Managing Major Peripheral Nerves in Forearm Level Amputations with TMR and RPNI: What is the Best Recipe?

Andrew B Rees, Samuel Posey, Julia Mastracci[1], Bryan J. Loeffler, Raymond Glenn Gaston
[1]Atrium Health

INTRODUCTION:

Although targeted muscle reinnervation (TMR) and regenerative peripheral nerve interfaces (RPNI) can prevent painful neuroma formation and facilitate myoelectric prosthesis use, forearm level amputation presents a plethora of potential TMR targets and RPNI options that can be used for the major peripheral nerves—leaving surgeons uncertain of which recipe of nerve handling is ideal. We hypothesized that forearm TMR targets that are deep and distal are more effective at preventing the development of symptomatic neuromas than targets that are superficial and proximal.

METHODS:

A retrospective review was completed of all patients who underwent forearm level amputation amongst a large quaternary upper extremity surgery group between 2017-2022. All patients that underwent forearm level amputation during this period were included. Patients with previous TMR surgery by outside providers, follow up <6 months, or insufficient surgical documentation were excluded. Demographics, medical comorbidities, injury characteristics, surgical treatment of major peripheral nerves (TMR, RPNI, traction neurectomy, etc), prosthesis use, and post-operative complications were collected. The primary outcome measure was development of a symptomatic neuroma as determined by the Eberlin criteria. Patients undergoing TMR were divided a priori into two groups: 1) superficial and proximal TMR targets and 2) deep and distal targets. [Figure 1] A Fisher's exact test was run to compare rate of symptomatic neuroma formation in these groups and descriptive statistics were generated for the remaining nerve treatment options (RPNI, traction neurectomy, etc).

RESULTS: 39 patients met inclusion criteria. 16 symptomatic neuromas developed, as determined by the Eberlin criteria. No patients that had a deep or distal TMR target developed a symptomatic neuroma—thus the Fischer's exact test could not generate an assessment of statistical significance. Only one nerve out of 12 treated with RPNI developed a symptomatic neuroma. The development of neuromas by treatment of each nerve is further detailed in Table 1.

DISCUSSION AND CONCLUSION:

In a retrospective cohort study of forearm amputations, deep and distal TMR targets prevented symptomatic neuroma formation more than superficial and proximal targets. RPNI is a useful adjunct for neuroma control, especially for the radial sensory nerve. Patients with poorly controlled diabetes may not require advanced nerve management. This represents the largest and most detailed report of nerve management for forearm level amputees and will help guide surgeons in determining the best recipe for nerve management in each unique patient scenario.

Figure 1. Predetermined Groupings for Nerve Treatment at Time of Amputation

Forearm TMR		RPNI	Traction Neurectomy	Other Targets
Superficial and Proximal Targets Brachioradialis (BR) Extensor carpi radialis longus (ECRL) Extensor carpi radialis brevis (ECRB) Flexor carpi radialis (FCR) Flexor carpi ulnaris (FCU) Palmaris longus (PL) Flexor digitorum superficialis (FDS)	**Deep and Distal Targets** Pronator teres (PT) Flexor digitorum profundus (FDP) Pronator quadratus (PQ) Flexor pollicis longus (FPL)			Coaptation with another nerve Buried into bone Buried under muscle Salvage TMR (above elbow) No treatment/none recorded Transposed with intact native targets No treatment/none recorded

Table 1. Symptomatic Neuromas by Nerve Treatment at Time of Amputation

	Target	No Neuroma	Neuroma
Median Nerve	Superficial/Proximal TMR	14	5
	Deep/Distal TMR	8	0
	RNPI	0	0
	Traction Neurectomy	6	0
	Other Targets	2	2
Ulnar Nerve	Superficial/Proximal TMR	17	3
	Deep/Distal TMR	6	0
	RNPI	1	0
	Traction Neurectomy	5	0
	Other Targets	3	2
Radial Sensory Nerve	Superficial/Proximal TMR	4	0
	Deep/Distal TMR	2	0
	RNPI	10	1
	Traction Neurectomy	9	2
	Other Targets	15	0
All Nerves Combined	Superficial/Proximal TMR	35	8
	Deep/Distal TMR	16	0
	RNPI	11	1
	Traction Neurectomy	20	2
	Other Targets	20	4