# Timing and Technique of Peripheral Nerve Repair

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#### Summary

Surgery of the peripheral nerves is briefly reviewed with special emphasis on the timing and the techniques of nerve repair.

The sooner a severed nerve can be repaired, the better the quality of the recovery. While delays of a few months after injury appear to have no serious effect on the outcome of nerve sutures, the chances of successful recovery decline after six months. It is not common for markedly good recovery to follows nerve suture a year or more after injury. Investigation of the local neuropathological factors and the metabolic changes within the neuron suggests that, in the divided nerve, the interrupted fascicles should be sutured as soon as the longitudinal extent of the injury can be accurately determined. A short delay in nerve repair, however, is often indicated when successful regeneration of the budding neuron across a repair site is thought possible. The possibility for recovery of a lesion in continuity can be predicted eight to twelve weeks after injury by recording nerve action potentials. Nerve action potential recording in the early months after injury allows identification of partial injury and the neuroapraxic element of an injury. It also provides a measure of relatively early regeneration.

The traditional method of repairing peripheral nerves has been the epineurial suture. Concern over the reaction to suture materials which might interfere with nerve regeneration resulted in the search for sutureless methods of uniting the nerve ends. Plasma clot maintains the nerve ends in apposition and does not appear to set up any reaction, but it is absorbed before natural healing has effected a firm union at the nerve ends. Sheathing methods have been designed to hold the nerve ends together and protect the junctional zone by an encircling tube of biological or non-biological materials, and at the same time confine regenerating axons to the suture line by preventing them from straying further afield. None of these methods has eliminated the malalignment of axons and is suitable for large nerves or nerve sutures with a tension on the suture line.

A good epineurial closure does not always mean that all of the internal architecture of the nerve has been restored. Funicular nerve suture to improve the results of nerve repair was discussed by Langley and Hashimoto as early as 1917. By careful approximation of the corresponding fascicles, this method can improve the quality of the recovery after nerve suture by preventing the wasteful regeneration of axons outside funiculi and their entry into functionally unrelated endoneurial tubes. With the increasingly wide use of the operating microscope in neurosurgical practice, it is now clear that this method can be applied more generally.

Key words: Peripheral nerves

# Introduction

We are not certain when surgical treatment of peripheral nerves was first attempted. On the basis of a reference made to Hypocrates' remark that "when the nervous system is cut, it does not repair itself neither does it reunite," it is assumed that such an operation had already been carried out at that time. The concept of "nerve," however, was so indistinct that any whitish tissue, such as tendons and ligaments, was called a "nerve". Apart from the reliability or achievement of the surgical technique, it is implied that operations on peripheral nerves were a matter of primary concern for surgeons from ancient times. From our literature search, it appears that Brown-Séquard<sup>1)</sup> made the first report on surgical technique applied to nerves. He described a case of hypoglossal neuralgia in which the hypoglossal nerve was excised and the optic nerve was transplanted into the defect. Considering that nerve transplantation was described in this report, peripheral nerve suture can be traced back at least this far.

It is often said that during wars, medical science makes rapid progress in every field, especially in the field of surgical techniques. Peripheral nerve surgery is one of those which have made great progress. In England, the Committee on the Injury of the Peripheral Nerves was inaugurated in the British Medical Research Council as early as the First World War, and the Committee published its first report in 1920.9) In Germany, a similar report was published in the following year.<sup>8)</sup> By reference to these reports, it is clearly seen that the basic technique of epineurial suture, which is now commonly employed, had already been established at that time. The method of epineurial suture was described in which the cut ends of the nerves were completely renewed, and only the epineurium was sutured in such a way that the rotation of the nerves could be avoided by means of guide sutures (or orientation sutures). Moreover, a number of problems concerning the surgery of the peripheral nerves were undoubtedly proposed earlier than 1920. These include topics such as: surgical techniques for the extension of nerves by means of various techniques, nerve suture in combination with bone resection, non-suture methods, transplantation of peripheral nerves, and neurolysis. Special emphasis has been placed on such surgical techniques as funicular suture (or perineurial suture) and fascicular perineurial neurolysis (or internal neurolysis), which are still under investigation.

