

Supplementary file 5. Included Studies

	Study title	First author	Year of publication
1	Effectiveness and safety of home-based muscle electrical stimulator in brachial plexus Injury patient	Limthongthang	2014
2	Elbow proprioception sense in total arm -type brachial plexus injured patients after neurotisation: a preliminary study	Homreprasert	2014
3	Comparison between the anterior and posterior approach for transfer of the spinal accessory nerve to the suprascapular nerve in late traumatic brachial plexus injuries	Souza	2014
4	Ultrasound-guided peripheral nerve stimulation for neuropathic pain after brachial plexus injury: two case reports	Kim	2017
5	Contralateral lower trapezius transfer for restoration of shoulder external rotation in traumatic brachial plexus palsy: preliminary report and literature review	Satbhai	2014
6	Restoration of shoulder abduction in brachial plexus avulsion injuries with double neurotization from the spinal accessory nerve: a report of 13 cases	Huan	2017
7	Transfer of the musculocutaneous nerve branch to the brachialis muscle to the triceps for elbow extension: anatomical study and report of five cases	Bertelli	2017
8	Posterior approach for accessory to suprascapular nerve transfer: an electrophysiological outcomes study	Rui	2013
9	Reliability of functioning free muscle transfer and vascularized ulnar nerve grafting for elbow flexion in complete brachial plexus palsy	Potter	2017
10	Management of infraclavicular (Chuang Level IV) brachial plexus injuries: A single surgeon experience with 75 cases	Lam	2015
11	Functioning free muscle transfer for the restoration of elbow flexion in brachial plexus injury patients	Estrella	2016
12	Radial to axillary nerve transfers: A combined case series	Desai	2016
13	Thalamic deep brain stimulation for neuropathic pain after amputation or brachial plexus avulsion	Pereira	2013
14	Nerve transfers for shoulder function for traumatic brachial plexus injuries	Estrella	2014
15	Results of operative treatment of brachial plexus injury resulting from shoulder dislocation: A study with a long-term follow-up	Gutkowska	2017
16	Surgical treatment of brachial plexus posterior cord lesion: A combination of nerve and tendon transfers, about nine patients	Oberlin	2013
17	The medial cord to musculocutaneous (MCMc) nerve transfer: a new method to reanimate elbow flexion after C5-C6-C7-(C8) avulsive injuries of the brachial plexus—technique and results	Ferraresi	2014
18	Transfer of a terminal motor branch nerve to the flexor carpi ulnaris for triceps reinnervation: anatomical study and clinical cases	Bertelli	2015
19	Free functioning gracilis muscle transfer with and without simultaneous intercostal nerve transfer to musculocutaneous nerve for restoration of elbow flexion after traumatic adult brachial pan-plexus injury	Maldonado	2017(a)

Supplementary file 5. Included Studies

20	Isolated latissimus dorsi transfer to restore shoulder external rotation in adults with brachial plexus injury	Ghosh	2013
21	Functional outcome and quality of life after traumatic total brachial plexus injury treated by nerve transfer or single/double free muscle transfers	Satbhai	2016
22	Successful graded mirror therapy in a patient with chronic deafferentation pain in whom traditional mirror therapy was ineffective: A case report	Mibu	2016
23	Bipolar Transfer of Latissimus Dorsi Myocutaneous Flap for Restoration of Elbow Flexion in Late Traumatic Brachial Plexus Injury: Evaluation of 13 Cases	Azab	2017
24	Comparison of objective muscle strength in C5-C6 and C5-C7 brachial plexus injury patients after double nerve transfer	Tsai	2014
25	Phantom remodeling effect of dorsal root entry zone lesioning in phantom limb pain caused by brachial plexus avulsion	Son	2015
26	Comparison of surgical strategies between proximal nerve graft and/or nerve transfer and distal nerve transfer based on functional restoration of elbow flexion: A retrospective review of 147 patients	Hu	2018
27	Reconstruction of shoulder abduction by multiple nerve fascicle transfer through posterior approach	Ren	2013
28	Intercostal nerve transfer to neurotize the musculocutaneous nerve after traumatic brachial plexus avulsion: A comparison of two, three, and four nerve transfers	Xiao	2014
29	Use of the DEKA Arm for amputees with brachial plexus injury: A case series	Resnik	2017
30	Polyester tape scapulopexy for chronic upper extremity brachial plexus injury	Leechavengvong	2015
31	Contralateral C7 nerve transfer with direct coaptation to restore lower trunk function after traumatic brachial plexus avulsion	Wang	2013
32	Outcome of surgical reconstruction after traumatic total brachial plexus palsy	Dodakundi	2013
33	Bionic reconstruction to restore hand function after brachial plexus injury: a case series of three patients	Aszmann	2015
34	Surgical treatment of the plexus brachialis injury using long-lasting electrostimulation	Tsymbalyuk	2013
35	Phrenic nerve transfer for reconstruction of elbow extension in severe brachial plexus injuries	Flores	2016
36	Direct coaptation of the phrenic nerve with the posterior division of the lower trunk to restore finger and elbow extension function in patients with total brachial plexus injuries	Wang	2016
37	A prospective study comparing single and double fascicular transfer to restore elbow flexion after brachial plexus injury	Martins	2013
38	Chronic post-traumatic neuropathic pain of brachial plexus and upper limb: a new technique of peripheral nerve stimulation	Stevanato	2014

