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Treatment of Iatrogenic Saphenous Neuroma after Knee Arthroscopy with Excision and Allograft Reconstruction

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Background: The treatment of postoperative, painful sensory neuromas is an ongoing challenge for surgeons. Here, we describe a technique for treatment with excision and allograft reconstruction and report on early results of its use in treating painful saphenous neuromas after knee arthroscopy.

Methods: A retrospective review of a single surgeon's peripheral nerve clinic from January 1, 2013, to December 31, 2019, was conducted to identify post-knee arthroscopy saphenous neuroma cases in which reconstruction with processed human nerve allograft distally implanted into healthy muscle belly was performed. We examined the outcomes for each patient, including subjective pain self-assessment and need for further surgical treatment.

Results: In total, 9 cases were identified, with patient ages ranging from 21 to 74 years. The average time to referral to peripheral nerve clinic was 31 months (range: 4–143 months). Upon exploration, all nerves were found to have a neuroma in continuity. Six of the 9 patients reported subjective improvement through final follow-up. Three of the 9 patients reported initial improvement, with recurrence of pain at/near the site of the neuroma. The average follow-up time was 9 months (range: 1–21 months).

Conclusions: Here, we report on a novel technique of using a processed human nerve allograft after neuroma resection to provide an organized environment for bridging regenerated axons into muscle tissue. We also describe our early results using this technique to treat iatrogenic saphenous neuromas after knee arthroscopy. Results are encouraging, with 6 of the 9 patients experiencing subjective reduction in pain at final follow-up. *(Plast Reconstr Surg Glob Open 2021;9:e3403; doi: 10.1097/GOX.0000000000003403; Published online 15 February 2021.)*

INTRODUCTION

The treatment of postoperative, painful sensory neuromas is an ongoing challenge. Neuroma development is unpredictable, the diagnosis often confusing, and treatment techniques and efficacies vary widely. Rates of postoperative neuroma formation after nerve injury vary, with an incidence rate ranging from 1% to 60%.[1–5] Identification can be challenging both due to the unpredictability of painful neuroma development and to the unfamiliarity with the symptomatology and diagnosis. Together, this can lead to substantial delays in appropriate referral and treatment.

With the increasing incidence of knee arthroscopy in the United States, the recognition of the potential for nerve injury with portal placement is important in addressing this debilitating complication.[6] The infrapatellar branch of the saphenous nerve (IBSN) is a sensory nerve arising from the saphenous nerve distal to the adductor and branching as it crosses transversely over the patellar tendon to the lateral knee. A study of its anatomic variation found both the number and location of branches to be highly variable, with up to 3 branches and in many possible anatomic locations of the anterior knee.[7] Prior literature has identified rates of IBSN injury after arthroscopy ranging from 0.06% to 22.2%, with symptoms varying from sensory changes to painful neuroma development.[8–11] Although the rate of painful neuroma is likely substantially lower than the injury rate overall, when

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a neuroma develops it can mean significant functional impairment, psychological stress, and worse outcomes overall.[12–14] This has prompted the continued exploration and development of new treatment techniques.

The use of processed human nerve allograft as a method of physical containment has been briefly mentioned in the literature.[15,16] Despite this mention, we are not aware of a surgical technique or patient outcomes publication available in the current literature to describe the technique. The theoretical advantage of this procedure is to provide the resected stump with an organized environment for bridging regenerated axons. We believe the additional length from the processed allograft provides an environment to allow nerves to continue to grow and dissipate the energy that otherwise might be used to produce another neuroma. Here we describe a technique for neuroma excision with allograft reconstruction and report on early results in its use in treating painful saphenous neuromas after knee arthroscopy.

MATERIALS AND METHODS

Ethical approval for this study was obtained from the university institutional review board. A retrospective review of a single surgeon's peripheral nerve clinic from January 1, 2013, to December 31, 2019, was conducted to identify post-knee arthroscopy saphenous neuroma cases in which reconstruction with processed human nerve allograft was performed. Following apposition of the distal end of the intact nerve to the allograft, the distal end of the allograft was implanted into healthy muscle. Patients were excluded if they did not have a diagnosis of infrapatellar branch saphenous neuroma or if they did not undergo surgical treatment utilizing the excision and allograft reconstruction technique. In addition to relevant findings on history and physical examination of pain, numbness/tingling, and tenderness to palpation, short acting anesthetic injections at the suspected location of neuroma were used to assist in diagnosis and localization. We analyzed demographic and comorbidity data as well as initial surgical treatment, the time from initial arthroscopic surgery to peripheral nerve clinic evaluation, post-arthroscopy symptoms, and eventual surgical care. We then examined the outcomes for each patient including subjective pain self-assessment and need for further surgical treatment. The allogenic nerve graft used in this study (Axogen Avance Nerve Graft) is currently approved for clinical use.

