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ORIGINAL ARTICLE
Peripheral Nerve

Optimal Technique for Cutting Peripheral Nerves in Nerve Transfer Surgery: A Survey of Peripheral Nerve Surgeons

Joseph Catapano, MD, PhD*†
Chloe R. Wong, MD†
Tara Sarkhosh, BSc‡
Stephanie Stefaniuk, HBSc‡
Jana Dengler, MD, MASc, MHSc†‡

Background: Nerve transfer procedures are performed in patients with proximal nerve injuries to optimize their potential for functional recovery. The study aimed to determine the preferred surgical technique and tool used by peripheral nerve surgeons to transect nerves in nerve transfers.
Methods: All current members of the American Society of Peripheral Nerve were invited to complete a cross-sectional 10-question survey. Data on practice demographics, nerve-cutting instruments/techniques used, and their belief on whether this impacted patient outcomes were collected.
Results: A total of 49 American Society of Peripheral Nerve members participated in the study, the majority of whom were over 10 years into practice (n = 30/49; 61%). The most common response was a scalpel blade (n = 26/49; 53%), with the remaining 47% using iris scissors, micro-serrated scissors, a razor blade, specialized nerve microscissors, or a specialized nerve-cutting device. The number of years in practice ($P = 0.0271$) and the percentage of practice that involves treating patients with peripheral nerve injuries ($P = 0.0054$) is significantly associated with the belief that crushing the donor nerves during transection may result in worse outcomes following nerve transfer. Only the latter is significantly associated with this belief in recipient nerves ($P = 0.0214$).
Conclusions: Our findings demonstrate that peripheral nerve surgeons believe that the technique used to transect nerves before coaptation influences outcomes after nerve transfer. Further ex vivo studies are necessary to investigate how different cutting techniques influence nerve morphology and scarring at the coaptation site to optimize outcomes after peripheral nerve surgery. *(Plast Reconstr Surg Glob Open 2024; 12:e6162; doi: 10.1097/GOX.0000000000006162; Published online 13 September 2024.)*

INTRODUCTION

Restoring premorbid function after peripheral nerve injury remains challenging, and many patients are left with incomplete motor recovery and permanent disability.[1–5] Various factors may contribute to poor outcomes after nerve injury, including the slow rate of nerve regeneration and distance from the injury site to the denervated target muscle.[6] To overcome the challenge of long regeneration distances, nerve transfers are performed.[1–3,7–9] In a nerve transfer, a healthy, expendable donor nerve is cut and repaired end-to-end to the recipient nerve, thereby bringing regenerating axons closer to the target muscle. Recovery is dependent on successful nerve regeneration across the coaptation site. Following reinnervation of the target muscle, patients recover function by learning to recruit the reinnervated muscle.

The quality of the nerve repair is dependent on both the skill and experience of the operating surgeon, with a high-quality repair yielding the best patient outcomes.[10] However, although a meticulous nerve repair limits axonal

*From the *Division of Plastic and Reconstructive Surgery, St. Michael's Hospital, Toronto, Ontario, Canada; †Division of Plastic, Reconstructive and Aesthetic Surgery, University of Toronto, Toronto, Ontario, Canada; and ‡Division of Plastic and Reconstructive Surgery, Tory Trauma Program, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada.*

Received for publication April 15, 2024; accepted July 24, 2024.

DOI: 10.1097/GOX.0000000000006162

Disclosure statements are at the end of this article, following the correspondence information.

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escape and is acknowledged to improve recovery, little is known regarding how best to prepare the recipient and donor nerve for transfer, including the optimal technique for cutting the nerve. Scarring at the site of nerve transection and repair can limit axon regeneration across the coaptation site.[11] As such, proper surgical preparation of the donor and recipient nerve ends is necessary to ensure that the coapted nerve ends are free of scar tissue and neuroma, which can impede nerve regeneration. Performing a "clean cut" of the nerve to visualize the fascicles and create matching flat surfaces is generally accepted to maximize nerve regrowth across the coaptation. Currently, there exists no research to inform surgeons as to what the best technique is to cut the nerve.[12,13] Thus, it is important to investigate these surgical variables to optimize outcomes.

