Improved Mobility After Peripheral Nerve Repair for Phantom Limb Pain

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Abstract

Background: Phantom limb pain (PLP) is a common complication after major lower extremity amputations (MLEA), occurring in approximately 85% of patients. PLP significantly affects amputees' mobility, ability to perform tasks of daily living, and overall quality of life (QoL). Previous studies have discussed surgical treatments for PLP that can improve ambulation and mobility after MLEA. Herein, we describe 3 patients who underwent peripheral nerve repair (PNR) to alleviate PLP and reported decreased pain and improved QoL. **Methods:** A retrospective chart review identified 3 patients whose ambulation and QoL were limited by PLP and underwent PNR during 2023. The charts were reviewed for demographics, current functional status, self-reported pre- and post-operative pain scale ratings, vascular QoL scores, and the Prosthetic Limb Users Survey of Mobility (PLUS-M) scorecards from the patients' prosthetists. **Results:** All patients were men (3/3, 100%), mean age 60.7 years (range 39-73 years). The numeric rating scale for pain showed an average preoperative pain score of 8.5 (range 8-9), postoperative score of 5.6 (range 3.6-7), and 3-month follow-up score of 2.7 (range 1-4, *P*=.003). VascuQoL-6 scores showed an average preoperative score of 10.7 (range 9-12), postoperative score of 14 (range 13-15), and 3-month follow-up score of 19.3 (range 19-20, *P*=.0008). The PLUS-M scorecard T-score mean before PNR was 13.45% (range 1.2%-33.7%) and 54.87% (range 51.9%-60.8%, *P*=.0175). **Conclusion:** The PLUS-M scorecards used by the patients' respective prosthetists showed improved ambulation after surgical intervention. The surgical treatment of PLP with PNR after the best medical therapy has been exhausted can improve ambulatory ability in these patients.

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Each year in the US, over 150,000 patients undergo a lower extremity amputation, with over 3.6 million people projected to be living with an amputated limb by the year 2050.[1] A major lower extremity amputation (MLEA), which is defined as an amputation of the lower limb proximal to the ankle, is a life-altering procedure that results in reduced mobility and impairment in performing activities of daily living. The ability to walk independently with a prosthesis after MLEA been cited as a key factor for enhanced quality of life (QoL) after amputation.[2] Factors negatively impacting ambulation after MLEA include higher body mass index, higher modified frailty index, dependent preoperative functional status, chronic pain, and lack of family support.[3] With approximately 50% of all MLEA patients being ambulatory 1 year postprocedure,[3] identifying strategies to limit the factors negatively affecting ambulation post MLEA is essential to improve post-amputation QoL.

Phantom limb pain (PLP) is a known complication of MLEA, affecting up to 85% of patients who undergo amputation.[4] PLP is pain in the amputated extremity that is described as shooting, burning, and/or cramping sensations.[5] PLP can significantly affect one's ability to perform tasks of daily living, mobility, and negatively affect overall QoL.[6] Surgical treatments for PLP have been described in the literature and offer promising results. Types of peripheral nerve repair (PNR) include targeted muscle reinnervation (TMR) and regenerative peripheral nerve interface (RPNI), which focus on successful repurposing of transected peripheral nerves to promote neural regeneration, thereby decreasing the likelihood of developing PLP.[7] Because PLP can be a hinderance to ambulation after MLEA, we hypothesized that mitigating PLP would improve amputees' ability to ambulate in addition to decreasing pain and improving QoL.

This brief report describes 3 MLEA amputees whose ability to ambulate with a prosthesis after MLEA was limited due to PLP, which improved after surgical treatment with PNR.

Methods

After obtaining approval from the Institutional Review Board (HP-00085462), a retrospective chart review identified 3 patients whose ambulation and QoL were limited by PLP and underwent PNR. Patient charts were reviewed for demographics, patient risk factors, current functional status, self-reported pre- and post-operative pain scale ratings, vascular QoL scores, and Prosthetic Limb Users Survey of Mobility (PLUS-M) scorecards from the patients' prosthetists. Prior to PNR, each patient had undergone a nerve block, which relieved their PLP for up to 12 hours. Each of the 3 patients had undergone below-knee amputation (BKA) previously and were followed in the outpatient setting.

The TMR procedure involves the transfer and implantation of severed peripheral nerves to adjacent motor nerves within de-innervated segments of muscle.[8] The RPNI procedure involves first identifying a severed peripheral nerve, then wrapping the peripheral nerve in excised muscle tissue.[7] The technical details of these procedures are different; however, the outcomes of both procedures support the hypothesis that successful repurposing of transected peripheral nerves promotes neural regeneration, thereby decreasing the likelihood of developing PLP, which for these patients would improve their ability to ambulate (**Figure 1**).

