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Review Article

DECISION MAKING IN PERIPHERAL NERVE INJURIES

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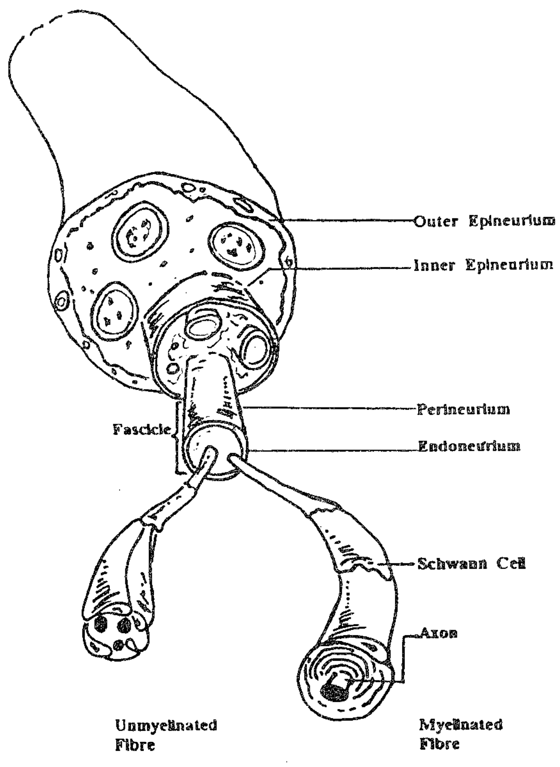
INTRODUCTION

Over the last two decades the therapeutic approach towards nerve injury has changed significantly, notwithstanding the significant developments during the two world wars[1]. Facilities of electrodiagnosis, intraoperative magnification, and a better understanding of the peripheral nerve structure (Fig.1) and function have improved the results of nerve repair. Surgeons doing nerve repairs attempt to restore nerve continuity to provide optimal conditions for axon sprouting and bridging of neural gap. Many factors, majority of them biological rather than surgical, influence nerve regeneration and the quality of functional return. Hence surgeons are still unable to guarantee functional results.



(Fig-1) Architecture of the nerve fibre

HISTORY

Nerve as an anatomical entity was described by Herophilus (3rd century B.C.). Later, Galen (131-201 A.D.) reported attempts at nerve repair by unknown workers. Heuter first suggested and used epineural nerve suturing, which after several refinements became the classical method of nerve repair[2]. Results of nerve repairs were such that during the late 1950s the general attitude to functional return changed dramatically from optimism to pessimism. In 1980, at the First International Congress on Hand Surgery, Moberg[3] presented a dismal review of "what had been achieved by nerve repair" so far. Onne[4] in 1962 demonstrated that tactile sensibility never returned to normal. Krenkel recorded a failure rate of 30%, and later it was towards this failure rate at which attempts were made in technical refinements[2]. Newer techniques like tubulisation, nerve grafting, repairing under microscope and nerve crossovers came much later.

CLASSIFICATION

Seddon[5] (1948) and Sunderland[6] (1968) retrospectively analysed their experience with peripheral nerve injuries and individually developed a classification system for nerve injuries based on the disruption of the internal structure of the peripheral nerve. It is grossly apparent in both that the prognosis of functional recovery is dependent on the degree of intraneural disruption.

Seddon's Classification

Neuropraxia : It is the mildest form of injury and denotes a localised conduction block. The axonal continuity is maintained, and therefore, recovery is rapid and complete.

Axonotmesis : There is disruption of axon with continuity of the connective tissue sheath. Conduction block is followed by distal axonal degeneration.It recovers with a good prognosis because the continuity of the supportive tissue is maintained.

Neurotmesis : There is complete anatomic severance with distal axonal degeneration and varying degree of proximal degeneration. Recovery needs surgical alignment of severed ends and it is never complete.

Sunderland's Classification

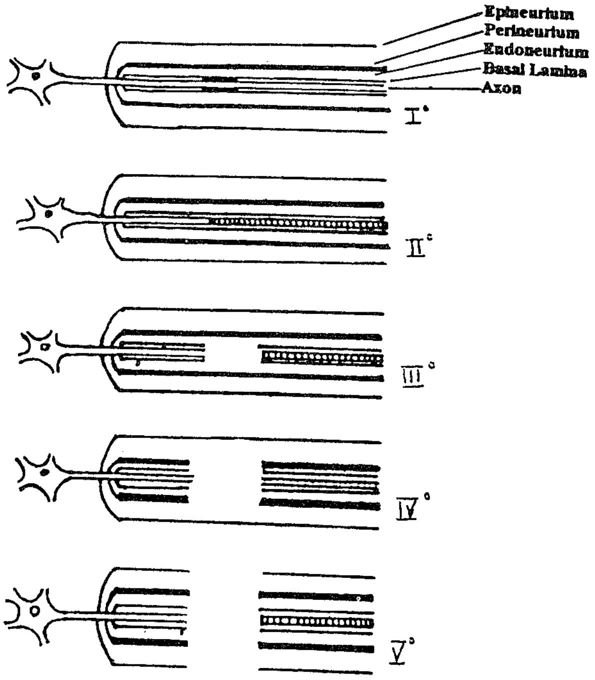
This classification correlates nerve injury with the fascicular structure of the nerve (Fig.2), and therefore, Seddon's axonotmesis was further expanded into three categories depending on the degree of disruption of the supportive structures. This has in effect simplified the classification as now it correlates well with the anatomic structure of the nerve and prognosis.

1^0 : No loss of axon continuity. Corresponds to neuropraxia.