The objective of this study was to determine the opinions of nerve surgeons regarding the importance of nerve preparation and transection before transfer, and to establish the diversity of techniques used by surgeons to perform nerve transection currently.

This is a cross-sectional survey of the American Society of Peripheral Nerve (ASPN) members. This study was approved by the institutional research ethics board at Sunnybrook Health Sciences Center at University of Toronto.

ASPN members were invited to participate in a study designed to understand the importance of the of nerve preparation and transection before nerve transfer. Members who were not actively practicing surgeons or who did not perform peripheral nerve transfers were excluded. Members were sent an initial email invitation to complete an online de-identified survey, and two follow-up reminder emails were sent. The survey link was embedded in the email.

The survey consisted of 10 questions that included demographic data: years in practice, percentage of their practice that involves treating nerve injuries, and the average number of nerve transfer procedures performed per month. (**See survey, Supplemental Digital Content 1**, which displays the survey questions. **http://links.lww.com/PRSGO/D498**.) Respondents were asked to rank (on a 10-point Likert scale) how much importance they place on the quality of nerve transection, and the instrument and technique they use to transect nerves before nerve transfer. These data were collected using Google Forms and transferred to a prepopulated Excel spreadsheet, including reference pictures for the instruments. (**See figure, Supplemental Digital Content 2,** which displays the surgical instruments. **http://links.lww.com/PRSGO/D499**.)

Data were analyzed with SAS Software. Categorical variables were described using frequencies and percentages. Variables collected via a numerical rating scale were reported as medians and interquartile ranges. Associations between categorical data were analyzed using Fisher exact test. Statistical significance was set a P value less than < 0.05.

Of the 350 ASPN members who were invited to participate, there were 51 respondents (response rate 15%).

Takeaways

Question: What is the optimal technique for cutting peripheral nerves in nerve transfer surgery?

Findings: A survey of peripheral nerve surgeons demonstrated that a majority (53%) use a scalpel blade. The number of years in practice and the percentage of practice that involves treating patients with peripheral nerve injuries is significantly associated with the belief that crushing the donor nerves during transection may result in worse outcomes following nerve transfer.

Meaning: Peripheral nerve surgeons believe that the technique used to transect nerves before coaptation influences outcomes after nerve transfer.

However, respondents were excluded from data analysis if they did not perform nerve transfers (n = 2). The remaining 49 study respondents were eligible for inclusion in this study.

Study respondents represented a broad range of experience, with the majority being over 10 years into practice (n = 30 of 49; 61%). Respondents varied in the percentage of their practice that involves treating nerve injuries. The majority of surgeons reported that managing nerve injuries comprised less than 50% of their practice (n = 35 of 49; 71%), most of whom commonly performed one to two nerve transfers per month (n = 21 of 49; 43%). Please refer to Table 1 for further details.

The majority of respondents reported agreeing with the belief that crushing the donor (n = 35 of 49; 71%;) and recipient nerves (n = 40 of 49; 82%) during transection results in worse patient outcomes. Many believe that certain surgical instruments do limit nerve damage during transection (n = 41 of 49; 84%). On a scale of 1–10 (1 = no influence, 10 = high influence), respondents rated that the quality of nerve transection influences nerve regeneration and outcomes following nerve transfer as 8 of 10 (median, 8; interquartile range, 4). The most common instrument used to cut nerves was a scalpel blade (n = 26 of 49; 53%), followed by specialized nerve microscissors (n = 9 of 49; 19%), a specialized nerve cutting

Table 1. Demographic Characteristics of Study Respondents

Category	Frequency	Percentage
Years in practice		
0–5 y	15	30%
6–10 y	4	8%
11–20 y	16	32%
20+ y	14	29%
Percentage of practice involving treatment of nerve injuries		
10–20%	16	33%
30–40%	19	39%
≥50%	14	28%
No. nerve transfers performed per month (on average)		
<1	17	35%
1–2	21	43%
3–10	10	20%
>10	1	2%