Supplementary file 5. Included Studies

39	Effectiveness of contralateral C7 nerve root and multiple nerve transfer for treatment of brachial plexus root avulsion	Wei	2014
40	Combined proximal nerve graft and distal nerve transfer for a posterior cord brachial plexus injury	Plate	2013
41	The role of elective amputation in patients with traumatic brachial plexus injury	Maldonado	2016
42	Early microsurgical management of clavicular fracture combined with brachial plexus injury	Liu	2014(a)
43	Contralateral trapezius transfer to restore shoulder external rotation following adult brachial plexus injury	Elhassan	2016
44	Comparative study of phrenic nerve transfers with and without nerve graft for elbow flexion after global brachial plexus injury	Liu	2014
45	Shoulder and elbow recovery at 2 and 11 years following brachial plexus reconstruction	Wang	2016
46	Functional outcomes after treatment of traumatic brachial plexus injuries: clinical study	Aras	2013
47	Free gracilis transfer reinnervated by the nerve to the supinator for the reconstruction of finger and thumb extension in longstanding C7-T1 brachial plexus root avulsion	Soldado	2013
48	Restoration of hand function in C7–T1 brachial plexus palsies using a staged approach with nerve and tendon transfer	Zhang	2014
49	Neurotization to innervate the deltoid and biceps: 3 cases	Dy	2013
50	Arthroscopic arthrodesis of the shoulder in brachial plexus palsy	Lenoir	2017
51	Outcome of contralateral C7 nerve transferring to median nerve	Gao	2013
52	Intercostal nerve transfer to the biceps motor branch in complete traumatic brachial plexus injuries	Cho	2015
53	Tactile feedback for relief of deafferentation pain using virtual reality system: a pilot study	Sano	2016
54	Functioning free gracilis transfer to reconstruct elbow flexion and quality of life in global brachial plexus injured patients	Yang	2016
55	Evaluation of infraspinatus reinnervation and function following spinal accessory nerve to suprascapular nerve transfer in adult traumatic brachial plexus injuries	Baltzer	2017
56	Anatomic study of the intercostal nerve transfer to the suprascapular nerve and a case report	Hu	2014
57	Shoulder abduction and external rotation restoration with nerve transfer	Kostas-Agnantis	2013
58	Contralateral C-7 transfer: is direct repair really superior to grafting?	Bhatia	2017
59	Impact of phrenic nerve paralysis on the surgical outcome of intercostal nerve transfer	Kita	2015
60	Flow-through anastomosis using a T-shaped vascular pedicle for gracilis functioning free muscle transplantation in brachial plexus injury	Hou	2015
61	Free functional muscle transfer tendon insertion secondary advancement procedure to improve elbow flexion	Sechachalam	2017

Supplementary file 5. Included Studies

62	Dual nerve transfers for restoration of shoulder function after brachial plexus avulsion injury	Chu	2016
63	Cortical plasticity after brachial plexus injury and repair: a resting-state functional MRI study	Bhat	2017
64	Results of spinal accessory to suprascapular nerve transfer in 110 patients with complete palsy of the brachial plexus	Bertelli	2016
65	Magnetic resonance neurographic and clinical long-term results after oberlins transfer for adult brachial plexus injuries	Frueh	2017
66	Free functioning gracilis muscle transfer versus intercostal nerve transfer to musculocutaneous nerve for restoration of elbow flexion after traumatic adult brachial pan-plexus injury	Maldonado	2016
67	Results of wrist extension reconstruction in C5–8 brachial plexus palsy by transferring the pronator quadratus motor branch to the extensor carpi radialis brevis muscle	Bertelli	2016
68	Donor nerve sources in free functional gracilis muscle transfer for elbow flexion in adult brachial plexus injury	Nicoson	2017
69	Use of contralateral spinal accessory nerve for ipsilateral suprascapular neurotization in global brachial plexus injury: a new technique	Bhandari	2016
70	Objective evaluation of elbow flexion strength and fatigability after nerve transfer in adult traumatic brachial plexus injuries	Marcicq	2014
71	Outcomes of muscle brachialis transfer to restore finger flexion in brachial plexus palsy	DeGeorge	2017
72	Functional outcome of nerve transfers for traumatic global brachial plexus avulsion	Liu	2013
73	Transfer of a flexor digitorum superficialis motor branch for wrist extension reconstruction in C5–C8 root injuries of the brachial plexus: a case series	Bertelli	2013
74	Outcome after transfer of intercostal nerves to the nerve of triceps long head in 25 adult patients with total plexus root avulsion injury	Gao	2013
75	Good sensory recovery of the hand in brachial plexus surgery using the intercostobrachial nerve as the donor	Foroni	2017
76	The phrenic nerve as a donor for brachial plexus injuries: is it safe and effective? Case series and literature analysis	Socolovsky	2015
77	Complete avulsion of brachial plexus with associated vascular trauma: Feasibility of reconstruction using the double free muscle technique	Hattori	2013
78	Long-term outcome of brachial plexus re-implantation after complete brachial plexus avulsion injury	Kachramanoglu	2017
79	Force recovery assessment of functioning free muscle transfers using ultrasonography	Kodama	2014
80	Rhomboid nerve transfer to the suprascapular nerve for shoulder reanimation in brachial plexus palsy: A clinical report	Goubier	2016
81	Outcome of contralateral C7 transfer to two recipient nerves in 22 patients with the total brachial plexus avulsion injury	Gao	2013
82	Comparative study of phrenic and intercostal nerve transfers for elbow flexion after global brachial plexus injury	Liu	2015

Supplementary file 5. Included Studies

83	Donor-side morbidity after contralateral C-7 nerve transfer: results at a minimum of 6 months after surgery	Li	2016
84	Outcome after brachial plexus injury surgery and impact on quality of life	Rasulić	2017
85	Pronator teres branch transfer to the anterior interosseous nerve for treating C8T1 brachial plexus avulsion: An anatomic study and case report	Yang	2014
86	Operative treatment with nerve repair can restore function in patients with traction injuries in the brachial plexus	Stiasny	2015
87	Thoracodorsal nerve transfer for triceps reinnervation in partial brachial plexus injuries	Soldado	2016
88	Co-infusion of autologous adipose tissue derived neuronal differentiated mesenchymal stem cells and bone marrow derived hematopoietic stem cells, a viable therapy for post-traumatic brachial plexus injury: a case report	Thakkar	2014
89	Long-term clinical outcomes of spinal accessory nerve transfer to the suprascapular nerve in patients with brachial plexus palsy	Emamhadi	2016
90	Surgical treatment for total root avulsion type brachial plexus injuries by neurotisation: a prospective comparison study between total and hemicontralateral C7 nerve root transfer	Tu	2014
91	Deactivation of distant pain-related regions induced by 20-day rTMS: a case study of one-week pain relief for long-term intractable deafferentation pain	Qiu	2014
92	End-to-side neurorrhaphy in brachial plexus reconstruction	Haninec	2013
93	Reanimation of elbow extension with medial pectoral nerve transfer in partial injuries to the brachial plexus	Flores	2013
94	Early post-operative results after repair of traumatic brachial plexus palsy	Mohammad-Reda	2013
95	Satisfied patients after shoulder arthrodesis for brachial plexus lesions even after 20 years of follow-up	van der Lingen	2018
96	Posterior branch of the axillary nerve transfer to the lateral triceps branch for restoration of elbow extension: case report	Kilka	2013
97	Clinical analysis of repairing the whole brachial plexus nerve root avulsion by transferring C7 nerve root from the uninjured side	Liu	2014
98	Bipolar transfer of the pectoralis major muscle for restoration of elbow flexion in 29 cases	Cambon-Binder	2018
99	Thoracodorsal nerve transfer for elbow flexion reconstruction in infraclavicular brachial plexus injuries	Soldado	2014
100	Median nerve fascicle transfer versus ulnar nerve fascicle transfer to the biceps motor branch in C5-C6 and C5-C7 brachial plexus injuries: nonrandomised prospective study of 23 consecutive patients	Cho	2014
101	Free functional muscle transplantation of an anomalous femoral adductor with a very large muscle belly: a case report	Kaizawa	2013
102	Selective neurotisation of the radial nerve in the axilla using the intercostal nerve to treat complete brachial plexus palsy	Tuohuti	2016