STATISTICS

Descriptive statistical analyses were performed using Excel 2010 (Microsoft, Redmond, Wash.).

SURGICAL TECHNIQUE

Preoperatively the point of maximal pain was marked. An incision of a few centimeters spanning this area was made, and the infrapatellar branch or branches of the saphenous nerve were identified (Fig. 1). After identification of the neuroma based on its enlarged and nodular appearance, it was resected sharply such that only healthy appearing nerve remained (Fig. 2). Next a processed human nerve allograft was selected based on width matched as closely as possible to the width of the remaining nerve, and length based on distance needed to reach healthy appearing muscle bed without tension. The allograft was then sutured to the healthy nerve end, using microsurgical technique, wherein one 9.0 nylon suture is placed on each side, gently apposing the 2 ends together. Next, fibrin glue was applied to the graft site, and the end of the graft was embedded in nearby, healthy muscle bed (Fig. 3).

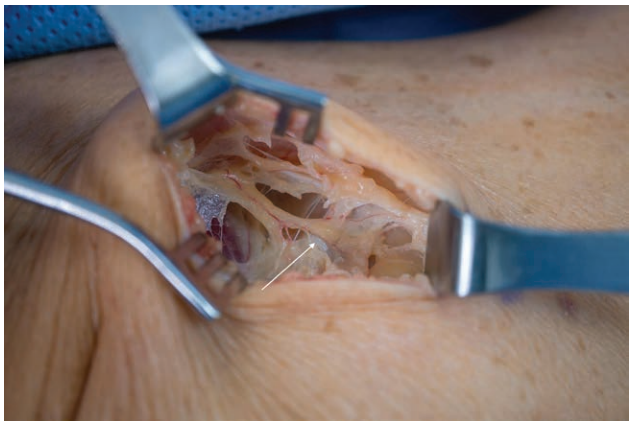

Fig. 1. The infrapatellar branch or branches of the saphenous nerve. The neuroma is labeled with a white arrow.

RESULTS

In total, 9 cases were identified, with patient ages ranging from 21 to 74 years. There were 6 women and 3 men, with an average BMI of 31. A detailed description of demographic and comorbidity data is provided in Table 1. Allograft sizes ranged from 4 cm × 1–2 cm to 7 cm × 1–2 cm. Distal muscular implantation sites were chosen based on nearby healthy appearing muscle bed and included quadriceps and medial head of the gastrocnemius. The average time to referral to peripheral nerve clinic was 31 months (range: 4–143 months). Upon exploration, all nerves were

Fig. 2. Neuroma is resected back to healthy nerve and processed human nerve allograft is sutured to the end(s).

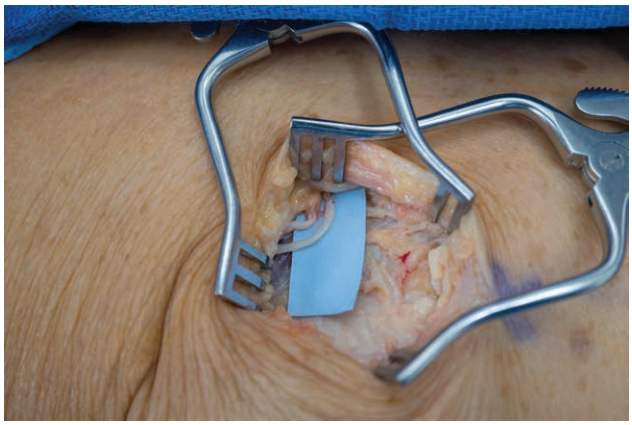

Fig. 3. Fibrin glue is applied to the graft site with the end of the graft embedded in healthy muscle bed.

found to have a neuroma in continuity. Six of the 9 patients reported subjective improvement through final follow-up. Three of the 9 patients reported initial improvement with recurrence of pain at/near the site of the neuroma. Two of the 3 patients who had recurrences had a concurrent diagnosis of chronic regional pain syndrome to the same extremity and received ketamine infusions during the postoperative period. No patient with sustained improvement had a concurrent diagnosis of chronic regional pain syndrome. The average follow-up time was 9 months (range: 1–21 months).

