was carefully recorded. Special attention was directed to the presence of root avulsion.

Patients were asked three questions about their long-term operative result: 1) Are you better, worse, or the same? 2) On a 1 to 10 pain scale, how would you rate yourself now as compared to before the operation? 3) Would you have had this operation if you knew what your result would be ahead of time? A good result was recorded if all three of the following criteria were met: the patient was better, was improved by more than three units on a 1 to 10 pain scale, and would have had the operation if the result were known ahead of time. All the patients were asked about postoperative complications. Specific questions were directed to the presence of weakness, numbness, or disturbance of bowel, bladder, or sexual function.

Results

Patient Population

Twenty-eight patients underwent the DREZ procedure to relieve post-amputation pain. Three patients with brachial plexus avulsion had undergone an amputation for the purpose of pain relief, and were not included in the study. Three patients were not able to be contacted for an interview, and were also not included. One patient had died of a pulmonary embolus many months after discharge; however, his wife supplied information enabling him to be included in our series.

Table I presents a clinical summary of the 22 patients in this series. Twenty (91%) were male, and two (9%) were female. They ranged in age from 19 to 69 years, with a mean of 50 years. Thirteen (59%) had upper extremity amputations, and nine (41%) had lower extremity amputations. Dorset nerve roots were treated with DREZ coagulation. Six (27%) of the 22 patients complained of stump pain alone. The pain was most commonly described as burning or aching, and at times so severe that one patient described it “like your thumbnail being ripped out and then salt rubbed in.” In most cases, phantom sensation was present, and “telescoping” of the phantom hand or foot into the respective shoulder or hip was common. The pain usually began immediately after the amputation, became progressively worse, and was severe in intensity. The pain was frequently described as becoming worse with manipulation of the stump or during cold weather, and nothing consistently caused improvement. Patients averaged 3.0 forms of prior medical therapy, and at least one previous operation, of which the most common procedures were stump revision and rhizotomy.

Long-Term Results

The overall results were poor. Eight (36%) of the 22 patients experienced good long-term relief. Successful outcomes were analyzed in relation to the six following variables.

Location of Pain. None of the six patients with stump pain alone obtained a good result. Six (67%) of the nine patients with phantom pain alone, and two (29%) of the seven patients with both stump and phantom pain achieved a good result.

Presence of Root Avulsion. Good results were obtained in five (83%) of six patients with post-amputation pain associated with root avulsion.

Circumstances of Amputation. Good results were obtained in six (35%) of 17 patients with traumatic amputations, and in one (20%) of five patients with amputations due to cancer or gangrene.

Time of DREZ Procedure After Amputation. Good results were obtained in four (31%) of 13 patients who had their DREZ procedure 1 to 5 years after amputation, in two (40%) of five patients with the procedure after 6 to 15 years, and in two (50%) of four patients with the procedure after 16 to 37 years.

Parameters of Lesion. Good results were obtained in six (60%) of 10 patients with thermal lesions, and in two (17%) of 12 patients with amperage lesions.

Age of Patient. Good results were obtained in four (33%) of 12 patients older than 50 years, and in four (40%) of 10 patients aged 50 years or younger.

Complications

No deaths, infections, or major surgical complications were associated with the DREZ procedure. Only one major neurosurgical complication occurred in a patient who became monoplegic and incontinent post-
<table>
<thead>
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<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Cause of Amputation</th>
<th>Limb Avulsed</th>
<th>Stump Pain</th>
<th>Phantom Pain</th>
<th>Prior Medical Therapy</th>
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*Trauma means limb avulsed at time of injury, or amputated after severe traumatic damage. DREZ = dorsal root entry zone; meds = medications; TNS = transcutaneous nerve stimulation; acup = acupuncture; biof = biofeedback; revision = stump revision; rhiz = rhizotomy; cordot = cordotomy; symp = sympathectomy; DCS = dorsal column stimulation; PNS = peripheral nerve stimulation.*

operatively due to an extradural hematoma; he made a partial recovery. Minor complications consisted of one patient with a cerebrospinal fluid leak, and nine patients who complained of a minor degree of persistent postoperative weakness, numbness, or sphincter dysfunction.