Supplementary file 5. Included Studies

103	Objective predictors of functional recovery associated with intercostal nerves transfer for triceps reinnervation in global brachial plexus palsy	Flores	2016
104	Nerve transfer to relieve pain in upper brachial plexus injuries: does it work?	Emamhadi	2017
105	Phrenic nerve transfer versus intercostal nerve transfer for the repair of brachial plexus root avulsion injuries	Abdixbir	2016
106	End-to-side neurorrhaphy to restore elbow flexion in brachial plexus injury	Limthongthang	2016
107	Chordata method combined with electrotherapy in functional recovery after brachial plexus injury:report of three clinical cases	De Oliveira	2016
108	Clinical outcome following transfer of the supinator motor branch to the posterior interosseous nerve in patients with C7-T1 brachial plexus palsy	Xu	2015
109	Transposition of branches of radial nerve innervating supinator to posterior interosseous nerve for functional reconstruction of finger and thumb extension in 4 patients with middle and lower trunk root avulsion injuries of brachial plexus	Wu	2017
110	Electromyographic findings in gracilis muscle grafts used to augment elbow flexion in traumatic brachial plexopathy	Kazamel	2016
111	Double distal intraneural fascicular nerve transfers for lower brachial plexus injuries	Li	2016
112	Restoration of elbow and hand function in total brachial plexus palsy with intercostal nerves and C5 root neurotisation. Results in 21 patients	Amal	2016
113	The phrenic nerve transfer in the treatment of a septuagenarian with brachial plexus avulsion injury: a case study	Jiang	2018
114	Outcomes of transferring a healthy motor fascicle from the radial nerve to a branch for the triceps to recover elbow extension in partial brachial plexus palsy	Flores	2017
115	Successful nerve transfers for traumatic brachial plexus palsy in a septuagenarian	Johnsen	2016
116	Free functioning gracilis muscle transfer for elbow flexion reconstruction after traumatic brachial pan-plexus injury: Where is the optimal distal tendon attachment for elbow flexion?	Maldonado	2017(b)
117	Results of distal nerve transfers in restoration of shoulder function in C5 and C6 root avulsion injury to the brachial plexus	Bhandari	2017
118	Bipolar dual-lead spinal cord stimulation between two electrodes on the ventral and dorsal sides of the spinal cord: consideration of putative mechanisms	Watanabe	2018
119	Triceps nerve to deltoid nerve transfer after an unsatisfactory intra-plexus neurotisation of the posterior division of the upper trunk	Al-Qattan	2017
120	Trapezius muscle transfer for restoration of elbow extension in a traumatic brachial plexus injury	Alrabai	2018
121	Transfer of the radial nerve branch to the extensor carpi radialis brevis to the anterior interosseous nerve to reconstruct thumb and finger flexion	Bertelli	2015

Supplementary file 5. Included Studies

122	Ultrasound-guided pulse-dose radiofrequency: treatment of neuropathic pain after brachial plexus lesion and arm vascularisation	Magistrone	2014
123	Phrenic nerve transfer to the musculocutaneous nerve for the repair of brachial plexus injury: electrophysiological characteristics	Liu	2015
124	Postoperative motor deficits following elbow flexion reanimation by nerve transfer	Hanneur	2018
125	Comparative study of phrenic and partial ulnar nerve transfers for elbow flexion after upper brachial plexus avulsion-a retrospective clinical analysis	Liu	2018
126	Contralateral medial pectoral nerve transfer with free gracilis muscle transfer in old brachial plexus injury	Yavari	2018
127	MEG-BMI to control phantom limb pain	Yanagisawa	2018
128	Complete brachial plexus injury- an amputation dilemma, A case report	Choong	2015
129	Reversal of phantom pain and hand-to-face remapping after brachial plexus avulsion	Tsao	2016
130	A newly developed upper limb single-joint HAL in a patient with elbow flexion reconstruction after traumatic brachial plexus injury: A case report	Kubota	2017
131	Free reverse gracilis muscle combined with steindler flexorplasty for elbow flexion reconstruction after failed primary repair of extended upper-type paralysis of the brachial plexus	Bertelli	2018
132	Multiple nerve and tendon transfers – a new strategy for restoring hand function in a patient with C7-T1 brachial plexus avulsions	Xu	2017
Studies included following updated review May 2021			
133	Outcomes after occupational therapy intervention for traumatic brachial plexus injury: A prospective longitudinal cohort study	Cole	2020
134	Lower trapezius transfer for patients with brachial plexus injury	Crepaldi	2019
135	Bionic upper limb reconstruction: A valuable alternative in global brachial plexus avulsion injuries—a case series	Hruby	2019
136	Transcranial Direct Current Stimulation and mirror therapy for neuropathic pain after brachial plexus avulsion: A randomised double-blind, controlled pilot study	Ferreira	2020
137	A comparative study of two modalities in pain management of patients presenting with chronic brachial neuralgia	Razak	2019
138	Do technical components of microanastomoses influence the functional outcome of free gracilis muscle transfer for elbow flexion in traumatic brachial plexus injury	Martins-Filho	2021

