Benefits of Sensory Nerve Transfers and Risks of Using the Superficial Radial Nerve as a Donor

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Nerve transfers have re-emerged in the past several decades as a powerful tool for restoration of neurological function and are an essential part of peripheral nerve surgical practice. There is extensive literature describing outcomes from nerve transfers for the restoration of motor nerve function and describing the complication profile. Recently, interest and use of nerve transfers for restoration of sensation has increased. In this review, we highlight the limitations of the current literature on outcomes from sensory nerve transfers and showcase potential complications from their use, particularly related to use of the superficial branch of the radial nerve as a donor sensory nerve. *(J Hand Surg Am. 2024;■(■):■−■. Copyright © 2024 by the American Society for Surgery of the Hand. All rights are reserved, including those for text and data mining, AI training, and similar technologies.)*

Key words Sensory nerve transfer, superficial branch of the radial nerve, surgical history, surgical procedure.

NERVE TRANSFERS WERE ESTABLISHED almost two hundred years ago, with the earliest reports describing experimental outcomes of nerve transfers by Pierre Flouren in 1828 and the first recorded nerve transfer in a human dating back to 1879 by Tomasz Drobnik.[1,2] The recent mainstream adoption of many nerve transfer techniques using expendable intraplexal donors is commonly attributed to Christophe Oberlin, who in 1994 reported on a technique using an ulnar nerve fascicle to neurotize the biceps muscle.[3] Nerve transfers have been developed and used for indications ranging from brachial plexus and spinal cord injuries to inflammatory peripheral nerve disorders and stroke among other pathologies.

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Sensory nerve transfers have become an emerging area of interest and clinical practice. These transfers are particularly important in cases of loss of sensation in the hand. If the fingers can move and grasp, but there is no sensation, then hand function is considerably impaired. This condition is known as a "blind hand."[4] Visual control is constantly required during activities, as objects may otherwise slip from the fingers. Similarly, the loss of sensation in the sole of the foot is a significant limitation because one cannot feel where the foot is located, providing no feedback while standing and walking. There are numerous studies describing outcomes from motor nerve transfers; however, there is a relative scarcity of published data on the outcomes of sensory nerve transfers, and even less on the potential complications of these transfers.

The goal of sensory nerve transfers is to restore useful and/or protective sensation to critical areas of the extremities, generally considered to be thumb and index sensation, protective sensation of the ulnar aspect of the hand, and protective sensation of the sole of the foot. Sensory nerve transfers have also been used successfully to restore corneal, nipple, and penile sensation.[5–7] Sensory nerve transfers are a potential option to restore sensation in situations where direct repair or nerve graft repair are not possible, such as with prohibitively long distances. As with motor nerve transfers, sensory nerve transfers offer certain advantages to graft repair, such as a single nerve coaptation and often a shorter distance to the end organ. Sensory nerve transfers require a sensory donor nerve, commonly the superficial radial nerve in the upper extremity or the saphenous nerve in the lower extremity. Some commonly used donor nerves for sensory transfers are known to be the cause of neuropathic pain following injury.[8] It is possible that sensory nerve transfers have a different complication profile than motor nerve transfers.

CASE EXAMPLE

In our clinic, we encountered a 60-year-old woman who had an extensive history of surgery on the left-sided median nerve, seeking a second opinion. A standard left-sided carpal tunnel release was performed, after which the patient continued to have progressive symptoms of sensory disturbance. A second release with a fat graft to the carpal tunnel was performed. This was complicated by injury to the palmar digital nerve of the thumb. To attempt sensory restoration to the thumb, a superficial branch of the radial nerve (SBRN) was used as a sensory nerve donor to perform an end-to-end transfer to the digital branch of the thumb. The patient developed a severe neuropathic pain syndrome with allodynia and dysesthesia at the area of the transfer and became unable to use the hand. Another surgery was performed where a regenerative peripheral nerve interface (RPNI) was made to envelop the neuroma; the RPNI was buried 10 cm proximally in the belly of the abductor pollicis longus. Additional nerve surgery was considered to be high risk of further exacerbating the patient's pain syndrome, and the patient continued nonoperative management in the pain clinic.

DISCUSSION

Sensory nerve transfers have the potential to increase useful and critical sensation and improve quality of life. The first sensory nerve transfer appears to have been performed in 1921 by Robert Harris, when a branch of the superficial radial nerve was transferred to the median nerve in an attempt to restore sensation after a severe low median nerve injury that could not be directly repaired.[9] This occurred in the era predating the use of nerve autografts.