(2^0, 3^0, & 4^0 injuries have axon damage to a degree that causes nerve disintegration.)

2^0 : There is damage to axon alone. This is followed by an uncomplicated axonal regeneration. This can result from traction injuries which may fracture the axon within the endoneural tube.

3^0 : There is damage to axon and the endoneural sheath. The perineurium is intact.It is followed by complicated axonal regeneration because of intrafascicular mixing of the growing axons.



(Fig-2) Sunderland's classfication of nerve injuries

4^0 : The nerve fasciculi are disrupted. There is disruption of the perineurium with extensive endoneural damage. However, nerve continuity is maintained because the epineurium is intact. Some spontaneous recovery is still possible but it will be accompanied with extensive intrafascicular mixing and scarring.

5^0 : There is complete disruption of the nerve trunk. It corresponds to neurotmesis. This will require surgical approximation.

Conduction losses can result from compression and ischaemia. The injury is reversible till a critical point is reached after which it leads to axonal degeneration. Ischaemia for more than 6 hours will lead to axonal damage.Large myelinated fibres are more susceptible to compression and ischaemic damage than unmyelinated fibres. Amongst these, the motor fibres are more susceptible than the sensory fibres. Traction injuries lead to mixed type of lesions and a longitudinal pattern of injury is observed, as the injury is rarely uniform over the length of the nerve. Although, ischaemic injury generally leads to a localised type of damage, mixed lesions are also possible.The extent of nerve injury following Sunderland's classification can be correlated well with the etiological factors.

1^0 : Results from compression and ischaemia upto 6 hours, as from closed fractures.

2^0 : Results from compression and ischaemia for more than 6 hours, as from closed fractures, missile and traction injuries.

3^0 : Results from compression and ischaemia upto 6 hours, as from compound fractures, missile and traction injuries.

4^0 : Results from compression and ischaemia for more than 6 hours, as from compound fractures, missile and traction injuries.

5^0 : Results from compound fractures, penetrating objects and associated with extensive soft tissue damage.

PROGNOSIS

The first and second degree injuries recover spontaneously and completely in a period of 4-6 months. One factor which has a tremendous influence in the quality of spontaneous recovery is nerve fibrosis[8]. Nerve fibrosis can be extraneural, interfascicular and intrafascicular. Intrafascicular and interfascicular fibrosis is very detrimental to regeneration and it is pronounced in third and fourth degree injuries resulting from traction and ischaemia[6]. As a result of nerve fibrosis the endoneural tubes get constricted and the requisite number of growing axons are unable to enter the distal tubes. Extraneural fibrosis results primarily from wound infection. An intact perineurium provides an effective barrier to the spread of infection. Fibrosis around the nerve involves the epineurium and besides constricting the nerve it also constricts the nutrient vessels , attaches the nerve to its bed firmly and reduces its elasticity[7].

Factors Which Affect the Outcome of Nerve Repair

Type of nerve : Repair of a pure nerve (motor or sensory) is technically easy and leads to better results. The relative predominance of sensory and motor component in a mixed nerve has a direct bearing on several surgical decisions as detailed subsequently.

Age of the patient : Younger patients have a more satisfactory outcome of nerve injury and repair than older persons. Some attribute the better outcome in younger individuals to the lesser length of the extremity and a better capacity for cortical reeducation.

Level of injury : Level of injury has a tremendous influence on the result of nerve repair and this is governed by several subfactors. Axons are a part of the nerve cell and can be related as a percentage to the total mass of the cell. Hence, more proximal the injury higher is the percentage damage to the nerve cell. This in turn reduces the regenerative capacity of the nerve[8]. Also, in proximal injuries the retrograde changes are more likely to involve the cell body. Results are also poorer in proximal injuries because of greater distance of axonal regrowth to reach the end organ. This indirectly increases the time period for reestablishing function in the end organ.

Extent of injury : The type of nerve injury and its extent correlates well with the regenerative capability of the nerve.

Length of Defect : Severe localised injury with pronounced retrograde reaction or a segmental loss presents a poorer prognosis.

Associated injury : Concomitant injuries like skin loss, vascular injury, joint injury and wound contamination do not warrant immediate nerve repair. At the same time, it has to be kept in mind that in a deferred repair the nerve fibrosis resulting subsequently makes the results of secondary repair less than optimal.

Surgical technique : The degree of technical excellence in nerve handling and suturing are of paramount importance.

Timing of nerve repair : Delay in nerve repair leads to intraneural fibrosis with shrinkage of endoneural tubes and atrophy of the end organ.

DIAGNOSIS

The classical clinical sign for assessing the progress of the regenerating nerve is Hoffman Tinel's sign (tapping along the course of the nerve from distal to proximal, will at the point of regenerating axon elicit a tingling sensory impulse towards the periphery of nerve distribution). This sign only indicates the presence of regenerating sensory axons, and therefore, is an unreliable guide to the outcome and quality of regeneration. Modern electrodiagnostic equipment is more precise in assessment and consists of :

Nerve conduction velocity : It measures the velocity of conduction of an evoked depolarisation potential elicited by an electrical stimulation[9].

Needle electromyography : This records the action potential produced by depolarisation and repolarisation of a small group of muscle fibres isolated by the tip of the needle electrode[10].

Somatosensory evoked potentials : Cortical responses can be recorded with distal stimulation. Degree of signal attenuation correlates with the extent of injury[10].

Role of Surgical Exploration in Diagnosis of Nerve Injury

Nerve exploration is indicated in the following situations[2,11].

