Centrocentral anastomosis of the proximal nerve stump in the treatment of painful amputation neuromas of major nerves

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The term “centrocentral anastomosis” is used to describe the end-to-end connection across interposed nerve grafts between paired fascicular groups of the proximal stump of a severed nerve. In 22 patients harboring a painful terminal neuroma following amputation of a lower limb (20 neuromas on the sciatic nerve and two on the peroneal nerve), a centrocentral anastomosis was performed on the end of the sectioned nerve to treat pain that had not improved with conventional conservative treatment. Follow-up review at 1 year revealed that the typical neuroma pain had disappeared in all cases, although sporadic diffuse pain persisted in four. Where previous phantom sensation was present, no change was observed. The results presented here are consistent with laboratory findings demonstrating the absence of neuroma formation after centrocentral anastomosis. Therefore, this technique is recommended for the treatment of painful amputation neuroma.

Key Words • centrocentral anastomosis • amputation neuroma • pain • peripheral nerve

The end-to-end connection across interposed nerve grafts between the fascicular groups of the proximal stump of a severed nerve is termed "centrocentral anastomosis." The aim of this operation is to guide the regenerative process of the fibers from the nerve stump through the normal nerve tissue of an autologous graft, thus avoiding the free and disorganized sprouting of the central axons into the surrounding connective reactive tissue, and preventing neuroma formation and the resulting pain. Since the initial description by Samii1 in 1981, some reports have demonstrated the efficacy of centrocentral anastomosis in the treatment and prevention of painful neuromas, mainly in cases of sensitive sectioned hand and finger nerves.9,11,12

Some years ago, we observed the positive results of centrocentral anastomosis in the prevention and treatment of painful neuroma following sciatic nerve section in rats.3,8 Translating this encouraging experience to the clinical practice, we used this procedure in the treatment of pain due to amputation neuroma in major nerves. In this article, we present and discuss our results with centrocentral anastomosis.

Clinical Material and Methods

Patient Population

During a 3-year period (September, 1988, to August, 1991), centrocentral anastomosis was performed on the stump of a severed major nerve in 29 patients harboring painful amputation neuroma. Of these, 22 had a documented follow-up period of at least 1 year and comprise the patients in this clinical series. The other seven patients were lost to review after the 3-month clinical control examination; although the last recorded evaluation showed good results regarding pain, these patients are not included in this study.

There were 20 men and two women, with an average age of 56 years (range 42 to 65 years). In 20 cases the level of amputation was the middle third of the thigh and a painful neuroma was present on the sciatic nerve. Amputation in these 20 patients was required due to peripheral arterial disease. In the remaining two cases amputation was below the knee and the painful nerve was the peroneal trunk. In both, the etiology of the amputation was traumatic.

In all cases a clinical diagnosis of painful amputation neuroma was made. The principal symptom was intense pain described as an electric shock, sometimes as spontaneous discharge and frequently elicited through any kind of contact or pressure on the area corresponding to the stump of the sectioned nerve. Due to the pain, a lower prosthetic limb could not be worn. Blocking the nerve with a local anesthetic agent temporarily alleviated the pain. Conventional conservative treatment with massage of the stump and transcutaneous electrical stimulation was not effective in any case. The average duration of this clinical situation, before neu-
Surgical Treatment

Surgery was performed with the patient undergoing spinal anesthesia. The severed nerve trunk was approached through the primary surgical incision. After identification, the nerve trunk was dissected distally and the neuroma totally exposed. The neuroma was then removed by cutting through normal nerve tissue. The epineurium over the nerve trunk was dissected off an area from 3 or 4 cm above the section; fascicular dissection was then achieved and a paired number of fascicular groups (four, six, or eight) was obtained, depending on the size of the nerve trunk. Each pair of fascicular groups of a similar size were sutured end-to-end using 8-0 nylon stitch. One fasciculus of each sutured pair was sectioned 2 cm above the suture and immediately sutured back into its position. A termino-terminal connection was thereby obtained within the fascicular group with an interposed autologous nerve graft. All sutures were reinforced with a biological adhesive (Tissucol*). The same procedure was used to connect each pair of fascicular groups. Since the unions between the fascicular groups were absolutely tension-free, in the last 12 patients only the biological adhesive was applied to maintain the connection, thereby minimizing the amount of foreign material used. Thus, the nerve stump was finally formed by two, three, or four fascicular loops, each loop comprising two fascicular groups of a similar size connected by a free autologous nerve graft nearly 2 cm long (Fig. 1). The nerve end with its loops were then relocated in a muscular, healthy, well-irrigated bed. Histological studies of the excised neuroma revealed the same typical structure in all cases.

Following surgery, the stump was allowed to heal with a moderately compressive bandage for 3 weeks, after which the patient was sent to a physiotherapist for specialized care.

Results

All 22 patients were followed with periodic monitoring; the last clinical review was carried out at least 1 year after the operation (average 15 months, range 12 to 24 months). In 21 cases there was total relief of pain due to the neuroma. This improvement was evident immediately after the operation. By 4 weeks after surgery, 18 patients could wear a prosthesis and begin a re-education program. In three patients some diffuse undefined stump pain persisted, possibly related to circulatory problems. None of these three patients could wear a prosthesis permanently.

