Review Article

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Current Trends in the Management of the Brachial Plexus Injuries

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Abstract

Background Data: BPIcomprise about one third of all peripheral nerve injuries and seen in just more than 1% of patients presenting to a trauma facility. They may range from weakness or paralysis of the shoulder and/or elbow to complete paralysis and loss of feeling in the entire upper limb. Over the last two decades, refinements in microsurgical techniques, and significant advances in the concepts of peripheral nerve repair and reconstruction have greatly expanded treatment options for these otherwise devastating injuries. Traction of the shoulder or arm, often with lateral flexion of the neck in the opposite direction, Penetrating trauma to the neck or the shoulder, and Birth-related paralysis are the most common causes of the BPI. They divided into supraclavicular and infraclavicular lesions. MRI of the brachial plexus and cervical spine, and myelography with CT, are the key of the final differentiation of the exact pathology. The surgical intervention may be indicated if there is little evidence of progressive spontaneous recovery of motor and sensory function by three months following injury, but no longer than 6 months. However, early surgical exploration is frequently indicated in penetrating or open injuries.

Purpose: The aim of the work is to update our knowledge about the current measures and the new techniques of management of the brachial plexus injuries

Study Design: Review article

Material and Methods: This study was done via the electronic searching on the clinical trials, systemic midline reviews through the PubMed clinical queries, WHO, Cochrane Collaboration and Evidence Based Medicine since 2008 till 2013.

Results: Analysis of the reviewed studies showed that recovery is very promising to the BPI patients that were faced the loss of hope of recovery in the previous years.

Conclusion: By applying the triad of recent imaging measures, proper management guidelines and excellent rehabilitation programs, the patient will gain the maximum functional outcome. While complete recovery is often difficult to obtain, an acceptable level of restored function is possible, and patients need to be made fully aware of realistic therapeutic goals. (2013ESJ54)

Keywords: Brachial plexus injury, nerve injury, gunshot wound, nerve graft, and nerve transfer.

Introduction

Brachial plexus injuries (BPI) range from transient nerve dysfunction to a completely flail upper limb associated with life-threatening injuries. Traumatic lesions are most commonly the result of motorcycle accidents and typically affect young men. Lesions can also occur following penetrating or sports related injuries, falls, industrial accidents, radiation therapy and iatrogenic causes like first rib resection, shoulder surgery , interventional radiology. Significant injuries lead to physical disability in addition to psychological and financial problems. The management of such cases is complicated by concurrent injuries that may delay or cloud the neurological assessment. In addition to this anatomical variations within the brachial plexus make these injuries a considerable challenge to clinicians responsible for their care. In this study we try to analyze the various measures and modalities of management according to type and degree of each injury.[22,42,43]

Material and Methods

This study reviewed most of the available literature regarding BPI and the wide verities in their management and the recent advances in the preoperative and post-operative guidelines and concerning on the functional neurological outcome and prognosis. The MEDLINE and PubMed databases were used to conduct a literature search for articles in the English language that were published between 2008 and 2013 with the following key words and phrases: “brachial plexus injury, Erb’s palsy, nerve transfer, nerve graft and nerve transfer”. Related articles were also searched for relevant titles. The MEDLINE database produced 122 overlapping titles that were examined for relevance. The PubMed database produced 315 overlapping titles that were examined for relevance. The articles that appropriately fit the selection criteria were chosen. Only primary clinical articles discussing BPI were included. Duplicate titles were eliminated. 180 articles were selected for review with attention.

Discussion

Avulsion and Stretch Injuries:

Avulsion and stretch injuries compromise the main bulk of the pattern of closed brachial plexus injuries, though less common than closed injuries open injuries do occur.

Brophy et al,[8] study had found that 70-75% of the lesions were supraclavicular and 89% had at least one of the roots avulsed. Of the avulsed roots, 59% involved C7, C8 and T1. 96% of the patients who underwent brachial plexus exploration had supraclavicular lesion. The dominant arm was found to be the most commonly injured.[24]

Sulaiman et al,[38] study also mentioned that there were 509 stretch injuries of the brachial plexus of which 366 (72%) were supraclavicular and 143 (28%) were infraclavicular.

