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Obstetric Brachial Plexus Palsy Nerve Transfer Review Article

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Abstract:

Obstetric brachial plexus palsy (OBPP) is a paralysis of the upper extremities resulting from damage to the principal nerves that supply the brachial plexus; specifically, C7, C6, C5, C8, & T1 are affected. It is a prevalent neurological birth injury that is frequently caused, although not exclusively, by the traction applied to the neck throughout a challenging childbirth. Depending on the extent of the damage, it may necessitate surgical intervention and/or rehabilitation therapy to stabilize over time.

The utilization of nerve transfers in brachial plexus reconstruction has experienced a significant rise in recent years. In a nerve transfer, which is an operation is performed to reinnervate a specific muscle by connecting an expendable nerve to a more vital nerve. For several years, the idea of nerve transfer has been understood. multiple types of nerve allocations are mentioned in the literatures and found to have variable outcomes. The triceps branches of the radial nerve are linked to the axillary nerve (AN). The long thoracic nerve is transferred to the suprascapular nerve. The lateral pectoral nerve is connected to the musculocutaneous nerve (MCN). Additionally, the ulnar nerve (UN) is also connected to the MCN.

Keywords: Nerve transfers, Obstetric brachial plexus palsy (OBPP), Brachial plexus.

1. Introduction

The nerves originate in the spine and traverse the ribcage and cervicoaxillary canal before emerging into the axilla. The greatest frequent reason for brachial plexus injury during delivery is traction of the neck [1]**.** Macrozomia & shoulder dystocia are the most significant risk factors. It is most commonly observed in neonates with macrosomia who required extrication from the birth canal. Possible injury to the brachial plexus results from the stretching caused by this motion. With the exception of shoulder dystocia and neonates of average weight, brachial plexus palsy can also occur on its own.**[2]**

An ultrashort second stage of labour, breech delivery, a maternal obesity, multipara mother, maternal diabetes, or hoover and forceps delivery are extra risk factors for OBPP injury. A caesarean section was also associated with the occurrence of OBPP **[3].**

Pathophysiology

As in figure (1) **[4],** To visualize the upper, middle, and lower trunks of the brachial plexus, it is essential to combine the ventral rami of the cervical spinal nerves C6, C5, C7, T1, and C8. Each trunk is made up of posterior & anterior divisions, which come together to create the medial, lateral & posterior cords, and then branch off to support the muscles of the upper limbs **[5].**