**Discussion**

**Review of Surgical Therapy**

The difficulty in treating post-amputation pain is reflected in the number and diversity of treatments that have been reported in the literature. Sherman, *et al.*, listed 68 medical and surgical approaches, and White and Sweet described 11 possible operations. These surgical treatments of post-amputation pain have been directed at the spinal cord, the brain, or the damaged peripheral nerves in the stump. Perhaps the earliest treatment of post-amputation pain was devised by Russell and Spalding, who adopted the unusual approach of striking the offending stump with a wooden mallet several times each day. Although initial results were good, less than one-half of their patients had long-term relief. White and Sweet described disappointing results after neuroma excision. This was often performed in conjunction with capping the cut nerve endings with metal or Plexiglas, or injecting them with alcohol, formalin, or phenol. Schoenberg reported that 10 (46%) of his 22 patients gained short-term relief after thermocoagulation of the stump neuroma. Other peripheral surgical procedures that have met with disappointing results are proximal neurotomy, posterior rhizotomy, and sympathectomy.

The most successful approach to post-amputation pain reported in the literature is anterolateral cordotomy. The initial 91% success rate in 22 patients reported by White and Sweet was criticized by Siegfried and Cetinalp, who stated that their follow-up period was not long enough, and the effects of cordotomy rapidly diminish after 6 months. However, Falconer reported a 75% response rate in 12 patients treated with
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The mechanism by which post-amputation pain occurs is unknown. The problem is complicated because pain in the phantom limb and pain in the stump may be separate entities requiring separate explanations, or may be inextricably entwined. Perhaps the earliest proposed mechanism of phantom pain production was by Mitchell, et al., who attributed it to an ascending neuritis arising from damaged nerve endings. Although this inflammatory process has never been verified histologically, much information has accumulated to support a peripheral nerve origin. Spontaneous electrical activity and abnormal mechanical sensitivity of peripheral nerves can cause chronic pain, and have been experimentally shown to exist in posttraumatic neuromas. Many authors believe that stump pain originates from painful neuromas and that reoperation on the stump with neuroma revision is often the treatment of choice.

In 1953, Falconer noted that anterolateral cordotomy improved phantom pain, while dorsal rhizotomy did not. His inference from these observations was that the neurons responsible for the pain were the cells in the substantia gelatinosa. Evidence supporting this theory has come from recent laboratory data which indicate the extensive degree of neuroplasticity that follows deafferentation of second-order neurons in the spinal cord. This plasticity includes alterations in peptide concentrations, and the appearance of self-sustaining neuronal excitation and hyperactive paroxysmal discharges. These chemical and physiological changes can cause chronic pain, and indicate the dorsal horn as an appropriate target for treating post-amputation pain.

Our findings support the concept that stump pain is peripheral in origin. Good results from DREZ operations were obtained in none of the six patients presenting with stump pain, and in only two (29%) of the seven patients presenting with stump and phantom pain. This indicates that the source of pain in these two groups is not the substantia gelatinosa, and that a better approach might be revision of the neuroma or peripheral nerve stimulation. Our findings also support the concept that phantom pain is central in origin. Six (67%) of the nine patients presenting with phantom pain had good results, and therefore DREZ thermocagulation is the treatment of choice. Lastly, we found that DREZ lesions were highly successful in patients with post-amputation pain associated with root avulsion. This finding suggests that these patients are suffering from the well described chronic pain that often follows brachial plexus avulsion. This pain is known to respond well to the DREZ operation; therefore, the favorable result in this group is, in retrospect, not surprising. Another observation is that root avulsion was present in six (35%) of the 17 patients who had traumatic amputations. To our knowledge, this high percentage has not been reported previously in the literature.

Summary

Long-term results in 22 patients who underwent a DREZ operation for post-amputation pain are presented. They suggest that a DREZ operation is indicated if the patient presents with phantom pain or pain associated with root avulsion. Stump pain does not respond to this form of therapy. Historical aspects of
the problem and the theoretical implications of our result are discussed.

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References


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