Selection for Surgery:

Patients were usually followed for 3 to 5 months before surgery. Typically this allowed for recovery from the frequently associated vascular and orthopedic injuries and time for adequate soft-tissue coverage if disrupted by the original trauma. In addition, in cases selected for surgery there was no early or significant clinical/electrophysiological reversal of loss. Surgery was more likely to be performed if loss persisted in the distribution of one or more plexal elements that could potentially be helped by operative intervention, especially if repair was necessary. It was found that stretch-related injury was less focal than other mechanisms for injury and less likely to be restricted to one level of the plexal elements alone, thus the cords alone seldom sustained the only damage that may extend from divisions to cords to more distal nerves.[5,6,7,19]

Malposition and brachial plexus injuries :

Brachial plexus injuries occurring postoperatively due to patient malpositioning have been described in the literature for nearly a century.[23,48] In 2000 Schwartz et al,[35] reported that 15 patients that had been did operation of spinal surgery for scoliosis in prone position had impending brachial plexopathies that identified by Somatosensory evoked potential (SSEP) recording, and recommend that positional brachial plexopathies can be avoided by intraoperative monitoring of SSEP in patients undergoing surgery in prone position**.** In 2002 Goettler et al**,**[15] reported that 2 patients that had been operated in prone position for necrotizing fasciitis of back experienced symptoms suggestive of brachial plexus injury and recovered within 2 weeks. In 2004 Ngamprasertwong et al,[30] reported one patient who had been operated for laparoscopic radical nephrectomy for 7 hours, in lateral decubitus position with left arm hyperabducted to 120 degree,

and experienced numbness and weakness in the left upper limb that recovered within 1 month and recommend that using chest roll and avoid suspension of the arm in the lateral decubitus position. In 2005 Brunette et al,[10] reported one patient who had been operated for gastric bypass for 5 hours, in supine position with arms abducted to 60 degree, and experienced numbness and weakness in bilateral arms and right Horner syndrome that recovered within 9 month. In 2007 Kent et al,[21] reported one patient who had been operated for laparoscopic sigmoid colectomy, in supine position with head down, arms abducted to 60 degree and shoulder braces placed to prevent sliding and experienced bilateral weakness and numbness and recovered within 3 years.

Nerve Transfer as a Line of Management:

Nerve transfer is considered the future in the management of the BPIs, and has many approaches, like: intercostal nerve, cervical plexus and medial pectoral nerve transfers.[41] Bertelli et al, [1,2]did a study by treating 335 adult patients with supraclavicular BPI over a 7-year period. Patients were categorized into 8 groups, according to functional deficits and roots injured: C5-C6, C5-C7, C5-C8 (T1 Hand), C5-T1 (T2 Hand), C8-T1, C7-T1, C6-T1, and total palsy. To restore function, nerve grafts, nerve transfers, and tendon and muscle transfers were employed. Patients with either upper- or lower-type partial injuries experienced considerable functional return. In total palsies, if a root was available for grafting, 90% of patients had elbow flexion restored, whereas this rate dropped to 50% if no roots were grafted and only nerve transfers performed. Root exploration and grafting helped to decrease or eliminate pain complaints within a short time of surgery especially when pain resolution become one of the upper priorities.[3]

Elbow Flexion Restoration:

In brachial plexus injuries, the most important function is elbow flexion, and thus renervation of the musculocutaneous nerve has the highest priority. The restoration of shoulder control comes next, and therefore the suprascapular and axillary nerves are next on the renervation list, to be followed by renervation of the median nerve to restore digital sensibility and forearm flexor function, and the radial nerve for elbow extensor, wrist extensor and finger extensors. Muscles innervated by the ulnar nerve are last on the priority list, not because they are unimportant, but because the chance of recovery of intrinsic muscle functions is minimal.[39]

Kakinoki et al,[20] study in 2010 measure significance of partial ulnar nerve transfer, Sixteen patients (13 men and three women) with BPIs for whom partial ulnar nerve transfer (PUNT) (eight patients) or intercostal nerve transfer (ICNT) (eight patients) had been performed to restore elbow flexion function. Obtaining motor power grade (M) M3 for elbow flexion and a full range of elbow joint movement against gravity with the wrist and fingers was reported with very good results. The study also reported that PUNT is technically easy, not associated with significant complications, and provides rapid recovery of the elbow flexion.[4,12]