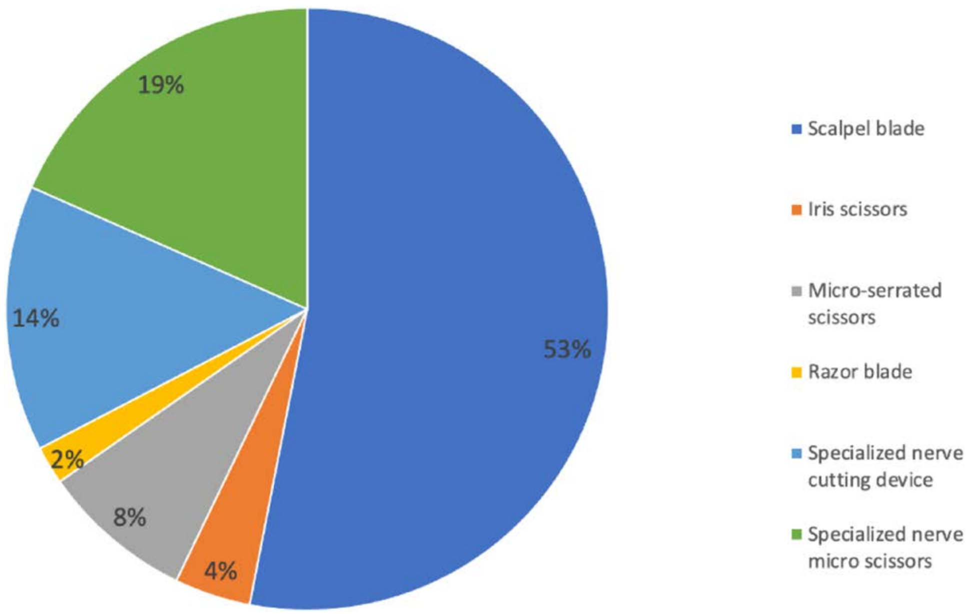

Fig. 1. Instruments and techniques used to cut nerves.

device (n = 7 of 49; 14%), microserrated scissors (n = 4 of 49; 8%), iris scissors (n = 2 of 49; 4%), and a razor blade (n = 1 of 49; 2%; Fig. 1). Among those who used a specialized nerve-cutting device, this included a neurotome, an assi nerve set, a guillotine-type device, and a micro blade.

Both the number of years in practice ($P = 0.0271$) and the respondent's percentage of practice that involves treating patients with peripheral nerve injuries ($P = 0.0054$) were significantly associated with the belief that crushing the donor nerves during transection may result in worse outcomes following nerve transfer. Only the latter was significantly associated with this belief in recipient nerves ($P = 0.0214$). There was no significant association between the average number of nerve transfer procedures per month with either belief (donor, $P = 0.0594$; recipient, $P = 0.0774$).

There was no significant association between the number of years in practice ($P = 0.0695$) or average number of nerve transfer procedures per month ($P = 0.1090$) with the belief that certain surgical instruments do limit nerve damage during transection. However, there was a significant association between the respondent's percentage of practice that involves treating patients with peripheral nerve injuries and the belief that certain surgical instruments do limit nerve damage during transection ($P = 0.0331$).

Our study demonstrates that, amongst a group of surgeons with expertise in peripheral nerve surgery, the current belief is that nerve preparation and transection does influence patient outcomes following nerve transfers. Further, there is a significant association between the respondent's percentage of practice that involves treating patients with peripheral nerve injuries and the aforementioned belief as well as the belief that certain surgical instruments do limit nerve damage during transection. In highlighting the heterogeneity in the instruments and techniques used to prepare nerve ends before coaptation, we have identified the need for establishing best practice guidelines.