Supplementary file 5. Included Studies

References

- [1] Limthongthang R, Muennoi P, Phoojaroenchanachai R et al. Effectiveness and safety of home-based muscle electrical stimulator in brachial plexus injury patients. *J Med Assoc Thai* 2014;97:S56–61.
- [2] Homsreprasert T, Limthongthang R, Vathana T et al. Elbow joint proprioceptive sense in total arm-type brachial plexus injured patients after neurotization: a preliminary study. *J Med Assoc Thai* 2014;97:S103–7.
- [3] Souza F, Bernardino S, Filho H et al. Comparison between the anterior and posterior approach for transfer of the spinal accessory nerve to the suprascapular nerve in late traumatic brachial plexus injuries. *Acta Neurochir (Wien)* 2014;156: 2345–9.
- [4] Kim JH, Shin SH, Lee YR et al. Ultrasound-guided peripheral nerve stimulation for neuropathic pain after brachial plexus injury: two case reports. *J Anesth* 2017; 31:453–7.
- [5] Satbhai NG, Doi K, Hattori Y, Sakamoto S et al. Contralateral lower trapezius transfer for restoration of shoulder external rotation in traumatic brachial plexus palsy: a preliminary report and literature review. *J Hand Surg Eur* 2014;39:861–7.
- [6] Huan KWSJ, Tan JSW, Tan SH et al. Restoration of shoulder abduction in brachial plexus avulsion injuries with double neurotization from the spinal accessory nerve: a report of 13 cases. *J Hand Surg Eur* 2017;42:700–5.
- [7] Bertelli JA, Soldado F, Ghizoni MF et al. Transfer of the musculocutaneous nerve branch to the brachialis muscle to the triceps for elbow extension: anatomical study and report of five cases. *J Hand Surg Eur* 2017;42:710–4.
- [8] Rui J, Zhao X, Zhu Y et al. Posterior approach for accessory-suprascapular nerve transfer: an electrophysiological outcomes study. *J Hand Surg Eur* 2013;38:242–7.
- [9] Potter SM, Ferris SI. Reliability of functioning free muscle transfer and vascularized ulnar nerve grafting for elbow flexion in complete brachial plexus palsy. *J Hand Surg Eur* 2017; 42: 693–9.
- [10] Lam WL, Fufa D, Chang N-J et al. Management of infraclavicular (Chuang Level IV) brachial plexus injuries: A single surgeon experience with 75 cases. *J Hand Surg Eur* 2015; 40:573–82.
- [11] Estrella EP, Montales TD. Functioning free muscle transfer for the restoration of elbow flexion in brachial plexus injury patients. *Injury* 2016;47:2525–33.
- [12] Desai MJ, Daly CA, Seiler JG et al. Radial to Axillary Nerve Transfers: A Combined Case Series. *J Hand Surg Am* 2016; 41:1128–34.
- [13] Pereira EAC, Boccard SG, Linhares P et al. Thalamic deep brain stimulation for neuropathic pain after amputation or brachial plexus avulsion. *Neurosurg Focus* 2013;35:E7.
- [14] Estrella EP, Favila AS . Nerve transfers for shoulder function for traumatic brachial plexus injuries. *J Reconstr Microsurg* 2014;30:59–64.
- [15] Gutkowska O, Martynkiewicz J, Mizia S et al. Results of Operative Treatment of Brachial Plexus Injury Resulting from Shoulder Dislocation: A Study with A Long-Term Follow-Up. *World Neurosurg* 2017;105:623–31.
- [16] Oberlin C, Chino J, Belkheyar Z. Surgical treatment of brachial plexus posterior cord lesion: A combination of nerve and tendon transfers, about nine patients. *Chir Main* 2013;32:141–6.

Supplementary file 5. Included Studies

- [17] Ferraresi S, Garozzo D, Basso E et al. The medial cord to musculocutaneous (MCMc) nerve transfer: A new method to reanimate elbow flexion after C5-C6-C7-(C8) avulsive injuries of the brachial plexus - Technique and results. *Neurosurg Rev* 2014;37:321–9.
- [18] Bertelli J, Soldado F, Ghizoni MF et al. Transfer of a terminal motor branch nerve to the flexor carpi ulnaris for triceps reinnervation: Anatomical study and clinical cases. *J Hand Surg Am* 2015;40:2229–2235.
- [19] Maldonado AA, Kircher MF, Spinner RJ et al. Free Functioning Gracilis Muscle Transfer With and Without Simultaneous Intercostal Nerve Transfer to Musculocutaneous Nerve for Restoration of Elbow Flexion After Traumatic Adult Brachial Pan-Plexus Injury. *J Hand Surg Am* 2017;42:293.
- [20] Ghosh S, Singh VK, Jeyaseelan L, et al. Isolated latissimus dorsi transfer to restore shoulder external rotation in adults with brachial plexus injury. *Bone Jt J* 2013;95:660–3.
- [21] Satbhai NG, Doi K, Hattori Y et al. Functional outcome and quality of life after traumatic total brachial plexus injury treated by nerve transfer or single/double free muscle transfers: A comparative study. *Bone Jt J* 2016;98:209–17.
- [22] Mibu A, Nishigami T, Tanaka K et al. Successful Graded Mirror Therapy in a Patient with Chronic Deafferentation Pain in Whom Traditional Mirror Therapy was Ineffective: A Case Report. *Pain Pract* 2016;16:E62–9.
- [23] Azab AA-H, Alsabbahi MS. Bipolar Transfer of Latissimus Dorsi Myocutaneous Flap for Restoration of Elbow Flexion in Late Traumatic Brachial Plexus Injury: Evaluation of 13 Cases. *Ann Plast Surg* 2017;78:98–201.
- [24] Tsai YJ, Su FC, Hsiao CK et al. Comparison of objective muscle strength in C5-C6 and C5-C7 brachial plexus injury patients after double nerve transfer. *Microsurgery* 2015;35:107–14.
- [25] Son BC, Ha SW. Phantom Remodeling Effect of Dorsal Root Entry Zone Lesioning in Phantom Limb Pain Caused by Brachial Plexus Avulsion. *Stereotact Funct Neurosurg* 2015;93:240–4.
- [26] Hu CH, Chang TN, Lu JC et al. Comparison of Surgical Strategies between Proximal Nerve Graft and/or Nerve Transfer and Distal Nerve Transfer Based on Functional Restoration of Elbow Flexion: A Retrospective Review of 147 Patients. *Plast Reconstr Surg* 2018;141:68e–79e.
- [27] Ren G, Li R, Xiang D, Yu B. Reconstruction of shoulder abduction by multiple nerve fascicle transfer through posterior approach. *Injury* 2013;44:492–7.
- [28] Xiao C, Lao J, Wang T et al. Intercostal nerve transfer to neurotize the musculocutaneous nerve after traumatic brachial plexus avulsion: a comparison of two, three, and four nerve transfers. *J Reconstr Microsurg* 2014;30:297–304.
- [29] Resnik L, Fantini C, Latlief G et al. Use of the DEKA Arm for amputees with brachial plexus injury: A case series. *PLoS One* 2017; 12: e0178642.
- [30] Leechavengvongs S, Jiamton C, Uerpairojkit C et al. Polyester tape scapulopexy for chronic upper extremity brachial plexus injury. *J Hand Surg Am* 2015;40:1184
- [31] Wang S, Li P, Xue Y et al. Contralateral C7 nerve transfer with direct coaptation to restore lower trunk function after traumatic brachial plexus avulsion. *J Bone Joint Surg Am* 2013;95: 821–2.
- [32] Dodakundi C, Doi K, Hattori Y et al. Outcome of surgical reconstruction after traumatic total brachial plexus palsy. *J Bone Joint Surg Am* 2013;95:1505–12.