# Classification

For classification of injuries of peripheral nerves, Seddon's method has been generally

used.<sup>13,14</sup>) Neurotmesis ( $\tau \mu \eta \sigma i \zeta$ , a cutting which implies a separation of the related parts) means a state of the nerve in which the peripheral nerve is either completely severed or in which in spite of the connection, the nervous tissue is so severely disorganized by the scar tissue that complete nervous paralysis is observed. In that case, an operation is mandatory because spontaneous regeneration is out of the question, but even surgical treatment cannot be expected to bring about complete recovery of nervous function for reasons to be discussed below. Neurotmesis can be caused by an incised wound, contused wound, bullet wound, traction injury, injection of noxious drugs, or ischemia. Axonotmesis indicates a state of injury of only the axons and their myelin sheaths, while the connection is maintained in such connective tissues as the endoneurium, perineurium, and epineurium. Since total degeneration of the axis-cylinders occurs in the periphery of the injured site, loss of perception and paralysis of motor functions are as complete as after severance of the nerve. However, regeneration occurs spontaneously and is of excellent quality because the intact endoneurial tubes guide the outgoing streams of axoplasm to their proper peripheral connections. Simple axonotmesis can be experimentally produced by crushing the peripheral nerve with pointed forceps. Clinically, axonotmesis can be caused by bullet wound, bone fracture, traction, long term pressure, injection, or ischemia. Neuroapraxia ( $\dot{\alpha}\pi\rho\alpha\xi i\alpha$ , non-action) means a state of temporary suspension of nervous function. This state is often caused by a bullet wound, traction or momentary pressure. Motor paralysis which is usually complete, but with only partial sensory loss and little or no disturbance of autonomic function, is characteristically found. The essence of the pathological findings of neuroapraxia is considered to be a selective demyelination resulting from injury of comparatively large nerve fibers.

According to Seddon's classification, neuroapraxia can be easily differentiated from neurotmesis and axonotmesis. However, both neurotmesis and axonotmesis are manifested by complete paralysis of nervous function, so that differentiation between them cannot be made without behavioral observations during the period when spontaneous recovery could occur. Furthermore, axonotmesis can naturally heal without any operation and function can completely recover; on the other hand, neurotmesis cannot be cured even by means of an operation and complete recovery of function cannot be expected. Accordingly, differentiation of these two types of injury is of the utmost importance from a clinical standpoint. Recently, Samii<sup>12</sup> isolated individual nerve fascicles using an operating microscope and classified the degrees of injury of the peripheral nerves at a chronic stage into three types on the basis of the presence of injury of the nerve fascicles.

## Timing of the Operation

Based on the results of clinical experience and fundamental research, various studies have been made on a number of factors determining the results of the operation on the peripheral nerves. The two main factors are found to be the patient's condition and doctor's experience.<sup>11</sup>) With regard to the patient's condition, the results of operations on pure motor nerves or pure sensory nerves are better than those on mixed nerves. The prognosis in younger patients is better than that in older patients. The more peripheral the site of the injury, the better is the result. The smaller the length of lost nerve, the better is the result. Concerning associated injuries, matters of concern are infection and injuries of such organs and tissues as bone, muscle, tendon, and blood vessels. Incidentally, the two factors which depend on the doctor, i.e., the timing of the operation and the surgical technique, depend on the doctor's judgement and experience. Consequently, endeavors to improve the results of surgery of peripheral nerves have been concentrated on these two factors.

With regard to timing, there are two methods, i.e., the primary suture and the secondary suture. In the former, the nerve suture is carried out immediately after an injury, and in the latter, the nerve suture is carried out once the wound has healed. Both have merits and demerits. Reference to the literature suggests that the decision of the timing of the operation has not been made following consideration of which of the two sutures would give better results, but rather that it depended mostly on such extramedical conditions as the time necessary to reach the patients, or prepare to receive the patient at a hospital where neurosurgeons are present. During the First World War, the secondary suture was carried out three to six months after the injury as a matter of principle.<sup>8.9)</sup> During the Second World War, early secondary suture was usually carried out about three weeks after the injury, because the transportation of patients became rapid.<sup>14,16)</sup> The results of the operations during the Second World War were remarkably improved as a consequence of the rapid progress in surgical science between the two world wars.