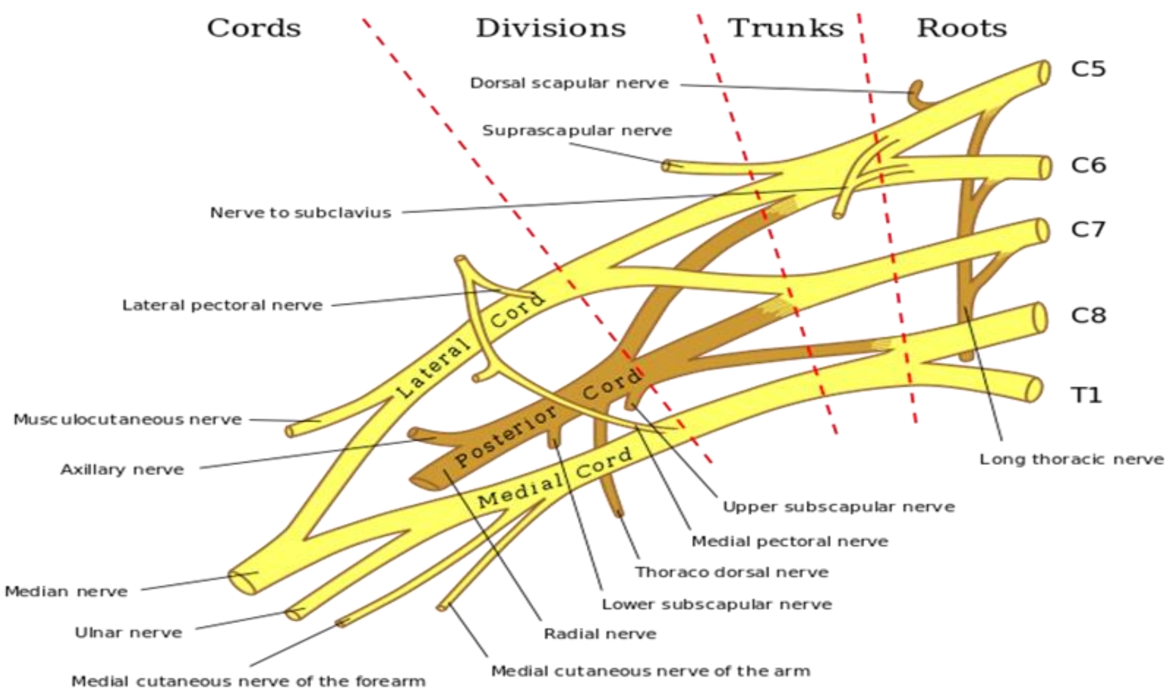

Figure (1):Diagramatic illustration of brachial plexus anatomy.[4]

Brachial Plexus Injury Classifications:

Narakas classification: Table (1):[6]

Narakas categorization	**Neurological involvement**	**Presentation**	**Likely outcomes**
Group 1	C5-C6	No elbow flexion, Shoulder paralysis	Spontaneous recovery occurs in more than eighty percent of cases and is excellent.
Group 2	C5-C7	Wrist drop, no elbow flexion, shoulder paralysis	In sixty percent of cases, there is a good recovery outcome for the shoulder and elbow.
Group 3	C5-T1(no Horner;s sign)	Shoulder paralysis of the limb without Horner's sign	There is a 30% to 50% chance of achieving good recovery in the shoulder and elbow, and in most cases, there is a good chance of recovering the hand.
Group 4	C5-T1(with temporary persistent Horner;s sign)	The upper extremity is completely paralyzed with a transient indication of Horner's syndrome	Intermediate among groups three & five
Group 5	C5-T1(with persistent Horner;s sign)	The upper extremity is completely paralyzed and exhibits the Horner's sign. Additionally, the extremity is cold and has a marbled appearance	The shoulder and elbow exhibit severe anomalies while the hand is in a very poor condition.

Rationale of nerve transfer for OBPP:

(A) For shoulder and elbow movements restoration:

Upper plexus dysfunction can appear in shoulder abduction, shoulder joint instability (C6–C5 injury) & elbow flexion or elbow extension loss (C7, C5, C6 injury), which can significantly impair an individual's ability to carry out routine activities. Reestablishing elbow flexion is a serious component in managing the injuries & is the initial target of nerve transfers **[7&8]**. Subsequently, shoulder joint stabilization nerve transfers are performed**.[7]**

Table (2) Several nerve transfers utilized to restore shoulder

Donor nerve	**Recipient nerve**
Spinal accessory nerve (SAN)	Suprascapular nerve (MC)/Axillary nerve (AN)
Phrenic nerve	Suprascapular nerve (MC)
Intercostal nerve	AN
Subscapular nerve	AN
Thoracodorsal nerve	AN
Pectoral nerve	AN

1. **Nerve Transfers for Shoulder**

SAN to Suprascapular Nerve Transfer

The SAN supplies the sternocleidomastoid and trapezius muscles as a cranial nerve. There are between one thousand five hundred and one thousand seven hundred nerve fibers in this nerve. SAN transfer is among the greatest frequently performed nerve transfer methods.**[9]**

In the 1960s, Kotani et al. significantly established the usage of the SAN for neurotization, which was initially indicated in the early 20th aera. **[10]**

Particularly when initiating the initial 30 degrees of shoulder abduction, the transfer of SAN to SSN is frequently utilized in cases of upper brachial plexus damage to stabilize the shoulder and reestablish shoulder function. By performing this transfer, shoulder function is effectively restored. Some authors also utilize SAN in pan-plexal injuries through the utilization of an interposition graft to neutralize the axillary nerve (which is accountable for shoulder function) or the MCN (which is accountable for elbow flexion). **[9]**