1. The external injury is of a type associated with suspected nerve severance, because this is inconsistent with spontaneous recovery. Penetrating injuries and those associated with fractures where the position of the bone fragments suggests a direct nerve damage fall in this category.
2. If the site, nature and the severity of injury points to severe damage at the root of the limb. eg. severe stretch injury is likely to damage the brachial plexus.
3. If there is a steadily deteriorating function.
4. If a recovery progressing satisfactorily gets arrested.
5. If spontaneous recovery is long overdue.

MANAGEMENT

Management starts with identification of the nerve that is injured. Then the level of injury, its nature and extent are determined. The spectrum of injury can range from first degree to fifth degree with inclusion of cases of doubtful extent and cases which are beyond repair.

It is important to exclude a first degree damage because spontaneous recovery is possible. This may be done by examining the nature of the wounding mechanism, characteristic features of the injury and by doing electromyographic studies (EMG), if necessary. Spontaneous recovery in a first degree lesion is generally seen within a month. When there is no recovery at 6 weeks time, a nerve conduction study is carried out. If the distal segment is conducting, it is better to wait for a further period of 1-2 weeks or else carry out neurolysis depending on the level of conduction observed. If the distal segment is not conducting an impulse at 6 weeks then the diagnosis was erroneous and it is advisable to explore, resect the injured site and repair. Never explore a suspected first degree injury prematurely and without carrying out a nerve conduction study because on exploration the external features of the nerve may conceal the pathology within the nerve or the apparent extent of damage seen may not be incompatible with spontaneous recovery. This will then pose a dilemma during surgery whether it is better to resect and suture or else await spontaneous recovery. If the nerve has been observed in continuity, the distal segment is conducting and the nature of the wounding mechanism suggests first degree injury, a neurolysis may be carried out and spontaneous recovery can be expected upto 6 months.

In a closed nerve injury if it is suspected that the extent of injury is second to fourth degree it is again necessary to wait for 6 weeks as spontaneous recovery is possible. Again before exploration it is mandatory to carry out a nerve conduction study to rule out the possibility of a premature exploration. In the event of carrying out a premature exploration the continuity of an exposed nerve ('nerve in continuity') must be respected and the damaged segment should not be hastily resected. Resection is deferred till the appearance or the non appearance of signs of spontaneous recovery, and this period of wait may be 4-6 months. Still, before resection a nerve conduction study must show that the distal segment is not conducting an impulse[10].

When is Spontaneous Recovery Overdue?

The expected time of nerve recovery can be estimated by the latent period, the rate of regeneration and the distance from the site of nerve lesion to the first muscle that it innervates. After providing 15-20 days for the latent period and calculating the rate of regeneration at 1 mm per day, it will take 4 - 6 months for the first sign of recovery to appear, if the site of lesion is 10-15 cm from the first muscle of innervation.

Neuroma on a "Nerve in Continuity"[12]

While exploring injured nerves a situation commonly encountered is neuroma on a "nerve in continuity". Neuroma is the result of a partial severence, traction or crushing in which all or part of epineurium and perineurium remains intact. It could be fusiform, which is contained within an intact perineurium or laterally placed, where perineurium is partially divided on one side and there are intact fascicles on the other side. While the presence of a neuroma foreshadows incomplete recovery it is not incompatible with an acceptable degree of recovery. At exploration the exposed 'neuroma in continuity' offers little information by its gross appearance about the presence or absence of intact fasciculi, although, firm, hard and fusiform neuroma are less likely to have significant intact fascicles than soft, smooth or laterally placed neuromas. Similarly, comparing the size of the nerve above and below the neuroma offers very little clue. To resolve this uncertainity William and Terzis[9] used intraoperative nerve stimulation to decide which fasciculi or part of the nerve should be left alone, neurolysed or divided and repaired. A dilemma can arise if the fascicle with a neuroma shows some conduction making it difficult to take a decision for resection. For such cases Van Beck and Massac[10] proposed that a nerve conduction velocity less than 10 - 20 m / sec should be considered unfavourable and such neuromas should be resected.

Management of Painful Neuromas

Incidence of pain in a neuroma varies from 2% (Wilson[13]) to 30% (Herndon[12]). There is no reliable way to predict which neuromas will be painful and in which pain will get resolved. There is no justification in excising and suturing a painful neuroma because it may be followed by a suture site neuroma. If the neuroma is painful but has an acceptable degree of functional recovery it is advisable to explore it, free it from the surrounding adhesions and to relocate the nerve, if possible, by avoiding pressure bearing areas.

When Should a Severed Nerve be Repaired?

A severed nerve should be repaired as soon as the local conditions are favourable. Available data on results of early and delayed repair are not comparable as they are practiced in entirely different settings. Secondary repairs are generally done in extensive trauma where the nerve repair takes a lower priority, whereas primary repairs are done in a clean and simple injury[14].

In an uncomplicated nerve severence the primary repair should be carried out within 24 hours of the injury, preferably in the first 12 hours. It offers the following advantages,

1. There is no preparatory trimming involved, and therefore, there is negligible tissue loss. Minimal or no mobilisation is required and accurate fascicular matching is possible as opposing ends have a corresponding fascicular pattern.
2. Nerve ends are easily located in the wounds as there is no retraction and large wound extensions are not necessary.
3. Upto 72 hours, fascicular identification by intraoperative stimulation and electrical scanning techniques is possible.
4. In the acute stage the tensile strength of the epineurium is adequate but not a secure base for sutures, and therefore, sutures will automatically cut through if the tension is excessive. Thus, a tension free primary repair can be reliably provided. After 3 - 5 weeks epineurium strength increases due to fibrosis which can tempt the surgeon to suture the nerve under tension.
5. Primary repair should obviate the need for future surgery.
6. The period of distal denervation and patient incapacitation is minimal.