One patient suffered a postoperative deep local infection that required reopening the surgical wound for drainage and antibiotic infusion. After 4 weeks, the pain recurred. Three months later, a second operation revealed a large fibrous neuroma in which it was impossible to identify the fascicular loops. After resecting this neuroma, another centrocentral anastomosis was performed. The pain due to the neuroma disappeared but diffuse nonspecific stump pain remained and interfered with the normal use of the prosthetic limb.

Where present, previous phantom sensations were not modified by the operation. Painful phantom limb was not apparent in any of the cases.

Discussion

The capability of centrocentral anastomosis to avoid neuroma formation and the effectiveness of centrocentral anastomosis in treating pain due to a neuroma are discussed here.
Centrocentral anastomosis for painful neuromas

Prevention of Neuroma Formation

Typically, pain that follows unrepaired peripheral nerve section in some cases is thought to be generated in the tissue of the neuroma at the end of the severed nerve. The most conspicuous histological fact of amputation neuroma is the disordered irregular regenerative growth of the bare axons, spreading out without endoneurial sleeves into the surrounding foreign connective tissue. In those cases, each regenerative axon grows immersed in a tissue environment with unusual histochemical conditions. Moreover, the fibers are subjected to mechanical stimuli produced by adherence of the neuroma to neighboring tissues. Finally, it is probable that the collagen produced by the fibroblastic reaction at the neuroma interferes with the blood supply to the growing cone of the axon, placing it in an ischemic condition.10 The nerve fibers, growing isolated from their physiological tissue environment, develop an abnormal function characterized by spontaneous electric discharges that appear to be related to a special sensitivity to mechanical and chemical (alpha-sympathetic) stimuli, to the presence of ephaptic (cross-talk) synapsis between the fibers themselves, and to a relative excess in the number of unmyelinated fibers.11 These peripheral discharges through their own irregularity, or perhaps through an undetermined action on more central levels of the nervous system, may be interpreted by the patient as pain.12,13 These phenomena are constant in all types of neuroma, but the specific biochemical, histological, or functional characteristics that distinguish painful from asymptomatic neuromas have still not been identified.

Given such a context, the most logical solution for treating pain from this origin would be one that can drastically inhibit chaotic axonal sprouting into the neuroma. This concept has encouraged the development of many surgical techniques, from capping of the nerve end to sealing of the perineural sleeves. However, the regenerative potential of the axon is so intense that generally these techniques do not contain enough barriers to prevent regeneration and, in many cases, the pain eventually resumes.14 End-to-end suture appears to avoid neuroma formation and alleviate the pain from severed nerves when both nerve ends are available for suturing and reconstruction.2,5

Theoretically, centrocentral anastomosis by means of an interposed nerve graft offers the best solution to the problem of amputation neuroma because it appears to allow the nerve fibers to regenerate within a physiological environment (the autologous nerve graft), thus avoiding neuroma formation as occurs in end-to-end suturing of the severed nerve. In fact, laboratory studies have confirmed this hypothesis.4,15,16 Also interesting is the clear-cut demonstration of the inhibition of the growth of the nerve fiber growth within the graft, before reaching the second suture.4,17 There is no good explanation for this finding. According to Seckel,18 the histochemical isolation of fibers growing within normal endoneurial tubes should avoid the influence of the neuromotrophic factors delivered by the end targets, thus arresting the axonal sprouting. But the possible growth-inhibiting effect of the high intraneuronal pressure produced by the presence of axons coming from two nerve ends or the obstacle to growth presented by the second suture itself should not be forgotten.19,20 In mixed nerves, the same mechanisms could be valid for both sensory and motor fibers. In any case, a clear conclusion can be reached and supported by a great deal of experimental evidence that centrocentral anastomosis avoids the anatomical formation of amputation neuroma, with all its functional implications.4,16,19,21

Clinical Effectiveness of Centrocentral Anastomosis

The second aspect to be discussed is the value of centrocentral anastomosis toward resolving pain. It is well known that no single technique solves the problem. In many cases clinical experience shows that there is substantial relief of pain with either the simple relocation of the nerve end2 or a simple neurectomy with neuroma excision,22 while other much more sophisticated operations produce a high rate of recurrence.7,10,15,16,21 In surgery for painful neuroma, it could be accepted that the success of one particular operation, in general, depends on the modifications relating to the newly created neuroma environment instead of the capacity of the technique itself to prevent neuroma formation. In that way the success obtained using the end-to-side suture of a central nerve stump or the direct end-to-end suturing of two different severed nerves without interposing nerve grafts22 can be understood. The same criticism may be applied to the many new surgical techniques for treating painful neuroma and even the mere relocation of the nerve end could be argued to explain our good results. However, the experimental findings of no new neuroma formation after this operation, the normal histological appearance of the regenerated fibers within the graft, and the spontaneous arrest of axonal growth near the second suture4,23 support centrocentral anastomosis.

Given these positive results and taking into account the simplicity of the technique, we would recommend centrocentral anastomosis as the first choice of surgical treatment for refractory amputation neuroma pain. The operation also could be considered when single neuroma resection and repositioning have been attempted and failed. Nevertheless, since no definite pathophysiological relationship exists between phantom pain and amputation neuroma, we have not used centrocentral anastomosis of the severed nerve to treat painful phantom limb after amputation.

References


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