Also, in 2003 Mackinon et al,[27] evaluated the outcome in patients with BPI who underwent nerve transfers to the biceps and the brachialis branches of the musculocutaneous nerve. The charts of eight patients who underwent an ulnar nerve fascicle transfer to the biceps branch of the musculocutaneous nerve and a separate transfer to the brachialis branch were retrospectively reviewed. [45] (Figure 1)

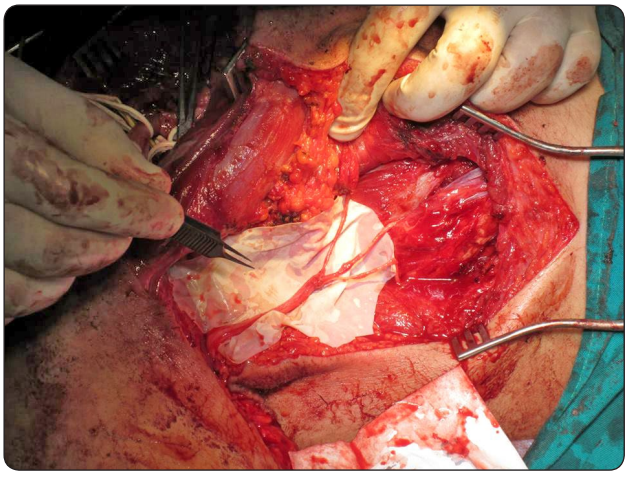

Figure 1: Intraoperative image showing musclucutanous nerve neurotization by three intercostal nerves.(Neurosurgery department, Suez Canal University, Ismalia, Egypt).

In 2009, Wellons et al,[48] in a retrospective study reviewed the office charts and hospital records of children undergoing brachial plexus exploration for persistent palsy following a traumatic event from January 1997 to April 30, 2008. There were

53 children who were deemed appropriate for intervention. In 20 of these cases, the children met the criteria of having received surgical treatment in the first year of life for birth-related brachial plexus palsy, having undergone medial pectoral nerve (MPN) to musculucutanous nerve (MCN) neurotization either alone or in combination with another reanimation procedure, and having been followed up for at least 9 months postoperatively. The results of preoperative and postoperative serial examinations were recorded through a multidisciplinary brachial plexus clinic. Success was deemed as the ability of the child to bring their hand to their mouth.[32]

In 2007 Rohde et al,[33] study reported elbow flexion restoration using intercostal transfer to the musculocutaneous nerve demonstrated success, 1,088 nerve transfers, which showed 72% of intercostal to musculocutaneous nerve transfers exhibiting M> 3 and 37% M> 4 bicep function.

Despite the encouraging results with intercostal nerve transfer, greater functional success has been achieved more recently by transferring intact branches of the ulnar or median nerves directly to the motor branches of the biceps and/or brachialis.[46] Results demonstrated 75 to 100% of patients achieved antigravity (M3) biceps strength or better and recent results show between 75 and 94% M4 strength. In 2005, Mackinnon [28]reported M4 or better strength of elbow flexion in six patients in her series with dual transfers for elbow flexion, with clinical reinnervation noted at a mean of 5.5 months.

C7 Nerve Transfer:

C7 forms middle trunk and no single muscle in the upper limb is innervated solely by C7. Therefore, dividing C7 will cause no permanent loss in sensory andmotor function. Usually, the patients will undergo numbness in the fingers in the first 3 months after operation. Xu et al,[49] study reported that the most affected fingers are index finger (74%), middle finger (58%) and thumb (38%). There will be temporary decrease in the grip strength but the pinch strength is not affected. It is worth pointing out that the C7 transection site should not be too distal (should never go infraclavicularly) and otherwise the fibers from upper and lower trunk may be injured and permanent motor and sensory deficits will be caused. Also they reported that cases of contralateral C7 transfer were followed up for over 2 years, the overall motor recovery rate (> = M3) was 50 – 80% depending on different recipient nerves. Terzis[40] recently reported the fair (M2+~M3), good (M3+~M4-) and excellent (M4+~M5-) rates of 56 cases, were 74% for biceps; 57% for triceps; 50% for deltoid, 62% for wrist and finger flexors and 50% for wrist and finger extensors, respectively. But in a report of 96 cases by Waikakul,[47] only 52% of patients had > = M3 recovery after contralateral C7 transfer to musculocutaneous nerve, and 20% recovery for the extensor of wrist/finger and 29% recovery for finger flexor. Sammer et al,[34] reported results from 2 groups of hemi-contralateral C7 transfer, that no patient developed useful function after median nerve repair and only 23% > = M3 recovery after SSN or axillary nerve repair. The most optimistic result was reported by Hierner[18] that 100% M3 biceps recovery was achieved in 6 patients while for median nerve the recovery rate was 25%.