Results of primary repair are good only if it is carried out by a skilled surgeon. Otherwise the results of a properly executed secondary repair may be superior.

In a complicated nerve severence where the nerve injury is accompanied by extensive tissue destruction or wound contamination which foreshadows healing with excessive scarring, or else there is a gap in the nerve, a primary repair of the nerve is contraindicated for the following reasons.

1. Acute inflammation and oedema postoperatively would lead to nerve separation because of friability of epineurium.
2. In high velocity missile injury the proximal and distal damage may be considerable and difficult to estimate as features may not be visible externally. Therefore, a segmental loss will be difficult to bridge.
3. If there is a nerve gap which cannot be closed without mobilisation, repair will have to be deferred because wound extension for mobilising the nerve cannot be done when the risk of infection is high.
4. Scarring during the healing period in such injuries may involve the suture site resulting in constrictive fibrosis.

Optimal time of nerve repair in these situations is 3-5 weeks after the injury. Such a secondary repair provides,

1. Clear identification of the state of the nerve trunk in relation to its bed.
2. Easy delineation of the intraneural changes (fibrosis) incompatible with good regeneration. Therefore, accurate trimming of the nerve ends is possible.
3. Easier mobilisation and transposition of the nerve.
4. Better handling of the nerve is possible with thicker epineurium.
5. Repair as a planned procedure can be carried out unhurriedly.
6. Neurons are still in an optimal capacity for regeneration.

It should be understood that the presence of debris of Wallerian degeneration in the distal tubes doesnot in any way hinder the growth of regenerating axons.

When is Nerve Repair No Longer Worthwhile?

Even if a nerve injury has escaped attention for many years or else the repair has not been carried out previously for a variety of reàsons, nerve repair may still be justified provided the denervated muscles have been kept in good nutrition and function[15]. The reasons for this are,

1. The neurons retain their capacity to regenerate axons for several years.
2. Conditions in the distal stump present no impenetrable obstacle to the regenerating axons. Generally after 6 months of injury the results start to deteriorate but even after many years the axons have retained a remarkable capacity to grow and force their way down the atrophic endoneural tubes. No time limit can be attributed to this, as results have been acceptable even after many years.
3. The denervated muscles can survive and regain function even after a year, provided a sufficient number of axons are directed to the end organs and the quiescent muscle is maintained in good nutrition.
4. The maximal possible delay is unpredicatble, however, it is recognised that after 3 years there are less chances of an acceptable recovery.

TECHNIQUES OF NERVE REPAIR

End to End Repair Versus Nerve Grafting

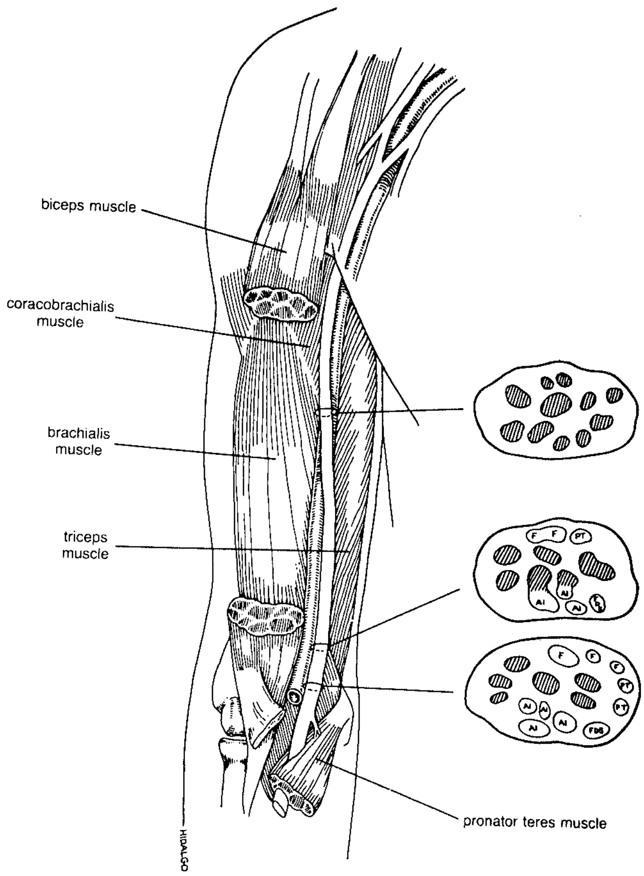
Before undertaking a nerve repair the following definitions of nerve defect and gap distance should be understood.

Nerve defect : It is the amount of nerve destroyed and not the distance ultimately separating the nerve ends.

Gap distance : This includes the amount of nerve destroyed, plus the degree of nerve retraction and the amount that would be sacrificed during trimming.

Gaps between the nerve ends can be bridged by slight stretching, mobilisation, transposition and limb flexion. It is necessary to draw a distinction between nerve gaps that can be closed by these techniques and are compatible with functional recovery, from those where nerve grafting would be necessary. Excessive tension in a nerve repair prejudices recovery by threatening structural and functional integrity, by compromising intraneural microcirculation and by aggravating scar formation. Therefore, two suture lines without tension are better than one suture line in considerable tension, although, it is even better to have one suture line in slight tension! Revascularisation of the nerve grafts can also pose greater problems than revascularisation of the suture site. In addition, autografting involves sacrifice of another nerve.