Descriptive statistics and t-test were utilized and compared before and after intervention. The Numeric Rating Scale was used to assess pain severity for specific moments in time on a scale from 0 to 10, with 0 being "no pain" and 10 being "the worst pain imaginable". The patients reported their current, worst, and least pain scores in the 24-hour period leading up to the encounter, which was averaged for a score.[9]

The VascuQoL-6 is a validated tool used to assess the health-related QoL for patients with peripheral arterial disease (PAD).[10] Higher scores indicate a better QoL, and lower scores indicate a worse QoL. Patients provided their responses during the preoperative appointment, postoperative appointment, and 3 months after PNR.

To define ability to ambulate, the PLUS-M T-score was utilized, which is a self-report instrument used for measuring the mobility of adults with MLEA.[11] The PLUS-M measures a prosthetic user's mobility (the ability to move intentionally and independently) in addition to the perceived ability to carry out tasks that require the use of both limbs.[12] The T-score has a mean of 50 and a standard deviation of 10, with a score of 50 representing the mean mobility reported by the development sample; a higher score corresponds to greater mobility.

Results

All patients were men (3/3, 100%) with a mean age of 60.7 years (range 39-73 years). Cardiovascular disease was present in 67% (2/3) of these patients, hypertension in 67% (2/3), diabetes in 33% (1/3), and PAD in 67% (2/3). One patient had no significant medical history other than trauma to the limb, while the other 2 patients received amputations due to nonhealing wounds. Each of these patients reported pain and decreased QoL for more than 3 months following their amputation despite the best medical therapy.

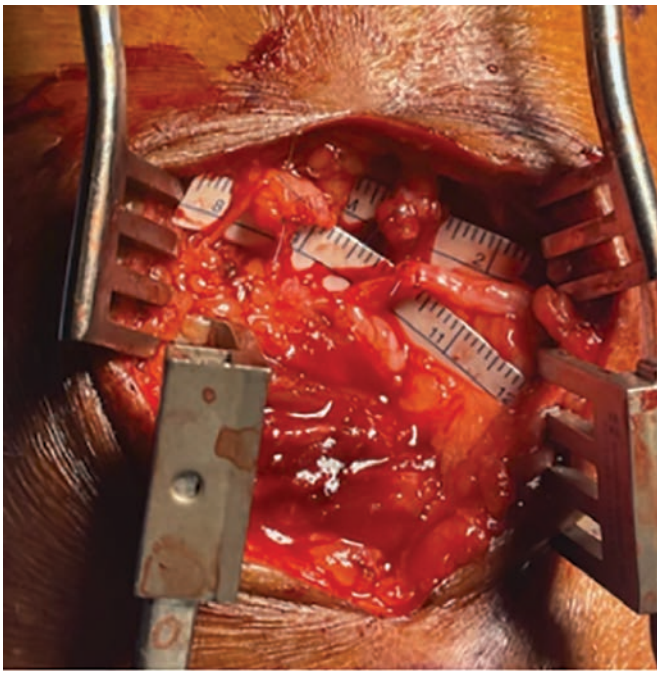

FIGURE 1. Surgical identification of peripheral nerves.

The numeric rating scale for pain assessment showed an average preoperative pain score of 8.5 (range 8-9), postoperative score of 5.6 (range 3.6-7), and 3-month follow-up score of 2.7 (range 1-4, *P*=.003). VascuQoL-6 scores showed an average preoperative score of 10.7 (range 9-12), postoperative score of 14 (range 13-15), and 3-month follow-up score of 19.3 (range 19-20, *P*=.0008) (**Figure 2**). The PLUS-M T-score mean before PNR was 13.45% (range 1.2%-33.7%) and 54.87% (range 51.9%-60.8%, *P*=.0175) once cleared to work with the prosthetist again (**Figure 3**).

Discussion

All patients had improvement in their residual limb pain score, VascuQoL-6, and their PLUS-M T-score mean after PNR. Each patient was able to bear weight on their residual limb and use their prosthetic to ambulate following PNR. All patients are at a minimum K-Classification System for Functional Ambulation (K-level) of 3.