Supplementary file 5. Included Studies

- [33] Aszmann OC, Roche AD, Salminger S et al. Bionic reconstruction to restore hand function after brachial plexus injury: a case series of three patients. *Lancet* 2015; 385:2183–9.
- [34] Tsymbaliuk VI, Tretiak IB. [Surgical treatment of the plexus brachialis injury using long-lasting electrostimulation]. *Klin Khirurgiia* 2013;59–61.
- [35] Flores LP, Socolovsky M. Phrenic Nerve Transfer for Reconstruction of Elbow Extension in Severe Brachial Plexus Injuries. *J Reconstr Microsurg* 2016;32:546–50.
- [36] Wang S, Li P, Xue Y et al. Direct Coaptation of the Phrenic Nerve With the Posterior Division of the Lower Trunk to Restore Finger and Elbow Extension Function in Patients With Total Brachial Plexus Injuries. *Neurosurgery* 2016;78:208–14.
- [37] Martins RS, Siqueira MG, Heise CO et al. A prospective study comparing single and double fascicular transfer to restore elbow flexion after brachial plexus injury. *Neurosurgery* 2013; 72:709–15.
- [38] Stevanato G, Devigili G, Eleopra R et al. Chronic post-traumatic neuropathic pain of brachial plexus and upper limb: a new technique of peripheral nerve stimulation. *Neurosurg Rev* 2014;37:473–9.
- [39] Wei W, Meihua S, Yafei L et al. [EFFECTIVENESS OF CONTRALATERAL C7 NERVE ROOT AND MULTIPLE NERVES TRANSFER FOR TREATMENT OF BRACHIAL PLEXUS ROOT AVULSION]. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2014;28:737–40.
- [40] Plate JF, Ely LK, Pulley BR et al. Combined proximal nerve graft and distal nerve transfer for a posterior cord brachial plexus injury. *J Neurosurg* 2013;118: 155–9.
- [41] Maldonado AA, Kircher MF, Spinner RJ et al. The role of elective amputation in patients with traumatic brachial plexus injury. *J Plast Reconstr Aesthetic Surg* 2016;69:311–7.
- [42] Liu Y, Wang W, Regmi AM et al. Early microsurgical management of clavicular fracture combined with brachial plexus injury. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2014;28:1329–32.
- [43] Elhassan BT, Wagner ER, Spinner RJ et al. Contralateral trapezius transfer to restore shoulder external rotation following adult brachial plexus injury. *J Hand Surg Am* 2016;41:e45–51.
- [44] Liu Y, Lao J, Gao K et al. Comparative study of phrenic nerve transfers with and without nerve graft for elbow flexion after global brachial plexus injury. *Injury* 2014;45:227–31.
- [45] Wang JP, Rancy SK, Lee SK et al. Shoulder and Elbow Recovery at 2 and 11 Years Following Brachial Plexus Reconstruction. *J Hand Surg Am* 2016;41:173–9.
- [46] Aras Y, Aydoseli A, Sabanci PA et al. Functional outcomes after treatment of traumatic brachial plexus injuries: clinical study. *Ulus Travma Acil Cerrahi Derg* 2013;19:521–8.
- [47] Soldado F, Bertelli J. Free gracilis transfer reinnervated by the nerve to the supinator for the reconstruction of finger and thumb extension in longstanding C7-T1 brachial plexus root avulsion. *J Hand Surg Am* 2013;38: 941–6.
- [48] Zhang CG, Dong Z, Gu YD. Restoration of hand function in C7-T1 brachial plexus palsies using a staged approach with nerve and tendon transfer. *J Neurosurg* 2014;121:1264–70.
- [49] Dy CJ, Kitay A, Garg R et al. Neurotization to innervate the deltoid and biceps: 3 Cases. *J Hand Surg Am* 2013;38:237–40.
- [50] Lenoir H, Williams T, Griffart A et al. Arthroscopic arthrodesis of the shoulder in brachial