Having understood this, it is mandatory to identify the critical gap distance, i.e. the greatest gap that can be safely and consistently closed by end to end repair, and the results of which are superior to grafting performed under identical conditions. When measured with limb extension this distance is 3-5 cm for ulnar, median, peroneal and tibial nerves. Within this gap distance nerves may be repaired by end to end approximation, but using a combination of extensive mobilisation, transposition and acute limb flexion to achieve end to end union is dangerous and in such situations it is better to resort to nerve grafting. Bone shortening to achieve end to end union is an obsolete procedure.



Median nerve, upper arm. F = superficial flexor m.; PT = pronator teres muscle; FDS = flexor digitorum superficialis m.; AI = anterior interosseous nerve; o = mixed fibers.

(Fig-3)

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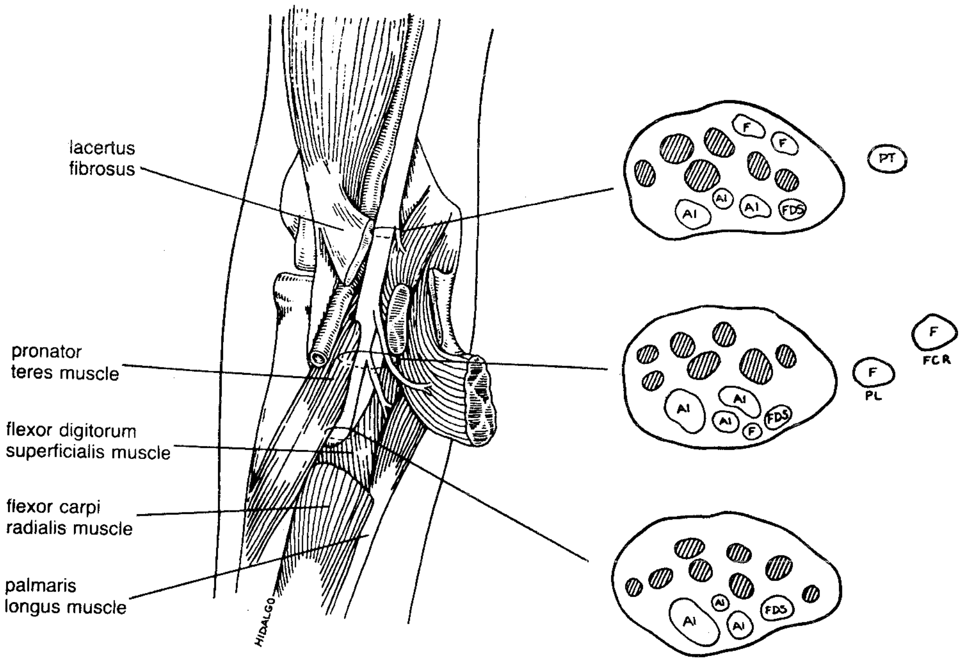
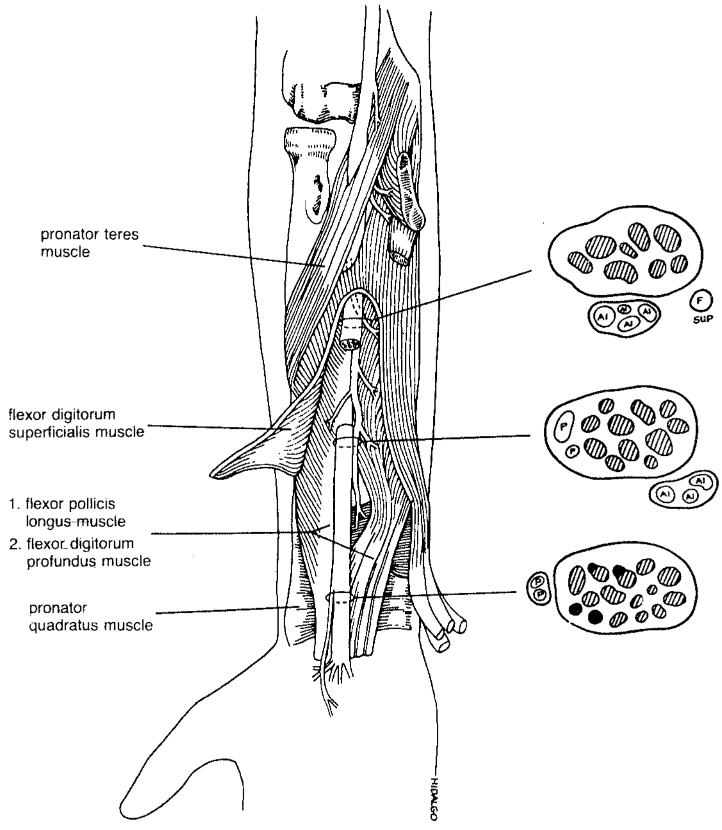


Median nerve, elbow. F = superficial flexor m.; PT = pronator teres m.; AI = anterior interosseous nerve; FDS = flexor digitorum superficialis m.; PL = palmaris longus m.; FCR = flexor carpi radialis m.; ⊘ = mixed fibers.

(Fig-4)



Median nerve, forearm. AI = anterior interosseous nerve; Fsup = flexor digitorum superficialis m.; P = palmar cutaneous branch; ● = thenar motor fibers; ⊘ = digital sensory nerves.