Following innervating the sternocleidomastoid muscle (SCM), the SAN traverses the supraclavicular fossa beneath the superficial & mid-cervical fascia. The nerve runs below the superficial branches of the cervical plexus & provides branches to supply the upper trapezius. It is located approximately three centimeters above the clavicle and passes distally over the end rami of the transverse cervical vessels. The exposure of SAN can occur dorsally or ventrally, a point of contention between proponents of both approaches. Dorsal approaches are supported by the assertion that more favorable outcomes result from the nerve being appropriately decompressed at the scapular notch & cooperating in close proximity to the targeted muscle with the donor nerve. **[9]**

a. Ventral Approach

The suprascapular nerve originates from the upper trunk of the brachial plexus and extends towards the suprascapular notch, passing beneath the omohyoid muscle. The omohyoid muscle can be utilized as a diagnostic tool for identifying the nerve. The skin incision is initiated slightly medially to laterally along the SCM border, approximately four to five centimeters in length, and is positioned parallel & two centimeters upwards to the clavicle. Separately, the platysma muscle is divided & cut to show the lateral border of the SCM. This border is subsequently elevated to unveil the adipose tissue located in the supraclavicular fossa. Subsequently, the supraclavicular fat pad is mobilized laterally, resulting in its pedicled position as opposed to its excision. By creating access to the supraclavicular space, this dissection enables visualization of the upper trunk, which exposes the SSN when followed laterally & distally. An additional significant anatomical feature is the omohyoid muscle, which originates among the scalenus anticus muscle and the SCM before traversing obliquely across the upper trunk. Laterally following the omohyoid muscle, which comes after a trajectory lateral to the acromial, the SSN can be recognized. Following that, the SSN is proximally dissected shortly following it emerges from the upper trunk, with the adipose supraclavicular layer being utilized to achieve maximum dissection. **[9]**

The ventral approach involves intraoperative stimulation to characterize the SAN on the anterior surface of the trapezius muscle. Subsequently, SAN is dissevered to a sufficient distance distally to ensure a tension-free anastomosis. Three to four SAN twigs are carefully preserved in the trapezius muscle during dissection in order to maintain trapezius function. A 10–0 nylon end-to-end microanastomosis is carried out under microscopic magnification; the adhesion is subsequently fortified with tissue adhesive. Transferring from SAN to SSN restores shoulder function to an acceptable degree. Numerous authors have reported successful shoulder abduction in ninety percent of cases involving upper plexal injuries and favorable external rotation in thirty percent of such cases. **[9]**

The dorsal approach involves exposing the SSN through the suprascapular notch & performing a tension-free anastomosis from the SSN to SAN. This distal nerve transference is favored by numerous authors, particularly in late cases, over the ventral strategy due to the anastomosis being conducted in close proximity to the muscle endplate. This strategy needs an obvious information about the anatomy of this region. The case is sited in prone site. Knowledge of the anatomical structure of this area is essential for this strategy. In a prone position, the case is situated. Prior to the beginning of the procedure, the SAN and SSN are surface-marked. Over the scapular spine, a line is delineated. The lateral SSN mark is approximately one-third of the space among the process of the acromion & the medial border of the scapula. Approximately three-quarters of the distance among the midline and acromion is designated medially for SAN. It is imperative to perform a skin incision along the scapular spine, beginning at the acromion and continuing all the way to the medial edge of the scapula. By severing the trapezius muscle's attachment to the scapular spine, a plane is formed across the supraspinatus & trapezius muscles. Following this, the anatomy is guided laterally in the direction of the suprascapular depression, that is subsequently felt with the index finger. Showing above the reflective white suprascapular ligament are the suprascapular vessels, which are subsequently encompassed in a vessel loop. Immediately after this, the suprascapular ligament is severed, so exposing the suprascapular nerve that is located below it. Proximally traced SSNs are cut with sufficient length to permit tension-free anastomosis with SAN. We progress in a medial direction, passing twigs to the muscle as we descend from above. The SAN is then cut with a 10–0 nylon suture, preserving a little number of branches leading to the trapezius muscle, & documented with the SSN **[9]**.

2. **Somsak's Procedure**

As a consequence of injuries to the upper trunk (C6-C5) of the brachial plexus, shoulder abduction, elbow flexion & external rotation are all affected. Restorative of the upper extremity function primarily aims to reinstate external rotation & shoulder abduction, subsequent to elbow flexion.