Brachial plexus injury and Muscle Transfer:

Vekris et al,[44] in 2008 published their experience with elbow reanimation in late cases of BPI utilizing latissimus dorsi muscle transfer. From 1998 to 2006 they operated 103 patients with brachial plexus paralysis. Among these patients, 21 were late cases and underwent latissimus dorsi muscle transfer for elbow reanimation. Ten patients had free latissimus dorsi transfer for elbow flexion. Free latissimus dorsi muscle was neurotised either directly via three intercostals in three patients or with a nerve transfer procedure using the contralateral seventh cervical nerve root in seven patients. Care was taken to maintain the proper tension to the muscle, which must hold the elbow in static flexion of about 120 degree at the end of the procedure. Powerful elbow flexion (M4 to M4+) or extension (M4) was obtained after the first 3 months in all patients who had an ipsilateral pedicled latissimus dorsi transfer. In the group of free muscle transfers, elbow flexion was seen after 6 to 8 months. After the initiation of muscle contraction, eight of the patients regained elbow flexion of M3 to M4+. Latissimus dorsi muscle transfer is a reliable method for elbow reanimation.

Shoulder Abduction Restoration:

Shoulder abduction generally is accomplished by dual nerve transfers to restore strength of supraspinatus, infraspinatus, and deltoid muscles.[37] Study by Garg et al,[14] showed that dual transfers

to restore shoulder function (to suprascapular and axillary nerves) yielded significantly improved results when compared with single nerve transfer.

Chuang[11] recently reported 60 degree of abduction in patients with root avulsions and 90 degree or more in patients with upper root avulsions using a combination of nerve transfers for shoulder abduction. In a series of 577 spinal accessory nerve transfers, Songcharoen[36, 37] described 80% motor recovery (M> 3) with transfer to suprascapular nerve, obtaining 60 degree of shoulder abduction and 45 degree shoulder flexion. In the same series, spinal accessory transfer to axillary only achieved 60% success; the poorer results may be attributed to the longer reinnervationdistance and the requisite need for interpositional nerve grafts. The phrenic nerve has been transferred to the suprascapular nerve without grafting achieving grade 3 muscle recovery within 8 months however; phrenic nerve harvest has the potential to compromise diaphragmatic and pulmonary function, and is often contraindicated in patients who have had chest trauma. The most recent nerve transfer innovation for shoulder abduction involves the use of a single triceps branch of the radial nerve, transferred directly to the motor branch of the axillary.

Leechavengvongs[26]reported excellent results in five of seven cases using the long head branch of the radial nerve branch to axillary nerve. Most authorstoday would agree that a powerful combination of transfersfor shoulder abduction includes the spino-accessory to suprascapular nerve and a triceps branch to axillary nerve. (Figure 2)

Also, Malessy et al,[29] in 2004 published paper of retrospective study experiencing evaluation of the restoration of shoulder function by means of suprascapular nerve neurotization in adult patients with proximal C-5 and C-6 lesions due to a severe brachial plexus traction injury (BPTI). The primary goal of brachial plexus reconstructive surgery was to restore the biceps muscle function and, secondarily, to reanimate shoulder function. Suprascapular nerve neurotization was performed by grafting the C-5 nerve in 24 patients and by accessory or hypoglossal nerve transfer in 29 patients.