(Fig-5)

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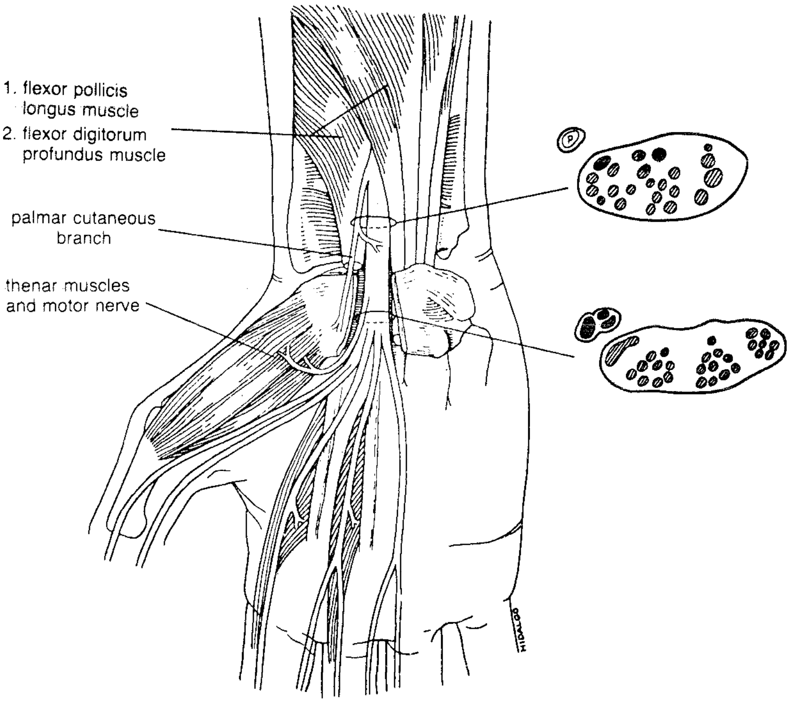
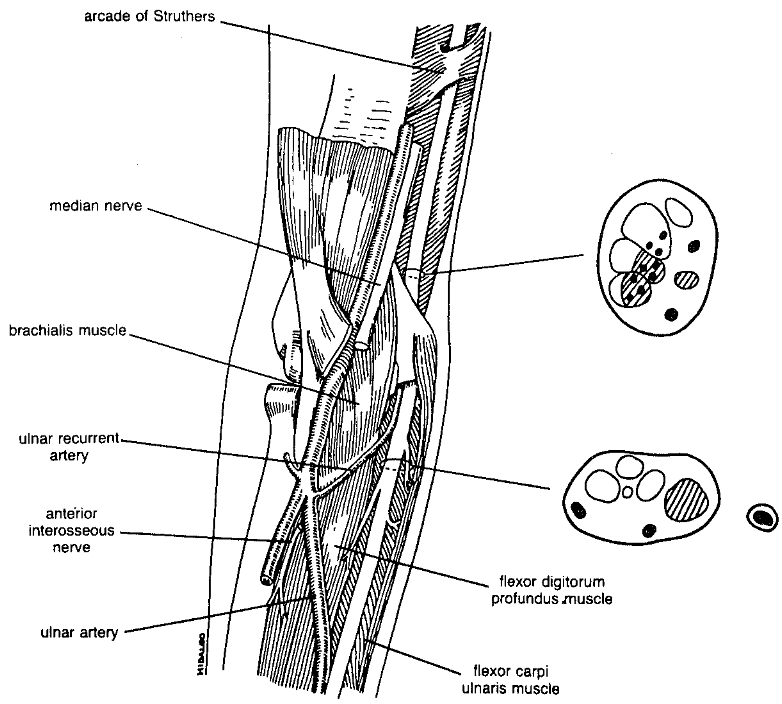


: Median nerve, wrist. P = palmar cutaneous branch; ● = thenar and lumbrical motor fibers; ⊘ = digital sensory nerves.

(Fig-6)



: Ulnar nerve, elbow region. ● = forearm fibers; ⊘ = dorsal cutaneous nerve fibers; ○ = mixed motor and sensory fibers to hand.

(Fig-7)

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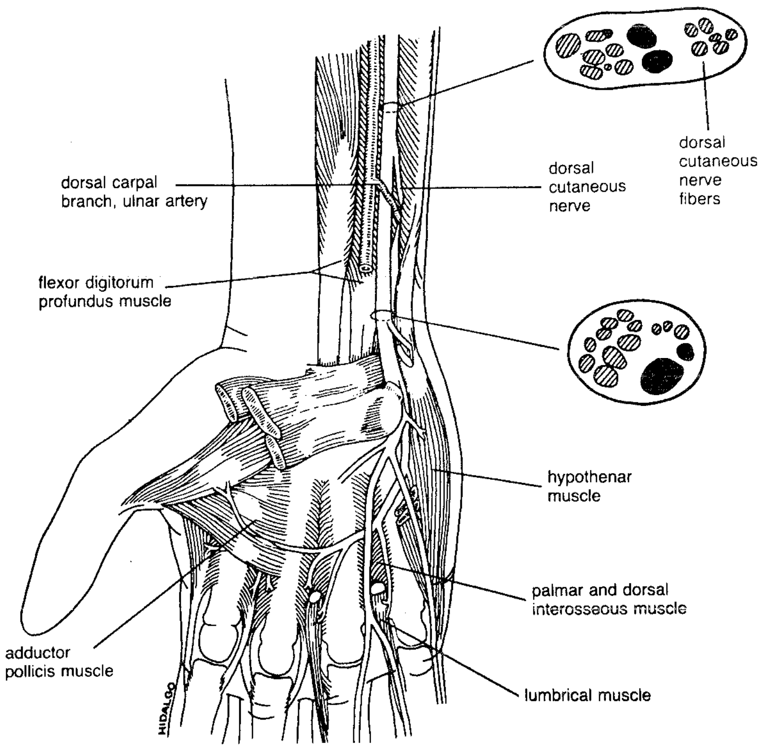

Ulnar nerve, distal forearm and wrist. ● = motor fibers; o = sensory fibers.