DISCUSSION

Treatment of patients who incur painful traumatic neuromas is variable and includes pharmacologic, psychologic, and surgical interventions. With regard to surgery, there are multiple techniques described in the literature, but not all have thoroughly described outcomes to guide management. In a recent systematic review and meta-analysis published in *Pain* by Poppler et al, the authors compared 54 studies that reported outcomes after surgical treatment of painful neuromas. Their goal in this report was to evaluate surgical effectiveness, hoping to establish a hierarchy of techniques. Their data suggested that clinically meaningful improvement of pain can be achieved with surgical intervention, but they were not able to conclude if there was an effective technique within the available literature. Their study found that 20%–30% of neuromas will continue to be symptomatic despite treatment, regardless of the type of surgery performed.[17] We believe that new treatment options to improve these currently reported outcomes should be pursued.

More than 100 surgical techniques have been described for neuroma treatment.[18–25] Once the need for surgical treatment has been identified, a number of surgical techniques exist to address the problem of preventing recurrence of the neuroma. These focus on addressing the resection site of the prior neuroma and generally include transposition, physical containment, crush, and physiological containment.[1] Transposition aims to relocate the nerve ending to a new substrate that provides both biomechanical protection from noxious stimuli and improved blood supply, with options including subcutaneous fat, muscle, bone, and veins.[26–31] Physical containment aims to provide a barrier that directly inhibits neuroma recurrence, with options including suture ligation, laser coagulation, silicone capping, epineural grafting, and fat grafting.[32–40] Finally, physiological containment attempts to utilize a theorized physiologic process of neuronal growth inhibition within nerves themselves by attaching two proximal nerve endings together or splitting a single ending longitudinally and attaching it to itself, termed centrocentral coaptation.[24,41] The crush technique described by Domeshek et al involves dissection proximal to a neuroma site, and crushing this offending nerve with a hemostat for 30 seconds to create a second-degree nerve injury and move the area of nerve axonal regeneration proximal. The theory behind this method is that the crush technique moves the site of nerve regeneration proximal and away from the site of nerve transection to "reset" and provide a period for the nerve to regenerate distally and to potentially decrease the number of viable regenerating axons. Studies have demonstrated inconsistent improvements in pain, depression, and quality of life following surgical neuroma treatment.[14]

This study describes early outcomes from a small case series using long processed nerve allograft for reconstruction after excision in the surgical care of painful post-traumatic neuromas. Nerve allograft is readily available and avoids the donor site morbidity of autologous nerve harvest, including the possibility of an additional sensory deficit or, worse, another painful traumatic neuroma. Most of the available data on sensory outcomes using allograft come from the adult trauma population. Our senior author has described this technique at academic meetings and conferences, but we are not aware of any publication describing the use of nerve allograft as a treatment for painful neuroma. We have seen the procedure mentioned briefly, without reference to specific technique or patient outcomes in a study by Safa and Buncke in 2016.[16]

Our technique of using a processed human nerve allograft after neuroma resection is predicated on the fact that the allograft provides a lengthy, organized environment for the regenerated axons to grow. In this series, we have described our experience in using this technique to treat iatrogenic saphenous neuromas after knee arthroscopy. This technique could be extrapolated to other anatomic sites of painful post-traumatic neuromas. However, due to the rise of arthroscopic knee surgery, we have seen an increase in the incidence of painful neuromas due to injury to the IBSN while placing the anteromedial arthroscopic portal.

From the results of this case series, we believe that people who are predisposed to forming painful traumatic neuromas may benefit from neuroma resection and nerve allograft reconstruction coapted to a healthy nerve stump. We believe that this technique may be superior to other surgical methods described in neuroma treatment such as excision, traction neurectomy, or burying healthy nerve ends into muscle. This reconstruction may promote neuronal sprouting in an organized manner.[42] The