Hand and Fingers Function Restoration:

Waikakulet al,[47] published paper about neurotization of the median nerve to restore finger flexion and sensation of the hand. All or a portion of the contralateral C7 nerve root can be transferred to the median nerve; a series of 111 such transfers yielded 30% M3 and 20% M2 function. Despite the discouraging motor results, 83% obtained protective sensory recovery (50% S3 and 33% S2) after this procedure.[9]

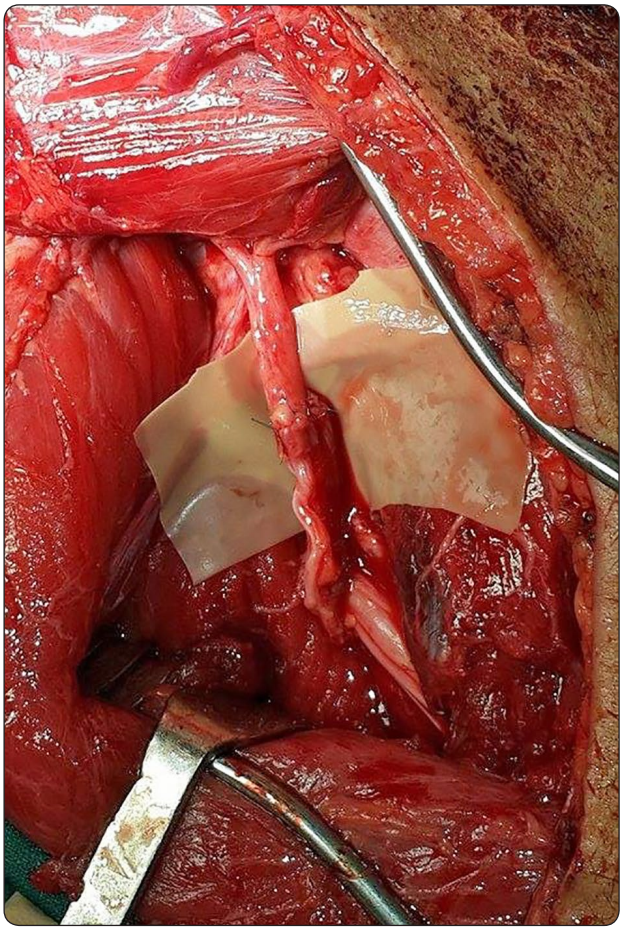

Figure 2. Intraoperative image showing axillary nerve neurotization by branch of the radial nerve. (Neurosurgery department, Suez Canal University, Ismalia, Egypt).

Flores[13] in 2010 reported a paper demonstrated the results of a double nerve transfer at the level of the hand for recovery of the motor and sensory function of the hand in cases of high ulnar nerve injuries. Five patients underwent a transfer of the distal branch of the anterior interosseous nerve to the deep ulnar nerve, and an end-to-side suture of the superficial ulnar nerve to the third common palmar digital nerve. Two patients recovered strength M3 and three cases were graded as M4; recovery of protective sensation (S3+ in three

patients and S4 in two) was observed in the fourth and fifth fingers, and at the hypothenar region. This technique of double nerve transfer is effective for motor and sensory recovery of the distal ulnar-innervated side of the hand.[17]

Brachial plexus injury and the Comprehensive Rehabilitation:

In 2012 Zhou et al,[51] published paper of forty-three cases of upper limb dysfunction after brachial plexus injury were divided into two groups randomly. The treatment group, which totaled 21 patients (including 14 cases of total brachial plexus injury and seven cases of branch brachial plexus injury), was treated with comprehensive rehabilitation including transcutaneous electrical nerve stimulation, mid-frequency electrotherapy, Tuina therapy, and occupational therapy. The control group, which totaled 22 patients (including 16 cases of total brachial plexus injury and six cases of branch brachial plexus injury), was treated with home-based electrical nerve stimulation and occupational therapy. Each course was of 30 days duration and the patients received four courses totally. After four courses, the rehabilitation effect was evaluated according to the brachial plexus function evaluation standard and electromyogram (EMG) assessment. Results In the treatment group, there was significant difference in the scores of brachial plexus function pre- and post-treatment in both "total" and "branch" injury. The scores of two "total injury" groups had statistical differences. EMG suggested that the appearance of regeneration potentials of the recipient nerves in the treatment group was earlier than the control group and had significant differences.[31,50]

Conclusion

The main objectives in treating severe adult BPI are restoration of shoulder abduction, restoration of shoulder external rotation, elbow flexion, forearm supination and relieving the pain that may be so severe and need surgery and it is essential that the surgical strategy be planned thoughtfully to maximize the functional outcome.The current lines of management are the conservative therapy, neurolysis, nerve grafting and repair, nerve transfer and tendon transfer, joint stabilization, free microneurovascular muscle transfer, orthotics and amputation and followed by appropriate program of the comprehensive rehabilitation treatment.