Supplementary file 5. Included Studies

- plexus palsy. *J Shoulder Elb Surg* 2017; 26: e115–21.
- [51] Gao K, Lao J, Zhao X et al. Outcome of contralateral C7 nerve transferring to median nerve. *Chin Med J (Engl)* 2013;126:3865–8.
 - [52] Cho AB, Iamaguchi RB, Silva GB et al. Intercostal nerve transfer to the biceps motor branch in complete traumatic brachial plexus injuries. *Microsurgery* 2015;35:428–31.
 - [53] Sano Y, Wake N, Ichinose A et al. Tactile feedback for relief of deafferentation pain using virtual reality system: a pilot study. *J Neuroeng Rehabil* 2016;13:61.
 - [54] Yang Y, Yang JT, Fu G et al. Functioning free gracilis transfer to reconstruct elbow flexion and quality of life in global brachial plexus injured patients. *Sci Rep* 2016;6:22479.
 - [55] Baltzer HL, Wagner ER, Kircher MF, et al. Evaluation of infrapinatus reinnervation and function following spinal accessory nerve to suprascapular nerve transfer in adult traumatic brachial plexus injuries. *Microsurgery* 2017;37:365–70.
 - [56] Hu S, Chu B, Song J, et al. Anatomic study of the intercostal nerve transfer to the suprascapular nerve and a case report. *J Hand Surg Eur* 2014;39:194–8.
 - [57] Kostas-Agnantis I, Korompilias A, Vekris M et al. Shoulder abduction and external rotation restoration with nerve transfer. *Injury* 2013;44:299–304.
 - [58] Bhatia A, Doshi P, Koul A, et al. Contralateral C-7 transfer: is direct repair really superior to grafting? *Neurosurg Focus* 2017;43:E3.
 - [59] Kita Y, Tajiri Y, Hoshikawa S et al. Impact of phrenic nerve paralysis on the surgical outcome of intercostal nerve transfer. *Hand Surg* 2015; 20:47–52.
 - [60] Hou Y, Yang J, Yang Y, et al. Flow-through anastomosis using a T-shaped vascular pedicle for gracilis functioning free muscle transplantation in brachial plexus injury. *Clinics (Sao Paulo)* 2015;70:544–9.
 - [61] Sechachalam S, O’Byrne A, MacQuillan A. Free Functional Muscle Transfer Tendon Insertion Secondary Advancement Procedure to Improve Elbow Flexion. *Tech Hand Up Extrem Surg* 2017;21: 8–12.
 - [62] Chu B, Wang H, Chen L, et al. Dual Nerve Transfers for Restoration of Shoulder Function After Brachial Plexus Avulsion Injury. *Ann Plast Surg* 2016;76: 668–73.
 - [63] Bhat DI, Indira Devi B, Bharti K, et al. Cortical plasticity after brachial plexus injury and repair: a resting-state functional MRI study. *Neurosurg Focus* 2017;42: E14.
 - [64] Bertelli JA, Ghizoni MF. Results of spinal accessory to suprascapular nerve transfer in 110 patients with complete palsy of the brachial plexus. *J Neurosurg Spine* 2016;24:990–5.
 - [65] Frueh FS, Ho M, Schiller A, et al. Magnetic Resonance Neurographic and Clinical Long-Term Results After Oberlin’s Transfer for Adult Brachial Plexus Injuries. *Ann Plast Surg* 2017;78:67–72.
 - [66] Maldonado AA, Kircher MF, Spinner RJ, et al. Free Functioning Gracilis Muscle Transfer versus Intercostal Nerve Transfer to Musculocutaneous Nerve for Restoration of Elbow Flexion after Traumatic Adult Brachial Pan-Plexus Injury. *Plast Reconstr Surg* 2016;138:483e-488e.
 - [67] Bertelli JA, Ghizoni MF, Tacca CP. Results of wrist extension reconstruction in C5-8 brachial plexus palsy by transferring the pronator quadratus motor branch to the extensor carpi radialis brevis muscle. *J Neurosurg* 2016;124:1442–9.

Supplementary file 5. Included Studies

- [68] Nicoson MC, Franco MJ, Tung TH. Donor nerve sources in free functional gracilis muscle transfer for elbow flexion in adult brachial plexus injury. *Microsurgery* 2017;37:377–82.
- [69] Bhandari PS, Deb P. Use of contralateral spinal accessory nerve for ipsilateral suprascapular neurotization in global brachial plexus injury: A new technique. *J Neurosurg Spine* 2016;24:186–8.
- [70] Maricq C, Jeunehomme M, Mouraux D, et al. Objective evaluation of elbow flexion strength and fatigability after nerve transfer in adult traumatic upper brachial plexus injuries. *Hand Surg* 2014;19:335–41.
- [71] DeGeorge B, Becker H, Faryna J, et al. Outcomes of brachialis muscle transfer to restore finger flexion in traumatic lower trunk brachial plexus palsy. *J Hand Surg Am* 2017;42:S33–4.
- [72] Liu Y, Lao J, Gao K, et al. Functional outcome of nerve transfers for traumatic global brachial plexus avulsion. *Injury* 2013;44:655–60.
- [73] Bertelli JA, Ghizoni MF. Transfer of a flexor digitorum superficialis motor branch for wrist extension reconstruction in C5–C8 root injuries of the brachial plexus: a case series. *Microsurgery* 2013;33:39–42.
- [74] Gao K, Lao J, Zhao X, et al. Outcome after transfer of intercostal nerves to the nerve of triceps long head in 25 adult patients with total brachial plexus root avulsion injury. *J Neurosurg* 2013;118:606–10.
- [75] Foroni L, Siqueira MG, Martins RS, et al. Good sensory recovery of the hand in brachial plexus surgery using the intercostobrachial nerve as the donor. *Arq Neuropsiquiatr* 2017;75:796–800.
- [76] Socolovsky M, di Masi G, Bonilla G, et al. The phrenic nerve as a donor for brachial plexus injuries: is it safe and effective? Case series and literature analysis. *Acta Neurochir (Wien)* 2015;157:1077–86.
- [77] Hattori Y, Doi K, Sakamoto S, et al. Complete avulsion of brachial plexus with associated vascular trauma: feasibility of reconstruction using the double free muscle technique. *Plast Reconstr Surg* 2013;132:1504–12.
- [78] Kachramanoglou C, Carlstedt T, Koltzenburg M, et al. Long-Term Outcome of Brachial Plexus Reimplantation After Complete Brachial Plexus Avulsion Injury. *World Neurosurg* 2017;103:28–36.
- [79] Kodama N, Doi K, Hattori Y. Force recovery assessment of functioning free muscle transfers using ultrasonography. *J Hand Surg Am* 2014;39:2269–76.
- [80] Goubier J, Teboul F. Rhomboid nerve transfer to the suprascapular nerve for shoulder reanimation in brachial plexus palsy: A clinical report. *Hand Surg Rehabil* 2016;35:363–6.
- [81] Gao K, Lao J, Zhao X, et al. Outcome of contralateral C7 transfer to two recipient nerves in 22 patients with the total brachial plexus avulsion injury. *Microsurgery* 2013;33:605–11.
- [82] Liu Y, Lao J, Zhao X. Comparative study of phrenic and intercostal nerve transfers for elbow flexion after global brachial plexus injury. *Injury* 2015;46:671–5.
- [83] Li XM, Yang JT, Hou Y, et al. Donor-side morbidity after contralateral C-7 nerve transfer: results at a minimum of 6 months after surgery. *J Neurosurg* 2016;124:1434–41.
- [84] Rasulic L, Savic A, Zivkovic B, et al. Outcome after brachial plexus injury surgery and impact on