Nerve repair with nerve transfer includes four important steps: preparation of the proximal and distal nerve ends, approximation, coaptation, and maintenance. This article focuses on the first of those four steps, with the goal of nerve preparation being limiting trauma to nerve endings during transection to limit scar tissue formation at the coaptation site. Although scar formation is necessary for repair following tissue injury, excessive scarring of the perineurium and endoneurium can impede axon regeneration[14] and diminish nerve microcirculation, causing ischemia and secondary axon degeneration.[15] Limiting perineurial scar tissue facilitates an appropriate environment for the donor nerve axons to first regenerate across the nerve coaptation site and then regenerate through the recipient endoneurial tubules toward the target end-organ.[16]

The heterogeneity in our results in nerve-cutting techniques is in keeping with the literature.[17–20] Many respondents use a scalpel (53%), with the remaining 47% using iris scissors, micro-serrated scissors, a razor blade, specialized nerve microscissors, or a specialized nerve-cutting device. The utility of nerve-specific cutting devices may be limited by cost, and without sufficient evidence to support the use of a nerve-specific cutting device, the cost may not be justified at many centers. Studies comparing the use of different instruments and techniques for the preparation of nerve endings is sparse.[20] The most effective method is still a subject of debate, with some advocating use of a scalpel and others use of microvascular scissors.[21–23]

Presently the ability of the surgeon to limit and assess damage to the nerve at the transection site is limited. Jernigan et al[20] investigated the impact of several nerve transection devices on the macroscopic quality. They dissected median nerves in a cadadveric model and excised 1-cm-long segments using either a 15-blade scalpel, microvascular scissors, tenotomy scissors, iris scissors, or a circumferential nerve-cutting guide.[20] Axial and sagittal photographs of each nerve segment were grouped together on a single digital file and presented to a panel of three hand fellowship–trained surgeons who were blinded to the instrument.[20] The panel evaluated each photograph, with "yes" indicating an acceptable cut and "no" indicating an unacceptable cut.[20] Compared with all other instruments, the majority of surgeons agreed that the specialized nerve-cutting device (the circumferential nerve-cutting guide) produced the most acceptable cuts.[20] Although these results may help guide surgeons, it remains unknown whether the macroscopic appearance of the nerve is correlated with perineurial and endoneurial scarring.

Rose et al[24] investigated the microscopic appearance of the nerve ends following different methods of nerve transection in a cadaveric model of median and ulnar nerve transection. They likewise excised 1–2 cm of each nerve using either an 11-blade scalpel, a razor blade, or a pair of scissors.[24] Using electron microscopy, a three-dimensional surface analysis of roughness was performed for each specimen using ZeeScan optical hardware and GetPhase software.[24] Statistical analyses comparing the roughness measures amongst cutting techniques revealed that 11-blade scalpels and the iris scissors produced the smoothest nerve preparations; razor blades resulted in inconsistent nerve ends.[24] Although nerve appearance was used as a surrogate for transection quality in both studies, it remains unknown whether this impacts nerve regeneration in vivo. What likely remains most important for axon regeneration is the maintenance of the architecture of the endoneurial tubules and scarring after transection, which has yet to be investigated directly. For instance, a smooth cut that may crush the endoneurial tubules and result in significant scarring may be less effective than a less smooth cut that leaves the endoneurial tubules less damaged.

The damaging effects of using microsurgical scissors and razor blades have been described in other studies as well. Behrman and Acland[25] noted that the cutting action of scissors resulted in damage to both the perineurium and axon orientation within the endoneurium. Archibald and Fisher et al. also described the damaging effects of using microsurgical scissors and razor blades.[26] Although Rose et al[24] found iris scissors were equal to scalpel blades at producing the smoothest nerve preparations, Archibald and Fisher[26] observed that the use of a razor or microsurgical scissors resulted in an uneven section of the nerve tissue and distortion of the internal and external structure of the fasciculus due to crushing and shearing actions.