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الملخص العربي

الاتجاهات الحالية في إدارة إصابات الضفيرة العضدي

تعد أصابات الضفيرة العضدية مشكلة كبيرة لا يمكن تجاهلها لأنها تؤثر على طبيعة الحياة لعدد كبير من المرضى على مستوى العالم , وتتيح الوسائل الحالية الأن فى علاج هذه الأصابات الكثير من الأمل فى الوقت الحالى و فى المستقبل و يعطى المزيد من الفرص لهؤلاء المرضى فى حياة جديدة.

و أفادت دراسات عدة أن الاستخدام الجراحى فى علاج أصابات الضفيرة العضدية أعطى نتائج جيدة تجعل التفكير فى أخذها نمطا يمكن أن يسود فى علاج مثل تلك الأصابات . و تعد هذه الدراسة استعراض شامل للطرق الجراحية و الغير جراحية الأكثر شيوعا.و يتراوح تأثير الضفيرة العضدية من ضعف حركى بالكتف أو الكوع الى حد الشلل بالطرف العلوى و فقدان حاسة الاحساس بأنواعه أيضا.

ومن طرق الأصابة و أكثرها شيوعا هى الشد الزائد جدا و الذى ينتج من الوقوع بقوة على مفصل الكتف و الرسغ و خصوصا فى وضعية الثنى بعيدا عن الرقبة, و أيضا الأصابات النافذة مثل أصابات حربة السكين و الزجاج و الطلق النارى و التى كثيرا ما تكون مصاحبة بأصابات فى الأوعية الدموية من شرايين و أوردة فى تلك المنطقة الخطرة القريبة من الرقبة , و أيضا يمكن أن تحدث أصابات الضفيرة العضدية فى حالات عسر الولادة و خصوصا عندما يكون الجنين ذو حجم كبير, و أيضا لنا ألا نغفل عن الأصابات الناتجة من الأشعاعات الضارة والأورام فى تلك المنطقة .

و نظرا للمسار الطويل للضفيرة العصبية و الأشكال الكثيرة لأصاباتها , فهناك تقسيمات للصور المرضية لها و من أشهرها :أصابات ما فوق الترقوة , و التى تنقسم الى أصابات الضفيرة بالكامل ,وأصابات الجزء العلوى فقط , و أصابات الجزء العلوى و الأوسط فقط , و أصابات الجزء السفلى فقط , أصابات ما تحت الترقوة , و التى تنقسم الى أصابات الضفيرة بالكامل , و أصابات الحبل الجانبى , وأصابات الحبل الخارجى, و أصابات الحبل الخلفى.

ويختلف العلاج المناسب لأصابات الضفيرة العصبية من شخص الى أخر على حسب الاعصاب التى تم أصابتها و الفترة التى مرت على حدوث تلك الأصابة. عمل الجبيرة و حمالة الكتف فى علاج اصابات الضفيرة العضدية الناتجة عن تمزق الأعصاب لها دور أساسى جدا فى الأصابات الحادة. و عندما تكون أحتمالية الشفاء من تلك الأصابات بالطرق العلاجية قليلة أو متدنية جدا , يكون هذا مدعاة الى التدخل الجراحى , و خصوصا بعد مرور ثلاثة أشهر و ليس أكثر من ستة أشهر من الأصابة. ولأن أغلبية أصابات الضفيرة العضدية تكون أصابات داخلية بالأعصاب المكونة لتلك الضفيرة, فتشخيصها يكون فى المقام الأول عن طريق الكشف الأكلينيكى الدقيق و عمل أختبارات تشخيصية مثل رسم العصب و الرنين المغناطيسى و الاشعة المقطعية , و جميعها يؤدى للتشخيص النهائى لنوع الأصابة, والجراحات التكميلية مثل زرع أو نقل الأعصاب تعد هامة جدا و عنصر أساسى فى اتمام الشفاء لتلك الأصابات فى خلال الستة أشهر الأولى من الأصابة كما تبين بعد العديد من الدراسات. وهناك أنواع متاحة أيضا من الجراحات التكميلية مثل نقل الأوتار و تثبيت المفاصل و الجراحات الميكروسكوبية الجراحية للأعصاب و العضلات يتم عملها للمرضى ذوى الأصابات المتأخرة جدا لعمل جراحات توصيل الأعصاب.