In **2003,** to reestablish shoulder abduction, there was a new nerve transfer that was recorded by **Leechavengvongs et al. [11],** which involved a triceps branch of the radial nerve being transferred to the axillary nerve. cases who have C5–C6 root avulsions and deltoid function loss now favor this particular reconstruction process.

Technique

A posterior approach employed in the quadrilateral area by a longitudinal cut, facilitated by elevating the deltoid superiorly, is required for the procedure. The case is placed in a reclining position, and the hand carrying the flag is positioned in front of the case's face. A surgical cut is made on the skin that extends from the acromion process to the point where the upper and middle thirds of the arm meet. This surgical cut includes both the long and lateral heads of the triceps muscle. This is the specific anatomical site where the triceps exercises are executed. To identify the branches of the radial nerve that connect the long head and lateral head of the triceps in the triangular area, a plane is formed between these two muscles. Direct nerve stimulation is then employed to precisely find these branches. The humerus acts as the medial barrier in this region, while the long head of the triceps acts as the lateral boundary, and the teres major muscle acts as the superior boundary. The branch that was developed for the transmission is the supply to the long head because to its near proximity to the axillary nerve and its larger quantity of axons. The major axillary nerve is situated within the quadrilateral space, which is delimited on the lateral side by the long head of the triceps and on the upper side by the teres minor muscle. Furthermore, the area is enclosed internally by the deltoid, humerus, and lateral head of the triceps, and below by the primary teres muscle. As a result, the donor nerve is then utilized in conjunction with either the main axillary nerve or its front branch. Although the posterior way is the predominant route for this therapy, there are also some writers who utilize the anterior approach. Some writers choose to concentrate on the medial triceps branch instead of the long head of the triceps branch. However, the latter not only facilitates the extension of the elbow, but it also contributes to the stabilization of the shoulder by means of adduction and retroversion. **[12]**

Typically, a SAN transfer to the SSN is conducted concurrently with a triceps transfer (double transfer); this procedure may be executed from the anterior or posterior aspect. With dissection occurring outside the area of injury, The triceps branch nerve transfer is a treatment that is reasonably quick and does not include any complications this method eliminates the need for a nerve graft or related donor-site morbidity. Theoretically, it also provides deltoid muscle reinnervation more rapidly and has an elevated rate of success **[13].**

3. Phrenic Nerve to SSN Transfer

Gu et al. introduced the phrenic nerve as a viable donor nerve, & numerous authors have documented its utility in shoulder abduction for upper brachial plexus injuries via phrenic nerve to SSN transmission.**[14]**

Numerous authors recognize that the phrenic nerve is a superior donor nerve in comparison to the SAN. This is due to the fact that the deficiency that is brought about by denervating a segment of the trapezius muscle, which is one of the scapulothoracic muscles, can be prevented in the phrenic nerve. SAN is the donor of choice, despite the considerable quantity of motor axons it contains and the potential respiratory compromise associated with the phrenic nerve, particularly in neonates & tobacco users. Phrenic nerve satisfies all the requirements for a potent axon donor and is a pure motor nerve. Approximately eight hundred to one thousand eight hundred myelinated nerve fibers comprise it. Grading by the Medical Research Council. While it doesn't cause respiratory complications, it is contraindicated in neonates, cases with chronic pulmonary disease, and those who have experienced traumatic pulmonary sequelae.

Phrenic nerve origin varies between C3 and C5. An accessory phrenic nerve, which may originate from C4-C3 or C6-C5 and connect to the major trunk distal to the clavicular level, may occasionally be observed.**[9]**

The phrenic nerve, which originates on the anterior surface of the anterior scalenus, traverses obliquely in front of the vein that leads to the hemidiaphragm before passing in front of the subclavian artery. **[9]**

Typically, Within the supraclavicular region, the phrenic nerve is extracted; however, Xu et al. carried out a complete harvest of the nerve via video-assisted thoracic operation, that is the preferred approach when undergoing operation more than nine months following the injury.**[15]** Supraclavicular exposure is carried out in the same manner as the SAN to SSN transference. To identify the phrenic nerve, one can proximally follow the C5 and C6 origins. It traverses the scalenus muscle lateromedially after traversing these origins. The nerve is subsequently verified using a nerve stimulator. Following this, the phrenic nerve is carefully dissected & severed as close to the distal end as possible. SSN is subsequently recognized at the initial branch of the upper trunk, which is positioned at the superior edge of the top trunk. While observing through a microscope, interrupted 10–0 nylon threads were used to suture the phrenic nerve directly to the SSN with no tension, via stitches positioned in the epineurium.**[15]**