K-level was developed by the Centers for Medicare and Medicaid Services to aid providers and prosthetists in choosing the appropriate style and components of the prosthetic.[13] The lowest K-level is 0, which indicates that a patient would not have any ability or potential to ambulate or transfer safely without assistance, opposed to a K-level of 4, indicating a patient who has the

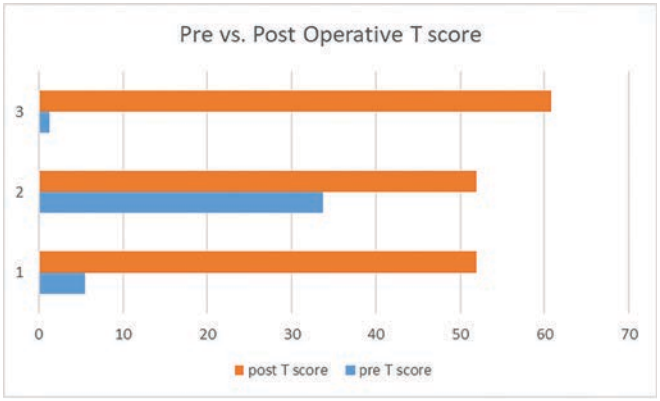

FIGURE 2. Pain score, pain intensity, and vascular quality of life: preoperatively, postoperatively, and at 3-month follow-up.

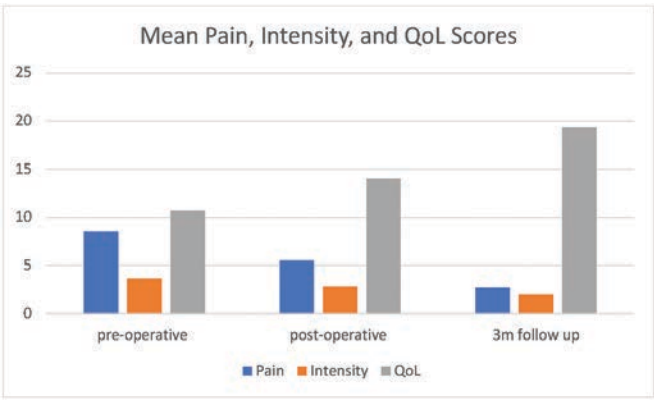

FIGURE 3. T-score from the Prosthetic Limb Users Survey of Mobility preoperatively compared with postoperatively for each subject.

ability or potential for prosthetic ambulation that exceeds basic ambulation skills such as an athlete.[13,14] Functional ambulation ability for these patients improved after PNR.

With the goal of performing MLEA to alleviate pain or gain source control of an infection, the other goal of the surgical team is to preserve the ability to ambulate with a prosthesis. Sansosti et al noted that the overall rate of ambulation in a prosthesis for a patient who underwent BKA is about 50%.[15] Six-month postoperative ambulation rates have been cited in other studies as 46.1%,[15] which echoes other findings of 1-year ambulatory rates of 46% after MLEA.[5] The Amputee Coalition of America conducted a cross-sectional telephone survey of 914 amputees and found that 95% of amputees have pain daily, with 79.7% of those citing PLP as the daily pain.[16] Being able to treat PLP effectively may increase the overall ambulatory rates of patients after MLEA.

Addressing the nervous system to treat PLP is not a novel idea. Economides et al demonstrated effective prophylactic reduction in PLP, neuroma formation, and improved ambulation rates after treating the severed nerves then adding a collagen wrap.[17] Ahuja et al found that MLEA patients with primary TMR had significantly less residual limb and PLP[18] than the control group.[19]

Ongoing chronic pain can be a hinderance to QoL post MLEA and alter one's ability to interact with society and socialize. One study noted that patients with MLEA who are less integrated with society are not capable of coping emotionally or physically with their new limitation.[20] Neil noted that amputees who are successful in using prosthetic limbs for mobility report a significantly higher QoL compared with amputees who experience stump pain or PLP.[21] With the rising incidence of diabetes and obesity and the anticipated rise of the percentage of older patients, the rates of MLEA will also rise. While limb salvage will always be preferred, some patients will benefit most from a well-healed amputation with early ambulation using a prosthesis.[5] Avoiding PLP will be essential for ambulation success.

There are limitations to this report. This is a single-center, single-surgeon experience with patients at a tertiary care referral center with a small sample size, which can be affected by selection bias. The mean PLUS-M score of 54.87% once patients were able to ambulate again and work with a prosthetist is just above the mean national average. It is the improvement in the mean PLUS-M score after PNR that makes this review unique.

Conclusion

Ambulation is a key indicator of adequate pain control and overall QoL for patients who have undergone MLEA. In this case series, the surgical treatment of PLP with PNR after exhaustion of the best medical therapy improved ambulatory ability and reduced chronic pain. Further research is needed to elucidate the pathophysiology of PLP and determine the optimal timing of PNR to maximize postoperative ambulation and mitigate chronic pain.

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