For sensory nerve transfers to be successful and improve functionality, they must offer protective sensation as well as locognosia, where touch is correctly localized by the somatosensory cortex to the area experiencing sensation. Regarding sensory relearning, substantial somatosensory cortical reorganization and plasticity has been shown following peripheral nerve injury.[10] There is evidence that somatosensory cortical plasticity is essential for sensory relearning and to facilitate cortical motor relearning.[10] Additionally, there is evidence of somatosensory reorganization after peripheral nerve injury where areas with loss of sensory input become reactivated by sensory input from other uninjured nerves. However, there are limits to this sensory rewiring, as observed in patients who underwent sensory nerve transfer for the upper extremity and their recovered sensation was experienced in the donor nerve distribution.[11] For sensory nerve transfers, the goal is for patients to recover correct locognosia, in which the sensation they recover from the transfer is localized to the appropriate area in the somatosensory cortex. Incorrect locognosia, where sensation is experienced in the distribution of the donor nerve, is a potential outcome from sensory nerve transfers.

Nerves that have been used as donors for sensory nerve restoration in the upper extremity include the SBRN, the intercostobrachial nerve, the lateral antebrachial cutaneous nerve, the medial supraclavicular nerve branches of C4, the dorsal cutaneous branch of the ulnar nerve, and digital branches of the ulnar nerve.[12–16] Indications for sensory nerve transfers have included sensory loss in the hands from complete brachial plexus injuries as well as irreparable median or ulnar nerve injuries.

There are important potential benefits from the use of sensory nerve transfers. However, there is also potential risk with sectioning healthy nerves of the extremities to use as donors. The SBRN is a commonly used donor for restoration of median region sensation in the hand. The SBRN is considered highly susceptible to neuropathic pain from minor traumatic or iatrogenic injury.[17,18] Wilson[19] emphasized caution in the use of the SBRN as a sensory donor nerve "because this is known to be an unforgiving nerve with regard to neuropathic pain." Prior studies have reported that 40% of SBRN neuropathies were because of iatrogenic injury, typically from procedures performed near the SBRN such as radial fracture repair or wrist surgery.[20] Anthony et al[21] noted that the SBRN is "susceptible to iatrogenic injury from seemingly innocuous procedures."

TABLE 1. Studies in Which the Superficial Branch of the Radial Nerve was Used as the Sensory Nerve Transfer Donor as Identified in the Literature Review

Source	No. of Patients	Type of Study	Outcome Measures	Outcomes
Harris[9] (1921)	1	Retrospective case report	Pinprick sensation; light touch	Recovery of pinprick sensation
Turnbull[23,24] (1948 and 1963)	5	Retrospective case series	Pinprick sensation; light touch; Temperature sensation; locognosia	Recovery of pinprick and light touch; variable recovery of hot/cold perception and correct locognosia
Tsuyama and Furusawa[26] (1973)	3	Retrospective case series	Pinprick sensation; light touch; temperature sensation; Locognosia	Recovery of pinprick and light touch; variable recovery of correct locognosia
Bedeschi et al[27] (1984)	5	Retrospective case series	BMRC scale for sensation	General recover of pain sensation; variable recovery of light touch
Rapp et al[11] (1999)	7	Retrospective case series	Pain perception; 2PD; locognosia	Protective sensation recovered in all patients; no patient recovered correct locognosia
Matloubi[25] (1998)	37	Retrospective case series	2PD of each reinnervated finger	Improvement in 2PD; locognosia not reported
Ozkan et al[28] (2001)	1	Retrospective case series	BMRC scale for sensation; light touch; temperature sensation; 2PD; stereognosis	Recovery of pain sensation; other outcomes not clearly reported
Brunelli[29] (2004)	14	Retrospective case series	Autonomic function; Higet-Zachary scale; 2PD; stereognosis	Nearly all patients recovered protective sensation; other outcomes not clearly reported
Ducic et al[30] (2006)	2	Retrospective case series	Locognosia; pain sensation; 2PD	Recovery of protective sensation, locognosia, and 2PD $<$ 10 mm
Bertelli, Ghizoni[31] (2011)	8	Retrospective case series	Locognosia; touch perception; pain perception;	Touch and pain sensation recovery; locognosia recovered in all thumbs; variable locognosia in index fingers
Rodriguez-Lorenzo et al[32] (2012)	1	Retrospective case report	BMRC sensory scale; 2 PD; locognosia	Recovered useful touch and pain sensation (S3+), but failed to recover locognosia
Agarwal et al[33] (2023)	1	Retrospective case report	2 PD; touch sensation; pain sensation; temperature sensation	Recovered protective sensation and tactile sensation (S3); locognosia not reported

2PD, two-point discrimination; BMRC, British Medical Research Council.