Table 1. Patient Demographic, Surgical, and Postoperative Characteristics

Patient	Age at Referral	Sex	BMI	Current/ Past Tobacco	Medical Comorbidities	Side	Index Surgery	Time from Injury (Sx) to Hand Surgeon Referral	Prior Surgical Procedures for Neuroma	Time from Inj to BTN Surg (mo)	Symptoms before BTN Procedure	Surgical Procedure	Function at Last Follow-up (Pain Level—No Change, Improved, or Results)	Any Subsequent Surgeries after N Surgery?	Time from N Surgery to Last Follow-up (mo)
1	69	F	37.81	N	Emphysema, COPD	R	Knee arthroscopy	3.27	NA	12.47	Pain, numbness in IBSN distribution	Resection of IBSN neuroma, grafting with 7 cm x 2–3 mm AxoGen nerve graft, implantation into muscle	Resolved	N	20.7
2	21	F	34.9	N	Chronic pain, CRPS (in operative knee)	R	Knee arthroscopy	52.8	Resection and muscle implantation (2013)	72.73	Pain, numbness in IBSN distribution	Resection of 2 IBSN neuromas, grafting with 4 cm x 2–3 mm and 5 cm x 1–2 cm AxoGen nerve grafts, implantation into quadriceps muscle	Improved then recurred	N	6.1
3	39	F	29.13	N	1st degree atrio-ventricular block	R	Knee arthroscopy, synovectomy and partial lateral meniscectomy	5.8	NA	9.97	Pain in IBSN distribution	Resection of IBSN neuroma, grafting with 7 cm x 1 mm AxoGen nerve graft, implantation into m. head gastrocnemius muscle	Improved	N	8.9
4	33	F	24.8	N	Asthma	R	Knee arthroscopy, meniscal repair	143.6	Neuroma resection (2005)	145.43	Pain, numbness in IBSN distribution	Resection of IBSN neuroma, grafting with 7 cm x 1–2 cm AxoGen nerve graft, implantation into quadriceps muscle	Improved	Diagnostic arthroscopy, partial medial meniscectomy	16.6
5	54	F	38.9	Y	HTN, anxiety, fibromyalgia, migraines	R	Knee arthroscopy, partial medial meniscectomy	4.4	NA	6.03	Pain in IBSN distribution	Resection of IBSN neuroma, grafting with 7 cm x 1–2 mm AxoGen nerve graft, implantation into m. head gastrocnemius muscle	Resolved	N	7.0
6	57	M	25.53	N	Hypothyroid, CRPS (in operative extremity)	R	Knee arthroscopy, partial medial meniscectomy	3.77	NA	5.57	Pain in IBSN distribution	Resection of two IBSN neuromas, grafting each with 7 cm x 1-2 mm AxoGen nerve graft, implantation into quadriceps muscle	Improved then recurred	N	5.6

(*Continued*)

Table 1. ***(Continued)***

Patient	Age at Referral	Sex	BMI	Current/ Past Tobacco	Medical Comorbidities	Side	Index Surgery	Time from Injury (Sx) to Hand Surgeon Referral	Prior Surgical Procedures for Neuroma	Time from Inj to BTN Surg (mo)	Symptoms before BTN Procedure	Surgical Procedure	Function at Last Follow-up (Pain Level—No Change, Improved, or Results	Any Subsequent Surgeries after N Surgery?	Time from N Surgery to Last Follow-up (mo)
7	32	F	25.56	Y	None	R	Knee arthroscopy, revision anterior cruciate ligament reconstruction	1.37	NA	3.43	Pain in IBSN distribution, hyperesthesia	Resection of IBSN neuroma, grafting with 7 cm x 1–2 mm AxoGen nerve graft, implantation into m. head gastrocnemius muscle	Improved then recurred	2 stage ACL revision with concomitant lateral meniscal root repair, posterior root repair, partial medial meniscectomy	12.4
8	66	M	30.25	N	GERD	L	Knee arthroscopy, meniscectomy	116.5	NA	116.87	Pain in IBSN distribution	Resection of two IBSN neuromas, grafting with 5 cm x 3–4 mm and 5 cm x 1 mm AxoGen nerve grafts, implantation into quadriceps muscle	Resolved	N	0.5
9	74	M	30.84	Y	Chronic kidney disease, type II diabetes, GERD, HTN	R	Knee arthroscopy, partial medial meniscectiomy	24.47	NA	50.97	Pain in IBSN distribution	Resection of 2 scarred branches of IBSN, grafting with 7 cm x 1–2 mm each, implantation into quadriceps muscle	Improved	N	1.5

downside to using processed nerve allografts is that they are expensive. Furthermore, processed nerve allografts may not be readily available at certain hospitals or surgery centers.

A substantial weakness of this study is the small number of patients in the series. Long-term follow-up is also needed to determine whether pain relief for patients is permanent, or whether neuroma pain could recur in the future, specifically when the nerve has regenerated the entire length of the allograft. A report on our larger series of patients treated with this technique for neuromas from multiple anatomic sites and with longer term follow-up is in progress.

In summary, our early results are encouraging, with 6 of the 9 patients experiencing subjective reduction in pain at final follow-up after undergoing excision and allograft reconstruction to address iatrogenic sensory neuroma secondary to arthroscopic knee surgery. As our collective understanding of the surgical care of painful neuromas advances, this technique deserves further study and consideration.

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