(Fig-8)

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The maximum permissible range of joint flexion to achieve end to end union is 30 degrees at wrist and 90 degrees at elbow and knee. Great tension is introduced when the limb is extended following healing, and therefore, these limits of flexion cannot be transgressed. Even within these limits extension following nerve repair is only commenced after 4-6 weeks, gradually achieving full extension at wrist in 3 weeks and at elbow or knee in 4-6 weeks. Traction damage during extension from flexion-posture occurs not only at the suture site but at other levels also, because after healing the suture site attains the same tensile strength as the rest of the nerve.

Tenets of End to End Repair

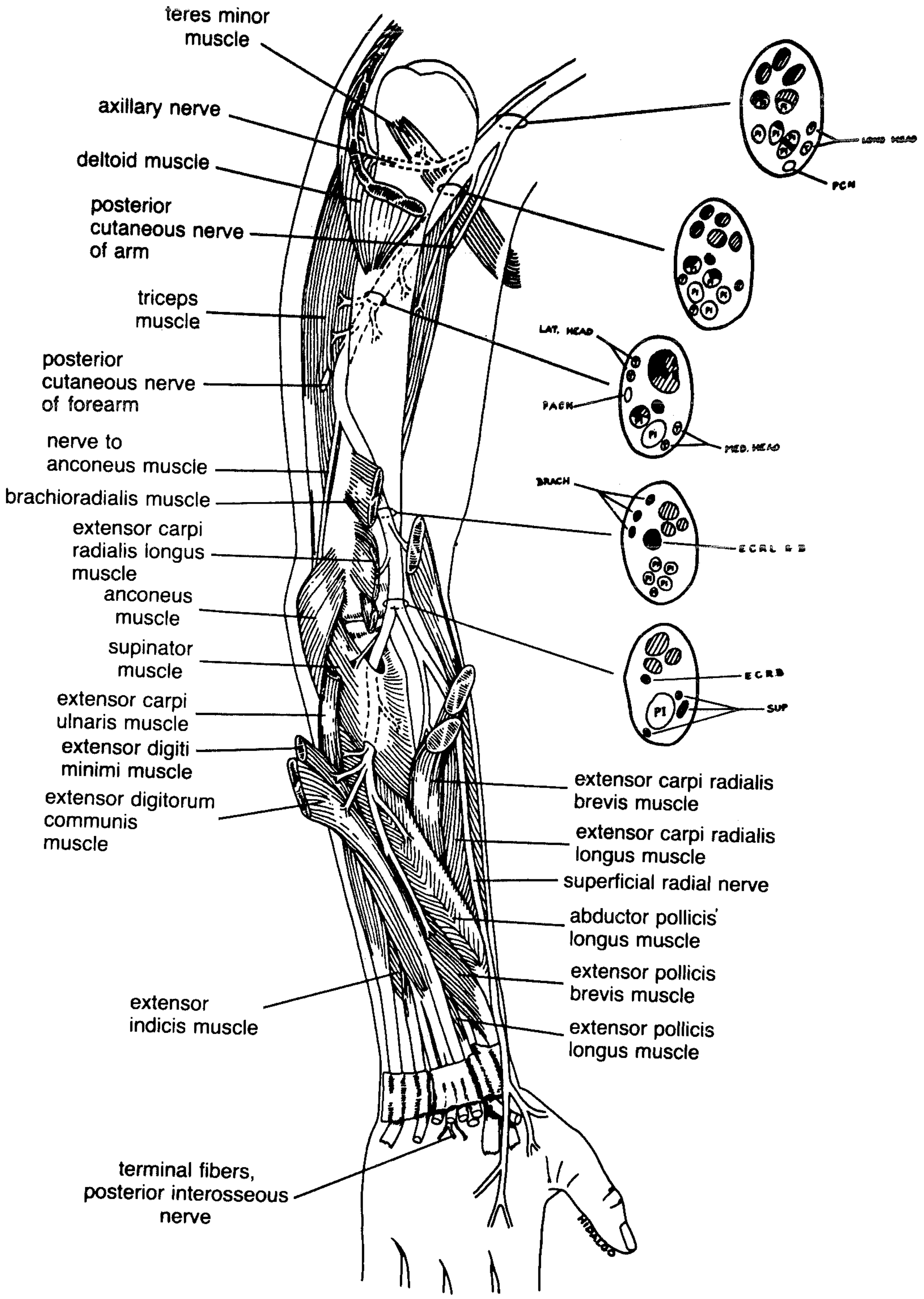
The surgeon is always the best judge of the situation in a particular case. It is not a question of whether an end to end repair is possible, but whether it should be done for the given patient or else nerve grafting should be resorted. The following guidelines can help in achieving a good end to end nerve repair[2].

1. Have a thorough knowledge of the anatomical structure of the nerve, including the fascicular pattern of important nerves at various levels.
2. Avoid extensive mobilisation as it will devascularise a segment of the nerve.
3. Avoid acute joint flexion.
4. Approach the injured area from the unscarred site.
5. Use extreme judgement when resecting the nerve ends for freshening.
6. Define your indications for epineural and group fascicular repair.
7. Have a tension free but secure suture line.
8. Use magnification for all nerve repairs.
9. Use a minimum number of ultrafine suture for repair.

Role of Microsurgery

There is much substance in recommendations that all nerve repairs must be carried out under magnification. Generally 4-6 times magnification provided by loupes is sufficient. Distinct advantages of this technique are,

1. It makes internal neurolysis easier.
2. It provides improved alignment and fascicular opposition.



Radial nerve overview. PI = posterior interosseous nerve; T = triceps muscle; PCN = posterior cutaneous nerve; PACN = posterior antebrachial cutaneous nerve; Brach = brachioradialis muscle; ECRL & B = extensor carpi radialis longus and brevis muscles; Sup = supinator muscle; ● = motor fibers; ⊘ = sensory fibers.