More recently, the issue of the timing of operations has been debated from largely different viewpoints. Firstly, the histological findings in the process of nerve regeneration at the injury site have been clarified by sequential observations.<sup>6)</sup> When a peripheral nerve is cut, demyelination and retrograde degeneration of the axis-cylinders of a short length develop centripetally from the injury site. Two or three days later, a remarkable proliferation of Schwann cells is observed. Then numerous processes of the regenerating axons extend peripherally, but it takes one to four weeks for the processes to pass across the injury site. After the regenerating axons enter the peripheral endoneurial tubes, they regenerate at the rate of about 1 mm/day. From these findings, it might be concluded that it is better not to carry out the early secondary suture until Schwann cells, which can induce the regenerating axons, proliferate sufficiently, than to carry out the nerve suture immediately after the injury. Secondly, owing to the recent progress in basic research, the rate of protein metabolism in the nerve cell body has come to be determined histochemically, as well as by the use of radioisotopes.<sup>3)</sup> After a peripheral nerve is injured, changes in protein metabolism in the nerve cell body is contrasted with the histological evidence of chromatolysis. Findings of recovery from chromatolysis are obtained at the mature stage of nerve regeneration; protein metabolism in the nerve cell body is found to be accelerated at the same time.5) Protein synthesized in the nerve cell body is carried to the periphery by axoplasmic flow, which maintains the function and shape of the

peripheral nerves and participates in regeneration of the nerve when necessary. When the nerve is cut, however, the axons are shortened. The demand for protein metabolism necessary to maintain the axis cylinders decreases. Consequently, the rate of protein synthesis in the nerve cell body decreases immediately after the peripheral nerve has been injured. At the next stage, the regenerating axons pass across the site of the injury and extend into the endoneurial tubes. The axis-cylinders in this stage are small in diameter and nonmedullated for the most part. Accordingly, remarkable increases in the protein metabolism in the nerve cell body are not found, and the rate of protein metabolism remains decreased. Incidentally, there is a theory that chromatolysis, which is seen in the nerve cell body at this stage, is morphological evidence indicating the acceleration of the regenerative ability of the nerve. However, there is another opinion concerning the functional significance of chromatolysis, i.e. that the function of chromatolysis is degenerative and not hyper-regenerative. The details of this problem will be omitted in the present discussion. With progressing nerve regeneration, the regenerating axons finish the recombination with the end organ and become larger in diameter at the mature stage when the myelin sheath formation becomes active. The rate of protein metabolism in the nerve cell body becomes accelerated in this stage of nerve regeneration.<sup>5)</sup> In the light of the observations on the rate of protein synthesis, it is considered to be injurious to the regenerative ability of the nerve cell to carry out a delayed secondary suture and to cut again the end of the proximal nerve stump. Therefore, the early secondary suture is supported by surgeons, because the nerve suture is carried out at a stage of chromatolysis before the mature stage.

Methods of electro-physiological examination, such as the recording of electromyograms and nerve action potentials, and the estimation of the rate of nerve conduction velocity and chronaxie, are used for evaluating nerve regeneration in clinical practice. When nerve action potential is recorded immediately after an injury or within two or three months after a nerve suture, the nerve injury is considered to be a partial injury of the neuroapraxia type, and significant regeneration of the nerve can be expected. If trans-lesional conduction of the nerve action potential is ascertained during operation, resection of neuroma on the occasion of the secondary suture is considered to be completely unnecessary.<sup>6)</sup> However, this method can not be used except when the regenerating axons extend across the injured site and toward the periphery to a considerable extent. In view of these conditions, it is best to carry out the secondary suture eight to twelve weeks later. If the secondary suture is delayed more than six months, the formation of a scar and the involution and degeneration of the peripheral end organ will occur, producing other problems. In particular, the results of the secondary suture which is delayed for more than one year become extremely poor.

On the basis of the accumulated knowledge from basic research and clinical experience, secondary sutures including the early secondary suture have come to be carried out more generally. However, most peripheral nerve injuries are no longer war-time wounds, but rather peace-time injuries. Cut wounds account statistically for more than 80% of the injuries of peripheral nerves, and glass-cut wounds or simple cut wounds without crushes represent most of the injuries. On the other hand, progress in transportation has led to rapid conveyance of patients to well-equipped hospitals, so that operations have come to be carried out within a few hours after injury. The use of antibiotics as well as the washing of wounds decreases the danger of infection even with the lapse of eight hours or more, so that the chances for performing primary nerve suture have increased.

The following problems have been previously pointed out as demerits of primary nerve sutures:<sup>11)</sup> (1) It is difficult to determine the extent and degree of the lesion immediately after the injury. (2) The epineurium is so thin that suturing is difficult with cracks accompanying the suture. (3) The proliferation of Schwann cells has not yet started although it is necessary to induce regenerating axons by connecting the ends of the upper and lower stumps of the peripheral nerve. (4) Measures to protect life and maintain the extremities intact take priority over treatment of the peripheral nerve, considering that the peripheral nerve injury itself does not influence the maintenance of life. (5) The danger of infection is thought to be large.