(B) Elbow movements restoration:

Restoration of elbow extension:

Functional advances are generated by the capacity to expand the elbow, which permits the performance of tasks at an elevation above the shoulder, such as the retrieval of things from a higher shelf. **[15, 16]** By employing conventional approaches, as moving the biceps or posterior deltoid muscle to the triceps muscle, multiple cases restored sufficient strength to withstand the force of gravity. **[18]**

Transferring to the triceps motor branches is feasible from either the posterior deltoid motor branch or the teres minor motor branch.**[19]**

Nerve transfers for elbow flexion are:

- FG stands for motor fascicular groupings. Oberlin technique: connecting UN to the biceps nerve**[20]**
- Mackinnon states that there is a dual transmission of nerve fibers from the median & UN to the biceps & brachialis muscle **[21]**
- An intercostal nerve (ICN) to MCN graft that is either positive or negative**[22]**
- From the Phrenic Nerve (PhN) to MCN
- From the Medial Pectoral Nerve (MPN) to MCN
- From the Thoraco Dorsal Nerve (TDN) to MCN
- From the Contralateral C7 (CC7) to MCN.
- SAN is transferred to MCN with or without nerve graft.
- Cervical Plexus C3-C4 to the MCN.

Motor fascicular groups (FGs) of flexor carbi ulnaris of UN to biceps nerve (Oberlin method)

Oberlin proposed in 1990 that motor FGs of the flexor carbi ulnaris, which are sited at the midarm level, could be transferred from the UN to the biceps branch of the MCN with no require for an intervening nerve graft**[23].**

Following a longitudinal epineurotomy of two to three centimeters in the UN, 1 or 2 fascicles are found and sutured end-to-end with three to four stitches of 10–0 nylon to the branch of the nerve that leads to the biceps muscle. 90% of cases show improved elbow flexion with the Oberlin technique compared to the MRC G4 method**[24].**

Electrostimulation intraoperatively is required for recognizing motor FGs of the ulnar nerve's flexor carbi ulnaris. Contraindications of Oberlin method include lesions of the T1-C7-C8 region and a long interval among the injury & the operation procedure**[25].**

Mackinnon technique

MacKinnon provided in 2005 that the original Oberlin technique be modified to involve motor FGs of the median nerve reinnervation of the brachialis branch of the MCN **[24].** Flexor carpi radialis (FCR) & flexor digitorum superficialis (FDS) nerves are located in the optimal median nerve donor fascicle; intraoperative electrostimulation of the motor fascicle of the median nerve induces wrist flexion. Numerous studies comparing single and dual reinnervation have been reported. Although it may seem logical that a greater number is more effective, a major current prospective randomized trial failed to establish any discernible distinction in objective results when comparing the Oberlin procedure & the MacKinnon technique**[27].**

b. **Intercostal nerves (ICN) table (3)**

Authers	**Year**	**The nerve transfer**
Hara & Tsuyama	1968	Proposed the relocation of two or more ICN to MCN[22].
Celli	1978	This is a preliminary comment on the surgical procedure for neurotized torn roots of the brachial plexus [23].
Dolenec	1984	The ICN neurotization into MCN, radial, axilary, or motor FG of the UN (sural nerve graft interposition) were shown through a number of different neurotization [24].
Oberlin	2003	utilized an ICN transmission to neurotized triceps[25].