(Fig-9)

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3. Sharp definition of the healthy and devitalised tissue is possible.
4. It facilitates the use of ultrafine sutures.
5. It makes group fascicular repair possible.

Epineural Versus Group Fascicular Grafting

Each type of nerve repair has definite indications and the established criteria are not interchangeable[16].

Epineural repair is the procedure of choice for a clean severence. The fascicular pattern here is identical between the two ends and it provides correct alignment. It is also undertaken where fasciculi even if mismatched are closely packed, so that loss of axons into interfascicular tissue is minimal[16]. Advantages of end to end repair are that it is an easy technique, it provides excellent functional recovery by maximising the entry of axons into distal stumps, there is minimal loss of the regenerating axons into the surrounding tissues, correct co-axial alignment can be provided, and it can hold the ends under slight tension with fewer sutures.

Group fascicular repair is done for a gap in the nerve where a fascicular branch localisation is present to provide some alignment. When it is certain that by epineural repair the fascicular tissue of the proximal end would get opposed to interfascicular tissue at the distal end it is best to align the fascicles as far as possible. When there is a risk of the sensory fibres entering the motor distal ends, or vice versa, fascicular alignment is necessary. In nerve grafting procedures best results are always obtained by fascicular alignment to minimise the loss of regenerating axons. Certain disadvantages of group fascicular repair are that it can only be done by an experienced and skillful surgeon, it is tedious and time consuming, absolute tension free repair is required, and a large number of sutures placed internally, which even if fine, promote scarring and has a detrimental effect on return of function[17].

Nerve Grafting

Nerve grafting restores the continuity between the cut ends of the nerve by bridging the defect and taking advantage of the remarkable capacity of the axons to regenerate. It provides a structural framework to the growing axons and not only guides them to the distal stump but does it in a manner that is closest to restoring the original pattern of innervation. This reduces the loss of growing axons. Nerve grafting is the most superior mode of bridging a nerve gap of more than the critical gap distance. Axonal growth through the nerve grafts is orderly and there is an improved prospect of return of function. It is also felt that the nutritional needs of the growing axons are better met in a revascularised graft. Whether, the nerve graft also provides some neurotropic agents that guide the directional growth of the axons, is still a debatable issue. However, nerve grafting is quite an exacting procedure if good results are to be expected. Not only is it technically difficult but the cases where nerve grafting is involved are generally severe injuries .It also entails placing two suture lines and sacrifice of another nerve[18].

Selection of a nerve for grafting

Only cutaneous nerves are generally selected for grafting as their sacrifice leads to minimal sensory deficit. Nerve selected should be readily accessible, constant in position, and have an available length longer than the gap. Each strand of the cable used should be free of branches.

Cable vs Full thickness grafting

Full thickness grafting, where the diameter of the nerve graft is equal to or exceeds the diameter of the recepient nerve, is technically easy, but it is impossible to find a suitable nerve to match the calibre of a large nerve. Cable grafting, by multiple strands of nerve graft of thinner diameter, has to be used in majority of cases. A major problem of full thickness grafting with a larger diameter nerve is the poor revascularisation of the graft from the bed, leading to central necrosis within the graft. Also, the fascicular structure of the larger diameter graft is such that it lends to considerable shift of fibres from one sector to another whereas in a single or bifascicular nerve graft the regenerating axons are confined to the same strand only without any shift. Hence, cable grafting is more practical in large diameter nerves[19].

When to abandon nerve grafting?

Length of the graft required is a limiting factor. A large nerve defect associated with severe injury which otherwise entails poor prognosis should not be considered for nerve grafting. Besides the problem of obtaining sufficient donor nerve, the problem of two suture lines at a considerable distance worsens the prognosis. In such severe injuries the nerve bed is also damaged to an extent that revascularisation is delayed. In these injuries the options of nerve crossover or a free vascularised nerve grafting should be considered.

Free vascularised nerve grafting[19]

This involves the use of a nerve graft harvested alongwith its mesoneurium and a named vessel (with venae comitantes). Circulation through the mesoneurium is reestablished by microsurgical anastamosis at the recepient site. Although, this is indicated in large nerve defects with scarred beds, there are conflicting reports in literature about its possible merits. The theoretical advantages of faster regeneration, better survival and faster removal of myelin debris are offset by the severe nature of injury where they are indicated and by the need to sacrifice a large and important nerve. Superficial radial nerve with radial artery has been the most commonly used nerve for this purpose.

Nerve crossover[19]

A normal nerve is partially or completely sacrificed for reinnervating the distal segment of another irreparably injured nerve. The procedure has limited application as a suitable normal nerve is not always available in the vicinity and the reinnervation which ultimately takes place is incomplete and imperfect. Hypoglossal - facial nerve crossover has been the most successful of this form of reinnervation and that too is employed with the least priority in the management of facial paralysis.

Care of the injured extremity[20]

This includes avoidance of extremes of temperature, prevention of pressure sores and physical therapy.

Physical Therapy

Physical therapy is aimed at prevention of joint stiffness and deformity, minimising muscle atrophy, and reeducation of the muscles after reinnervation. Physical methods include active and passive excercises, limb elevation to reduce oedema, splintage in position of function, massage and heat treatment to improve circulation. Electrical methods include galvanic stimulation to decrease muscle atrophy. The current should be strong enough to elicit a forceful contraction. The frequency of application should be 30 times per minute for a single muscle, repeated for three sittings in a day.

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