On the other hand, the greatest merit of the primary suture is the simplicity of carrying out the end-to-end anastomosis because in this stage there is no contraction of the nerve end nor adhesion with scars around the nerve trunk. The use of microsurgery brings about an enlarged view of the nerve bundles so that it is possible to determine the extent of the injury.<sup>12)</sup> The state of the epineurium largely does not come into question, because the perineurial suture is carried out using very thin sutures. Especially in case of a funicular suture, the primary suture is much easier to carry out than the secondary suture, since the funicular suture is carried out by microsurgical procedures in which the upper and the lower ends of the funiculi corresponding to each other are confronted and sutured. Many of the problems which have been considered to be demerits of the primary suture have been gradually solved, as mentioned above. As a result, the primary suture has been recently used preferentially for operations on fingers because of the difficulty of employing the secondary suture, and also for operations on infants, where there is still regenerative ability. It is thus expected that with the spread of microsurgery, the chances for primary nerve suture will increase.

### **Operative Technique**

The second factor which influences the results of operations on peripheral nerve, is the operative technique of the nerve suture itself. The basic technique of epineurial suture, which is now used most commonly, is, as mentioned above, thought to have been established earlier than 1920. This method has been continued for more than half a century without modification. This does not mean, however, that no new methods have been devised because this method had been thought to be the best method of nerve suture. As a matter of fact, several new methods of nerve suture were devised in that period, and some of them were employed to a considerable extent at certain times, but they have not been used to such an extent as to gain general support. Currently, the method of epineurial suture is still used as the standard technique.

Nerve suture brings about a proliferation of reactive connective tissue, but the extent depends upon the quality and quantity of the suture materials used. Excessive proliferation of connective tissue presents a major obstacle to nerve regeneration. Ordinary suture materials such as silk or catgut have been used for epineurial sutures, but these kinds of sutures cause marked proliferation of connective tissues. Accordingly, wax or silicone is applied to silk sutures in such a way that the silk will not make a direct contact with the tissues. Human hair has also been used in place of the silk suture, but it has been found that considerable reaction is still brought about by these methods.<sup>4)</sup> Subsequently, new methods were devised to perform nerve suturing without any suture material which is a foreign body. One of the methods is the plasma clot method.<sup>18)</sup> In this method, the space between the upper side and the lower side of the ends of the cut nerve is filled with the patient's own plasma. which is coagulated by the addition of fibrin. One of the reasons that Seddon and others produced such excellent results in the treatment of injuries of the peripheral nerves during the Second World War is that they employed this method. However, the main demerit of this method is that the anastomosed site of the nerve is weak in traction. There is another method worthy of special mention as an alternative to the non-suture methods. It is called the wrapping method or tubulation method, in which the anastomosed site of the nerve is covered with a tube or thin film.<sup>19)</sup> In this case, it is necessary to employ materials producing little reaction, such as a film or tube. Materials include those from the living body, such as an arterial tube, venous tube, collagen film, and dura mater; and foreign bodies, such as rubber, millipore-film, and silicone film. At the time when the proliferation of connective tissues was ascribed to fibroblasts around the nerve tissue, it was expected that by the use of the wrapping method, the connective tissue of the anastomosed site might be inhibited from proliferation, and simultaneously that the regenerating axons might be protected from straying out of the nerve bundles. However, it was found that the connective tissue of the anastomosed site comes mainly from the epineurium. Other demerits were also found,

i.e., a long time after the covering materials were imbedded, the degeneration or contraction of the materials occurred and resulted in compression of the nerve from the outside. In addition, when the materials became fragile or were broken, they caused scar formation.