Rummings et al[27] compared the incidence of neuroma formation following transection of rat sciatic nerves via: a 15-blade scalpel with a tongue depressor, micro-serrated scissors, nerve-cutting guide forceps with a straight razor, and bipolar cauterization. Despite the most visual damage and disorganization found in the No. 15 scalpel blade group, there were no significant differences in the caliber or incidence of neuroma formation between the groups.[27] Although these results demonstrate that the subjective appearance of the nerve after transection is not influenced by technique, it remains unknown whether the macroscopic appearance of the nerve correlates with the microfascicular architecture of the nerve, which is most likely to impact axon regeneration.

Our results demonstrate that the only practice variable that is significantly associated with the belief that crushing the donor and recipient nerves leads to worse patient outcomes and that certain surgical instruments limit damage during nerve transection is the respondent's percentage of practice that involves treating patients with peripheral nerve injuries. Although length of nerve practice and number of nerve procedures performed are also surrogates of peripheral nerve surgery experience, the percentage of practice may better represent a surgeons focus on nerve surgery and potentially their understanding. This finding highlights the necessity for further investigation to establish best practice guidelines for peripheral nerve surgery.

There are several limitations to our study. Although the response rate was 15%, the ASPN membership includes practicing surgeons, retired emeritus members, trainees, as well as a large number of basic scientists that do not practice clinically. The percentage of members who are not practicing surgeons is unknown, and it is therefore important to note that our response rate of 15% likely represents a much higher percentage of practicing surgeons within the ASPN. Our sample size of 49 respondents, although small, was sufficient to capture a diversity of nerve preparation techniques and establish that controversy exists regarding the preparation of recipient and donor nerve ends before nerve transfer. Of note, a third of the survey population comprised of surgeons who have recently completed their training. These individuals may still be predominantly influenced by the practices of their training mentors and might not have had sufficient time in independent practice to develop their own opinions and preferences. This underscores the possibility that their survey responses may not entirely represent their personal views, but rather the techniques they were trained in. Our survey study is also subject to volunteer bias, where respondents may feel strongly about the topic in comparison to those who did not participate in the study. As such the study results may not be representative of all nerve surgeons. Moreover, practices may be influenced by practical considerations, such as convenience, which can impact the interpretation of results regarding tool preference. For example, opting for scissors over a blade may not imply a belief in the superiority of scissors, but rather a recognition that various methods can yield comparable results, with scissors being a quicker and more straightforward choice. Conversely, respondents might favor a blade due to a scarcity of sharp scissors, yet still maintain that a sharp pair of scissors would be equally effective. Lastly, we did not explore the morphological implications of the surgical instruments used for nerve transection and coaptation with laboratory investigation. Rather, the purpose of our study was to establish the prevalent practice patterns of nerve surgeons within the ASPN and establish the clinical equipoise necessary to justify further investigation. Future studies will seek to examine the effects of various surgical instruments by comparing the structure of endoneurial tubes of the nerve end before surgical transfer.

Expert opinion from our study demonstrated that the majority of respondents felt that the nerve-cutting technique influences nerve regeneration after coaptation for nerve transfer. Presently, surgeons use a variety of instruments to prepare nerve ends before coaptation. This study identified the technique most commonly used by nerve surgeons to be a scalpel blade. Although this study focused on the clinical paradigm of nerve transfers, these results are equally applicable to the much larger number of surgeons who perform nerve coaptations for repair following traumatic injury. Future studies will seek to investigate the microstructure of endoneurial tubules following different cutting techniques, and to determine whether cutting techniques impact nerve regeneration in animal models. These studies can provide the necessary evidence to guide decisions made daily in operating rooms that may impact outcomes after nerve surgery.

Jana Dengler, MD, MASc, MHSc
Tory Trauma Program, Sunnybrook Health Sciences Centre
University of Toronto
M1-500, 2075 Bayview Ave
Toronto, ON M4N 3M5
Canada
E-mail: jana.dengler@mail.utoronto.ca
Instagram: @nervesurgeon

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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