Supplementary file 5. Included Studies

- quality of life. *Acta Neurochir (Wien)* 2017;159:1257–64
- [85] Yang J, Jia X, Yu C, et al. Pronator teres branch transfer to the anterior interosseous nerve for treating C8T1 brachial plexus avulsion: An anatomic study and case report. *Neurosurgery* 2014;75:375–9.
 - [86] Stiasny J, Birkeland P, J. S. Operative treatment with nerve repair can restore function in patients with traction injuries in the brachial plexus. *Dan Med J* 2015;62.
 - [87] Soldado F, Ghizoni MF, Bertelli J, et al. Thoracodorsal nerve transfer for triceps reinnervation in partial brachial plexus injuries. *Microsurgery* 2016;36:191–7.
 - [88] Thakkar UG, Vanikar A V, Trivedi HL. Co-infusion of autologous adipose tissue derived neuronal differentiated mesenchymal stem cells and bone marrow derived hematopoietic stem cells, a viable therapy for post-traumatic brachial plexus injury: a case report. *Biomed J* 2014;37:237–40.
 - [89] Emamhadi M, Alijani B, Andalib S, et al. Long-term clinical outcomes of spinal accessory nerve transfer to the suprascapular nerve in patients with brachial plexus palsy. *Acta Neurochir (Wien)* 2016;158:1801–6.
 - [90] Tu YK, Tsai YJ, Chang CH et al. Surgical treatment for total root avulsion type brachial plexus injuries by neurotization: a prospective comparison study between total and hemicontralateral C7 nerve root transfer. *Microsurgery* 2014;34:91–101.
 - [91] Qiu YQ, Hua XY, Zuo CT et al. Deactivation of distant pain-related regions induced by 20-day rTMS: a case study of one-week pain relief for long-term intractable deafferentation pain. *Pain Physician* 2014;17:E99–105.
 - [92] Haninec P, Mencl L, Kaiser R. End-to-side neurorrhaphy in brachial plexus reconstruction. *J Neurosurg* 2013;119:689–94.
 - [93] Flores LP. Reanimation of elbow extension with medial pectoral nerve transfer in partial injuries to the brachial plexus. *J Neurosurg* 2013;118:588–93.
 - [94] Mohammad-Reda A. Early post-operative results after repair of traumatic brachial plexus palsy. *Turk Neurosurg* 2013;23:1–9.
 - [95] van der Lingen MAJ, de Joode SGJ, Schotanus MGM, et al. Satisfied patients after shoulder arthrodesis for brachial plexus lesions even after 20 years of follow-up. *Eur J Orthop Surg Traumatol* 2018;28:1089–94
 - [96] Klika BJ, Spinner RJ, Bishop AT et al. Posterior branch of the axillary nerve transfer to the lateral triceps branch for restoration of elbow extension: case report. *J Hand Surg Am* 2013;38:1145–9.
 - [97] Liu J, Wang X, Zhang S, et al. A clinical analysis of repairing the whole brachial plexus nerve root avulsion by transferring C7 nerve root from the uninjured side. *J Neurol Sci* 2014;31:521–31.
 - [98] Cambon-Binder A, Walch A, Marchei P et al. Bipolar transfer of the pectoralis major muscle for restoration of elbow flexion in 29 cases. *J Shoulder Elb Surg* 2018;27:e330–e336
 - [99] Soldado F, Ghizoni MF, Bertelli J. Thoracodorsal nerve transfer for elbow flexion reconstruction in infraclavicular brachial plexus injuries. *J Hand Surg Am* 2014;39:1766–70.
 - [100] Cho A, Paulos R, De Resende M, et al. Median nerve fascicle transfer versus ulnar nerve

Supplementary file 5. Included Studies

- fascicle transfer to the biceps motor branch in C5-C6 and C5-C7 brachial plexus injuries: nonrandomized prospective study of 23 consecutive patients. *Microsurgery* 2014;34:511–5.
- [101] Kaizawa Y, Kakinoki R, Ohta S, et al. Free functional muscle transplantation of an anomalous femoral adductor with a very large muscle belly: A case report. *J Brachial Plex Peripher Nerve Inj* 2013;8:11.
- [102] Tuohuti T, Yu Q, Yang J, et al. Selective neurotization of the radial nerve in the axilla using intercostal nerve to treat complete brachial plexus palsy. *Int J Clin Exp Med* 2016;9:22880–5.
- [103] Flores LP. Objective Predictors of Functional Recovery Associated with Intercostal Nerves Transfer for Triceps Reinnervation in Global Brachial Plexus Palsy. *Brazilian Neurosurg* 2016;35:271–8.
- [104] Emamhadi M. Nerve transfer to relieve pain in upper brachial plexus injuries: Does it work? *Clin Neurol Neurosurg* 2017;163:67–70.
- [105] Abdixbir A, Li P, Ilhamjan U, et al. Phrenic nerve transfer versus intercostal nerve transfer for the repair of brachial plexus root avulsion injuries. *Chinese J Tissue Eng Res* 2016;20:7660–5.
- [106] Limthongthang R, Vathana T, Wongtrakul S, et al. End-to-Side Neurorrhaphy to Restore Elbow Flexion in Brachial Plexus Injury. *J Med Assoc Thai* 2016;99:1203–8.
- [107] De Oliveira C, Da Silva Melo D, et al. Chordata method combined with electrotherapy in functional recovery after brachial plexus injury: Report of three clinical cases. *Sci Med (Porto Alegre)* 2016;26:22425.
- [108] Xu B, Dong Z, Zhang CG, et al. Clinical outcome following transfer of the supinator motor branch to the posterior interosseous nerve in patients with C7-T1 brachial plexus palsy. *J Reconstr Microsurg* 2015;31:102–6.
- [109] Wu X, Cong XB, Huang QS, et al. Transposition of branches of radial nerve innervating supinator to posterior interosseous nerve for functional reconstruction of finger and thumb extension in 4 patients with middle and lower trunk root avulsion injuries of brachial plexus. *J Huazhong Univ Sci Technolog Med Sci* 2017;37:933–7.
- [110] Kazamel M, Sorenson EJ. Electromyographic Findings in Gracilis Muscle Grafts Used to Augment Elbow Flexion in Traumatic Brachial Plexopathy. *J Clin Neurophysiol* 2016;33:549–53.
- [111] Li Z, Reynolds M, Satteson E, et al. Double Distal Intraneural Fascicular Nerve Transfers for Lower Brachial Plexus Injuries. *J Hand Surg Am* 2016;41:e15-9.
- [112] Arnal M, Cambon A, Marcheix P. Restoration of elbow and hand function in total brachial plexus palsy with intercostal nerves and C5 root neurotization. Results in 21 patients. *Hand Surg Rehabil* 2016;35:283–7.
- [113] Jiang Y, Lao J. The phrenic nerve transfer in the treatment of a septuagenarian with brachial plexus avulsion injury: a case report. *Int J Neurosci* 2018;128:467–71.
- [114] Flores LP. Outcomes of Transferring a Healthy Motor Fascicle From the Radial Nerve to a Branch for the Triceps to Recover Elbow Extension in Partial Brachial Plexus Palsy. *Neurosurgery* 2017;80:448–53.
- [115] Johnsen PH, Wolfe SW. Successful Nerve Transfers for Traumatic Brachial Plexus Palsy in a Septuagenarian: A Case Report. *Hand (N Y)* 2016;11:NP30–3.