Since the epineurium is not tightly connected with the funiculus, there is some mobility between them. However well the epineurial suture may be apparently finished, the inside funiculi do not necessarily correspond to each other, and such conditions as off-sets, gaps, and kinking are often found.4,15) Perineurial suture is the method of nerve suture which avoids such demerits by directly suturing the perineurium of each funiculus. This method is by no means new; in 1917, Langley and Hashimoto<sup>7)</sup> described the details. According to their report, the perineurial suture is advantageous for the functional regeneration of the nerve, if it is possible to suture separately each funiculus which has an independent function in the nerve trunk. Incidentally, some demerits of the perineurial suture are also described as follows: It takes a long time to perform perineurial suture; nerve regeneration is prevented by vascular lesions of the suture site; and the proliferation of connective tissue is accelerated. The performance of such operations without any suitable magnifier must have been very difficult at Langley and Hashimoto's time. However, the most essential demerit of the perineurial suture is that the respective funiculi corresponding to each other are not always identified during the operation.<sup>7)</sup> When the identification cannot be reliably made, the perineurial suture should not be carried out. Although the perineurial suture has drawn the attention of surgeons for many years, it has not come to be widely used owing chiefly to its technical difficulties. With the spread of the surgical microscope as well as with the development of surgical instruments and especially very thin sutures, recently this method has again come to surgeons' attention, and a number of new modifications have been added.17)

The morphological changes in the early stage of regeneration of peripheral nerve have been observed sequentially. Following the separation of fibrin, Schwann cells proliferate remarkably although they were originally very sparse, and then they extend from both ends of the cut nerve, especially from the peripheral end. Subsequently, they join together and make a bridge of Schwann cells. Simultaneously, a number of regenerating axons extend from the nerve fibers which were originally in the form of a single piece, and they continue to extend along the surface of the cells of Schwann's tube toward the periphery. At first, a number of the regenerating axis-cylinders run in contact with the surface of the Schwann cells, and then one of them is taken into a Schwann cell. Thereafter, only this axon keeps growing and becomes thick in diameter. Schwann cells envelop this axis-cylinder to form a myelin sheath around it. In summary, several pieces of thin regenerating axons enter the Schwann's tube through which only a single piece of axis-cylinder originally passed. Finally, only one of several pieces of thin regenerating axis-cylinder is found to have become thick. In other words, when the axiscylinder is regenerated, the axoplasm puts out a number of pseudopods and extends in every direction. Thereafter, the axoplasm is gradually induced into Schwann's tube. However, some of the regenerating axons enter the space between the nerve fibers or into the connective tissues outside the funiculus, and others extend from the epineurium to the outside connective tissues. With respect to the mixed nerve, it is assumed that some of the regenerating axons successfully enter Schwann's tube with a particular function or that the others are induced into Schwann's tube with a different function. The regenerating axons which stray into the connective tissues cannot reach the peripheral end organs and disappear on the way. Incidentally, the regenerating axis-cylinders which enter Schwann's tube with a different function are thought not to show the development of nerve function even though they reach the periphery, as in the case when a sensory nerve reaches the muscle, or when a motor nerve is regenerated and reaches the skin. What kind of sensation is produced, when the nerve fiber for a tactile sensation enters Schwann's tube for a sense of pain, etc. remains to be determined. In any case, functional regeneration of the nerve is disturbed to a considerable extent when such a misconnection develops at the site of the nerve suture.

There is one question in which our interest

is particularly aroused: By what kind of mechanism do Schwann cells, make selections and how do the cells take in only one piece of regenerating axis-cylinder out of a number of regenerating axons at the initial stage of their regeneration. It can be assumed that the selection is made by a very reasonable mechanism—autotropism—from the viewpoint of functional regeneration. When autotropism is in action, the selection is not made indiscriminately, but only the regenerating axons which can be quickly recombined with specific end organs in the periphery are taken into the Schwann cell and then continue to grow.