The transmission of an ICN to either MCN or the radial nerve (long head of triceps) is the fourth option. While every ICN comprises approximately one thousand two hundred axons, it is crucial to bear in mind the following: ICN 1 is involved in the production of BP, whereas ICN 2 is extremely little and devoid of motor fibers. As many as twenty percent of the motor axons are found in ICN7–ICN12; ICN -6– ICN -3 are utilized for neurotization of MCN; thirty to forty five percent of the motor axons lose ten percent of the motor fibers every ten centimeters from the axillary line**[22]**, **[20].**

A procedure known as ICN harvest is one that requires a thorough approach & cautious dissection, along with appropriate hemostasis, to protect the insertion of the serratus anterior muscle**[28].**

ICN transfers are contraindicated in cases with rib fractures, ipsilateral PhN palsy, or Serratus anterior muscle palsy **[29].** Complicated aspects of ICN use include: 1) a degree of ipsilateral pulmonary atelectasis in neonates that is changeable; 2) pleural rupture, which some authors consider to be the major common complication **[30].**

At present, centers provided with the Da Vinci surgical robot system are capable of performing minimally invasive robotic surgery [25]. ICN and MCN are joined via sural nerve graft. The NT is denoted by the following ICN values: 1) The initial stage in the treatment of injuries to the brachial plexus of the shoulder is to increase the amount of flexion that the elbow can reach; 2) With no need for a nerve graft, reestablish elbow extension by inserting an ICN to the long head of the triceps nerve; subsequently, transmission of the reinnervated triceps to the biceps using the Carroll Method; 3) free muscle transmission of the gracilis, reinnervated with the ICN for flexing of the elbow **[31].**

c. Medial pectoral nerve (MPN)

There are roughly 1,100 to 2,100 motor fibers in MPN, which can be surgically obtained in lengths of up to seventy-eight millimeters and have a mean diameter that ranges from one point four to two point seven millimeters. MPN are formed of seventy-three percent of fibers from C8 and T1 **[32]**. The pectoral loop serves as the connection between the lateral pectoral nerve (LPN) and the medial pectoral nerve (MPN), which are both pectoral nerves. Pectoralis minor and lower pectoralis major are innervated by MPN, which may also have links to the intercostal nerves**[32].**

Each of the lateral & MPNs are responsible for supplying the pectoralis major muscle, thereby sustaining its functionality subsequent to MPN transfer**[21].** The MPN can be discovered by the use of electrostimulation & a deltopectoral incision that places an emphasis on the infraclavicular plexus, the MPN harvesting method is comparatively uncomplicated; It is possible to directly suture the branches of the MPN to the distal terminal of MCN, eliminating the need for nerve graft interposition. The MPN is sectioned after undergoing dissection to achieve an adequate length; the MCN branch that is destined for the biceps is isolated for an adequate length to enable tension-free neurotherapy with the MPN. This transfer is recommended for cases who have C6, 5, or C 7, 5, 6 lesions, but possess a strong pectoralis major**[33].**

d. Thoracodorsal nerve (TDN)

Originating from the posterior cord C8, C7, & not as commonly C8-C6, the TDN is a motor nerve. The length of the TDN are as follows: length: twelve point three centimeters; diameter: two point one to 3.0 millimeter; and number of myelinated fibers: 1530 to 2470 **[33].**

Recovery of elbow flexion with no nerve grafting is possible with the help of TDN which is a motor donor nerve**[35].** By making a cut at the point at which the outer (front) edge of the latissimus dorsi muscle is located while the upper extremity is in a ninety-degree abduction position, the TDN harvesting method is carried out. The TDN is attached to the motor FGs of the MCN with respect to the biceps muscle and to the motor FGs with respect to the brachialis muscle subsequent to a distal to proximal MCN intraneural dissection. Transferring the TDN to the MCN results in forearm flexion recovery in ninety percent of instances. Neurotization of additional nerves, such as the axillary, suprascapular, or serratus anterior, may be facilitated by TDN**[36].**

e. **Spinal accessory nerve (SAN)**

The SAN, which comprises around one thousand five hundred motor axons (C1 to C6), was initially employed by Marcelo Rosa de Rezende for MCN neurotization in 1980 **[37].** An anterior approach is utilized to harvest the SAN in order to transfer it to the MCN via a nerve graft. When transferring to the suprascapular nerve (SSN) or in conjunction with the triceps branch transfer to the axillary nerve, the posterior approach is utilized. By assessing forearm flexion following SAN to MCN transfers, sixty five to eighty three percent of cases have achieved MRC = M3 or higher **[21].**