Supplementary file 5. Included Studies

- [116] Maldonado AA, Romero-Brufau S, Kircher MF, et al. Free Functioning Gracilis Muscle Transfer for Elbow Flexion Reconstruction after Traumatic Adult Brachial Pan-Plexus Injury: Where Is the Optimal Distal Tendon Attachment for Elbow Flexion? *Plast Reconstr Surg* 2017;139: 128–36.
- [117] Bhandari PS. Results of Distal Nerve Transfers in Restoration of Shoulder Function in C5 and C6 Root Avulsion Injury to the Brachial Plexus. *Indian J Neurotrauma* 2017;14:21–5.
- [118] Watanabe M, Yamamoto T, Fukaya C, et al. Bipolar dual-lead spinal cord stimulation between two electrodes on the ventral and dorsal sides of the spinal cord: consideration of putative mechanisms. *Acta Neurochir (Wien)* 2018;160:639–43.
- [119] Al-Qattan M, Kattan A, Al-Qahtany B et al. Triceps nerve to deltoid nerve transfer after an unsatisfactory intra-plexus neurotization of the posterior division of the upper trunk. *Int J Surg Case Rep* 2017;37:124–6.
- [120] Alrabai H, Gesheff G, Hammouda A, et al. Trapezius Muscle Transfer for Restoration of Elbow Extension in a Traumatic Brachial Plexus Injury. *J Hand Surg Am* 2018;43:872.
- [121] Bertelli JA. Transfer of the radial nerve branch to the extensor carpi radialis brevis to the anterior interosseous nerve to reconstruct thumb and finger flexion. *J Hand Surg Am* 2015;40:323–328.
- [122] Magistroni E, Ciclamini D, Panero B. Ultrasound-guided pulse-dose radiofrequency: Treatment of neuropathic pain after brachial plexus lesion and arm revascularization. *Case Rep Med* 2014;201:429618.
- [123] Liu Y, Xu X, Zou Y, et al. Phrenic nerve transfer to the musculocutaneous nerve for the repair of brachial plexus injury: Electrophysiological characteristics. *Neural Regen Res* 2015;10:328–33.
- [124] Le Hanneur M, Walch A, Gerosa T et al. Postoperative motor deficits following elbow flexion reanimation by nerve transfer. *Hand Surg Rehabil* 2018;37:289–294
- [125] Liu Y, Zhuang Y, Yu H, et al. Comparative study of phrenic and partial ulnar nerve transfers for elbow flexion after upper brachial plexus avulsion: A retrospective clinical analysis. *J Plast Reconstr Aesthetic Surg* 2018;71:1245–51.
- [126] Yavari M, Mahmoudvand H, Nadri S. Contralateral medial pectoral nerve transfer with free gracilis muscle transfer in old brachial plexus palsy. *J Surg Res* 2018;231:94–8.
- [127] Yanagisawa T, Fukuma R, Seymour B, et al. MEG-BMI to control phantom limb pain. *Neurol Med Chir (Tokyo)* 2018;58:327–33.
- [128] Choong C, Shalimar A. Complete brachial plexus injury - An amputation dilemma. A case report. *Malaysian Orthop J* 2015;9:52–4.
- [129] Tsao J, Finn S. Reversal of phantom pain and hand-to-face remapping after brachial plexus avulsion. *Ann Clin Transl Neurol* 2016;3:463–4..
- [130] Kubota S, Hara Y, Shimizu Y, et al. A newly developed upper limb single-joint HAL in a patient with elbow flexion reconstruction after traumatic brachial plexus injury: A case report. *Interdiscip Neurosurg Adv Tech Case Manag* 2017;10:66–8.
- [131] Bertelli JA. Free Reverse Gracilis Muscle Combined With Steindler Flexorplasty for Elbow Flexion Reconstruction After Failed Primary Repair of Extended Upper-Type Paralysis of the Brachial Plexus. *J Hand Surg Am* 2019;44:112–120

Supplementary file 5. Included Studies

- [132] Xu B, Dong Z, Zhang C. Multiple nerve and tendon transfers: A new strategy for restoring hand function in a patient with C7-T1 brachial plexus avulsions. *J Neurosurg* 2017;127:837–42.
- [133] Cole T, Nicks R, Ferris S et al. Outcomes after occupational therapy intervention for traumatic brachial plexus injury: A prospective longitudinal cohort study. *Journal of Hand Therapy*. 2020;33:528-539
- [134] Crepaldi BE, Neto JQL, Rezende MR et al. *Hand*.2019;14(2):179-186
- [135] Hruby LA, Gstoettner C, Sturma A et al. *Journal of Clinical Medicine*. 2020;9(23):1-14
- [136] Ferreira CM, de Carvalho CD, Gomes R et al. Transcranial direct current stimulation and mirror therapy for neuropathic pain after brachial plexus avulsion: A randomised double-blind, controlled pilot study. *Frontiers in Neurology*. 2020;11:1-10
- [137] Razak I, Chung TY, Ahmad S et al. A comparative study of two modalities in pain management of patients presenting with chronic brachial neuralgia. *Journal of Alternative and Complementary Medicine*. 2019;1-7
- [138] Martins-Filho FVF, de Carmo Iwase F, Silva GB et al. Do technical components of microanastomosis influence the functional outcome of free gracilis muscle transfer for elbow flexion in traumatic brachial plexus injury? *Orthopaedics & Traumatology: Surgery & Research*.2021;107:1-5