It is ideal but technically impossible to identify the respective nerve fibers corresponding to each other, and to unite them again in order to avoid a "misdirection" at the site of the nerve suture. Accordingly, the method of funicular suture is used for the suture of the respective funiculi of the nerve trunk. The method is considered to be theoretically sound and practically feasible. Funiculi in the nerve trunk join together and separate from each other ceaselessly and repeatedly. The funicular pattern sometimes shows remarkable changes, especially at sites near the central nervous system. Accordingly, it is not always easy to identify the corresponding funiculus during the operation.<sup>17</sup>) Furthermore, if a mistake is made in the selection of a funiculus resulting in a wrong funicular suture, the functional regeneration of the nerve is markedly disturbed. When the misconnection is made among funiculi which are destined to reach the end organs of similar or synergistic functions, severe disturbance of the nerve function is not produced. When, however, the suture of funiculi which have functions antagonistic to one another is performed, postoperative reeducation is necessitated even though the misconnection is made among motor nerves only. When the funiculus of a motor nerve and the funiculus of a sensory nerve are sutured by the method of funicular suture, neither of the nerves shows regeneration of function. Therefore, funicular sutures should not be performed when it is impossible to identify with certainty the corresponding funiculus during the operation. As the nerve fibers do not always run parallel to one another inside individual funiculi, even if the corresponding funiculi are reunited carefully so as not to be rotated, the recombination of the original nerve fibers is quite at random. Using the present surgical method, misconnection is inevitable to some extent, regardless of the technique employed. It has often been reported that anatomical regeneration of 70 to 80% can be expected when the ordinary epineurial suture is used. Excellent recovery of function has also been reported. In view of the facts described above, it is suggested that autotropism participates in the recovery of nerve function, although the extent of participation of the autotropism is not now clear. On the assumption that sufficient functional regeneration is taking place through the mechanism of autotropism, the epineurial suture should be carefully performed so that there is no rotation and so that both cut ends can adhere to each other. The recovery of function following the epineurial suture will generally not be worse than that of the perineurial suture. Therefore, surgeons should master the standard surgical technique of epineurial suture before they try a new technique.

According to a number of results from clinical experience and fundamental research, it is necessary to pay attention to the following points when suturing the peripheral nerves. (1) The nerve tissue should be handled gently so as not to injure it; it is advantageous to use a magnifier. (2) The cut ends of the nerve should be appositioned exactly; it is especially necessary to attach the sections of funiculi to each other. (3) Tension at the suture line during and after the operation should be avoided. (4) Suture materials which do not cause foreign body reactions should be employed. Among these points, items (1), (2) and (4) are considered to have been almost solved by the use of microsurgery. In the case of a large defect, the immediate performance of an end-to-end anastomosis leads to the problem of excess tension. Accordingly, techniques for nerve extension and the means of making up the gap are necessitated. Methods such as lateral implantation, pedicle graft and nerve flap were devised as methods of nerve extension, but recently these methods have come to be used less frequently on account of the poor functional regeneration of nerves. Particular techniques of transferring the ulnar nerve to the median nerve and the nerve-crossing technique of transferring the intercostal nerve to the musculocutaneus nerve have been performed at times.

#### Transplantation of the Nerve

When the defect of an injured nerve is made up by transplantation of a suitable nerve, the problem of the tension can be solved. Two problems are, however, confronted: (1) What type of graft should be used and (2) How can the demerit of having two sites of nerve suturing be overcome. With respect to the second problem, Samii et al.<sup>12</sup> have recently found that the regenerative rate of the nerve in the case of autogenous grafting is higher than that in the case of the end-to-end anastomosis. The difference is ascribed to a reduction in tension. When a surgeon is sufficiently experienced in the surgical technique, the two suture lines may not constitute a significant demerit.

In terms of the kind of graft, none of the functions inducing the regenerating axons has been found in any graft although the results of various graft materials other than the nerve tissue have been taken into account. In the case of xenografts, the tissue reaction is so violent that no combination has been found which induces useful regeneration of the peripheral nerve even in animal experiments. Since the implant work of Medawar et al. on the phenomenon of allograft immunity, various kinds of allografts have been tried, and somewhat successful cases have been reported in clinical experience as well as in animal experiments. Injury of peripheral nerves themselves has not influence on the maintenance of life. Therefore, even in the case of allografts, methods for inhibiting allograft immunity, i.e., whole body application of metabolic inhibitors, have seldom been employed. Most efforts have been to reduce the antigenic property of the graft by means of chemical and/or physical treatment of the graft.

In the case of autografts, it is not necessary to consider the difficult problem of graft immunity, but generally it is very difficult to collect a nerve graft of the same thickness as that of the injured nerve. Peripheral nerves which can be used as grafts without producing serious deficits are very thin nerves such as intercostal nerves or cutaneous nerves. When the epineurial suture is used, it is impossible to suture nerves of markedly different thicknesses. However, when the perineurial suture is used, it has become possible to make a nerve suture which employs a piece of cutaneous nerve as a graft corresponding to one piece or several pieces of funiculi. Recently, Samii<sup>12)</sup> and Millesi<sup>10</sup> have reported a number of clinical cases using interfascicular autologous nerve grafts, and they maintain that the results of this method are better than those of various other methods for peripheral nerve operations. However, follow-up studies in support of their results have not yet been reported. Further studies on this method are necessary, not only with respect to the rate of anatomical regeneration but also with respect to functional regeneration.

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