f. **Phrenic nerve (PhN)**

To restore elbow flexion, Chinese surgeons conducted the first PhN transfers to the MCN in 1990 **[34].** In order to prevent dissection caused by retro clavicular scar tissue during the transfer of the PhN to the MCN, a ten-centimeter-long bypass nerve graft is utilized. PhN is an excellent donor nerve with eight hundred myelinated motor axons (C3, C4, C5), although its contribution to respiratory function shouldn't be ignored. Phrenic nerve (PhN) transfer to the medial cutaneous nerve (MCN) is contraindicated in minors younger than 2 years of age or cases with a history of pulmonary disease **[37].**

g. **Cervical plexus C3-C4 to MCN**

Monini L. and Georgio Brunelli proposed utilizing the anterior motor branches of the cervical plexus in 1984. Nearly fourteen thousand myelinated axons comprise the anterior branches of the cervical plexus; however, an intervening nerve graft is necessary to bridge the distance of coaptation between the C3 and C4 anterior branches and the target (MCN). The transfer of anterior branches of the cervical plexus is typically referred to as SAN and DNMN to MCN **[39].**

h. **Contralateral C7 (CoC7) transfer to MCN**

A group of Chinese authors reported the application of CoC7 in 1992 and achieved favorable functional outcomes, given that the method introduces novel perspectives for understanding total brachial plexus paralysis **[40].** David Chuang utilized CoC7 as a neurotization source in 1993; he attached it to the PB via an extensive sural nerve graft. Axonal growth in the sural graft was confirmed one year later, during the second operative session, and neurorehabilitation was conducted at MCN. There are 3 distinct methods for harvesting CoC7: the entire root, three-quarters of the root, and half of the C7 root, respectively. The functional recovery is significantly greater in the group that received the whole root CoC7 transfer, which gives a greater quantity of donor nerve fibers, compared to the group that received the partial transfer **[41].** Due to the high complication rate—severe bleeding caused by vertebral arterial damage throughout the operation, temporary recurrent laryngeal nerve palsy, pain & numbness in the donor site while swallowing, and dyspnea—direct coaptation and a modified prespinal route are not suitable for CoC7 nerve transfer. The donor site morbidity following the (CoC7) transfer was notably high, exceeding twenty percent. Despite the C7 containing a substantial number of fibers (8,467 ± 1019), it continues to be the last favorable alternative **[42].**

i. **Median Nerve to Biceps Nerve Transfer**

Al-Qattan et al, performed a surgery. (A longitudinal incision is executed along the bicipital sulcus, which is sited on the upper arm's medial region. The MCN is recognized and its distal branch is determined through analyzing it **[43].** Proximally (by one to two centimeters) from the primary trunk of MCN, the biceps nerve is separated. Following the identification of the median nerve, neurolysis is conducted in the opposite direction of the recognized biceps nerve. By means of a nerve stimulator, it is possible to determine which motor fascicle supplies the FCR. Distally dividing & inverting the donor fascicle in the direction of the biceps nerve. Neuropathy is coaptated using fibrin adhesive rather than sutures. The incision is closed and devoid of any drainage)**[44].**

The initial allocation of the median nerve to the biceps nerve in cases of obstetric palsy was documented by Al-Qattan et al. It is notable that the only one failure was observed in the kid that manifested at the latest, precisely nineteen months of age; furthermore, this child exhibited prolonged ERb's palsy**[23],[45]**.

Choosing cases who undergoing nerve transfer for birth palsy differs between centers. Belzberg et al.**[46]** When it comes to birth-related neuropathy, the timing of surgical intervention and the indications for it were identified as the most contentious issues among peripheral nerve surgeons surveyed internationally. There are numerous adverse events associated with prolonged muscle denervation, including atrophy of muscle fibers, alterations in neuromuscular junctions, heightened fibrosis in the distal nerve, & a reduction in Schwann cells in the distal nerve **[47]**.