Poublon et al[22] wrote that the SBRN is "known for developing neuropathic pain syndromes." Brakee et al[8] described treatment strategies for injuries of the "unforgiving" SBRN. Our patient experienced the unfortunate complication of this well-described pain syndrome after use of the SBRN as a donor nerve.

Over the past 100 years, there have been a small number of retrospective studies describing outcomes from sensory nerve transfers. Although the number of studies and patients are relatively small and limited, particularly over a period of a century, the outcomes described have been generally favorable, and no concerning complications have been reported.

The first reported case of sensory nerve transfer was by Harris[9] in 1921, who reported on a single case of SBRN to median nerve transfer in a case of median nerve injury with a large gap, with positive return of pinprick sensation with time and without complication. In 1948 and 1963, Turnbull[23,24] reported on five patients who underwent SBRN to median transfer who recovered tactile sensation and correct locognosia. In 1999, Rapp et al[11] reported on seven patients who had SBRN to median transfer, none of whom recovered correct locognosia. The largest series was by Matloubi[25] in 1988 who reported on 37 patients undergoing SBRN to median transfer; however, there were limited outcome measures and locognosia was not reported. Table 1 contains a summary of published studies on sensory nerve transfers using the SBRN as a donor.

The reported studies have several substantial limitations. The retrospective nature of these studies, as well as their small sample sizes, introduce the potential for bias and limited generalizability. Additionally, there are differing methodologies for assessing functional sensory outcomes in the upper extremity.[34] Importantly, the lack of a universal methodology to measure sensory function limits interpretation of results. The patients represented in the reported studies also have differences in etiology of nerve injury, patient-specific characteristics, and surgical factors.

To our knowledge there have been no complications reported in the literature related to sensory nerve transfers using the SBRN. The patient encounter example above is an illustration of the potential risks of sensory nerve transfer and a demonstration of a commonly reported phenomenon, namely, that the SBRN is a common cause of significant neuropathic pain secondary to even relatively minor trauma.

There are several theories of why the SBRN is so susceptible to neuropathic pain. One theory postulates that the close relationship between the distal lateral antebrachial cutaneous nerve and the SBRN results in a higher chance of a double sensory nerve injury.[35] Another potential factor is in cases where just part of the distal nerve is taken; the remaining distal branches may be irritable because of inflammatory factors more proximally.[22] In addition, given the relatively higher proportion of somatosensory cortex dedicated to hand sensation, loss of sensory input to the cortex after removing the SBRN is more noticeable and can result in a central pain response.[36] There may be potential evolutionary factors as well. In prehistoric times, all four extremities were used for ambulation. The densely innervated area of sensory coverage of the SBRN would have provided critical sensory feedback. With the emergence of bipedal ambulation, the SBRN sensation is less critical; however, the remaining high area of somatosensory cortex representation may confer a higher risk of neuropathic pain with injury to the SBRN.

SUMMARY

Sensory nerve transfers appear to be increasingly used for restoration of critical sensory deficits. However, published studies on sensory nerve transfers are (1) small based on the number of patients, (2) retrospective in nature, and (3) with complications often not reported in use of the SBRN as a sensory donor. We shared and discussed a complication and adverse outcome in the use of the SBRN as a sensory nerve donor, which is valuable, given the overall low number of studies published on sensory nerve transfers using the SBRN. Sensory nerve transfers are a potentially powerful tool for restoring protective and tactile sensation in critical sensory regions; however, there remains a significant knowledge gap with lack of high-quality outcome data on sensory nerve transfers. The use of the SBRN as a donor nerve has the potential for substantial neuropathic pain associated with iatrogenic injury to this nerve. Awareness of this potential complication is important as sensory nerve transfers increase in popularity and practice.

CONFLICTS OF INTEREST

No benefits in any form have been received or will be received related directly to this article.

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