(C) **Restoration of wrist and finger functions:**

1. Common Distal Motor Transfers: table (4) [48]

Motor Deficit	Recipient Nerve or Nerves	Donor Nerve or Nerves	Comments
Intrinsic hand	The motor branch of the UN	The distal anterior interosseous nerve	For high UN lesions
Thumb, finger extension	There is a branch of the radial nerve that is known as the posterior interosseous nerve.	Nerve to supinator For C7-	T1 plexus injuries
Finger & wrist extension	The radial nerve branches to supply the extensor carpi radialis brevis muscle & the posterior interosseous nerve	The median nerve fascicles that connect to the FDS and the median nerve fascicles that connect to the flexor muscle carpi radialis	Dual transfer
Finger & thumb flexion	Anterior interosseous nerve	The radial nerve branches out to the brachioradialis muscle	In cases of serious injuries to the median nerve or the lower trunk plexus, this medicine is recommended. Together with tenodesis of the four tendons that make up the flexor digitorum profundus in the forearm

2. **A tenodesis of the flexor Digitorum profundus associates with the Brachialis motor branch that supplies the anterior interosseous nerve.** To reestablish median motor function in patients with rare T1-C8 or lower trunk plexus injuries, and possibly in cases with significant median nerve damage, the motor branch of

the brachialis muscle from the MCN can be transferred to the posterior 3rd of the median nerve in the arm **[49& 50]** The AIN fascicles have been recognized by Zheng et al. **[50]** as the distal portion of the median nerve. The forces originated by the middle digits, which are controlled by the median nerve and include the index finger, need to be sent to the ring and tiny fingers, which are controlled by the UN. This transmission is achieved by performing a side-to-side flexor digitorum profundus tenodesis along with this transfer. At the eighteen-month monitoring, 5 of 6 cases described by Zheng et al. had recovered their digital flexion. Averaging sixty-six pound of grip strength. **[48]**

3. **Distal Anterior Interosseous Nerve to UN Motor Branch**
   In cases with severe UN damage, it is possible to transfer AIN branch of the pronator quadratus muscle to the motor branch of the UN **[51, 52].**

4. **Branching of the Supinator to the Posterior Interosseous Nerve**
   Although the digital function is absent in the rare cases of C7-T1 palsies of the brachial plexus, the function of the shoulder & elbow remains maintained. Supinator muscle function is maintained due to innervation originating from the C6 nerve root. Supination remains effective in cases of C7-T1 palsies, even when the supinator motor branches are sacrificed; this is due to the preserved function of the biceps muscle. In their cadaver feasibility research, Bertelli et al. **[53]** showed that it is feasible to redirect 1 or 2 branches of PIN to the supinator, hence redirecting the PIN branches responsible for innervating the extensor pollicis longus and extensor digitorum communis muscles.**[54]** Dong et al. **[55]** reported favorable outcomes regarding this transfer as well.

5. **Branches of the median nerve to those of the radial nerve**

The method involves redirecting branches of the median nerve to the radial nerve branch that controls the extensor carpi radialis brevis muscle, and redirecting branches of the median nerve to the FCR muscle to PIN define this dual transfer set technique. [56 &57]

(D) Restoration of the sensation:

Common Sensory Transfers are listed in table (5) [48]

Sensibility Deficit	**Recipient Nerve or Nerves**	**Donor Nerve or Nerves**	**Comments**
Radial hand	The lateral cord contributes to the formation of the median nerve.	Intercostal sensory nerve branches	Proximal transfer
Thumb and index finger	The radial digital nerve is responsible for supplying the thumb, while the common digital nerve is responsible for supplying the 1st web space	Superficial radial nerve	— Very distal transfer
	Those digital nerves that are responsible for providing innervation to the radial side of the index finger and the ulnar side of the thumb	The branches of the superficial radial nerve that are digital in nature	—
	The radial digital nerve of the thumb connects to the common digital nerve of the first web space	The digital nerve that is commonly seen in the 3rd web space.	—
	The radial digital nerve is responsible for the innervation of the thumb, while the common digital nerve is responsible for the innervation of the 1st web space	Innervation of the 4th web area is provided by the common digital nerve	—
	The radial digital nerve is responsible for the innervation of the thumb, while the common digital nerve is responsible for the	The dorsal branch of UN	

	innervation of the 1st web space		
Ring and small fingers UN	UN The common digital nerve innervates the 4th web space, while the ulnar digital nerve innervates the tiny finger	Lateral antebrachial cutaneous nerve The common digital nerve to 3rd web space	C7-T1 injuries —
Ulnar border of hand	The dorsal branch of the UN The dorsal branch of the UN	The lateral antebrachial cutaneous nerve The median nerve is located near the distal forearm, namely at the end and to the side	— —

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