PARTIAL RESECTION OF MOTOR NERVES IN SPASTIC PARALYSIS.

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The restoration of function in cases of spastic paralysis demands frequently a long continued treatment by developmental and educational exercise. A greatly defective balance of muscles and an actual contracture of joint may render rational exercise difficult, if not impossible, and may require surgical interference. Until recently, operations on the tendons and muscles were practically the only operative procedures used in these cases, but within the last few years operations on the nervous system directly have been devised in various ways.

Such operations are:
1. The resection of the posterior roots of the spinal cord (Foerster's operation).
2. Operations to cause temporary paralysis by the injection of the nerve tissue (Allison's method).
3. The decompression operation (Scharp and Farrell).
4. The partial resection of the motor nerves (Stoffel's method).

The partial resection of motor nerves has been devised and systematically developed by Stoffel on the basis of his thorough anatomical and clinical studies, although similar operations had been done before by Lorenz and probably others. It was to the great merit of Stoffel to show that every trunk nerve has its definite anatomical architecture which is practically identical for each individual. The knowledge of this architecture, therefore, enables the surgeon to find, at a given place, without difficulty, that nerve bundle for which he looks.

Any new method has to prove its superiority over the older ones before it can be generally adopted. This is a rather difficult task for the operator because it requires a much more exact technic than the old method of tenotomy and myotomy, which it is claimed to surpass in value and which it pretends to replace. It is not surprising, therefore, that the method has been received rather coolly and that it has been rejected by several prominent orthopedic surgeons. Lorenz opposed the method very sharply at the Orthopedic Congress in Berlin, 1912, but granted it, a year later, a certain right of application for the spastic
contracture of the pronator muscles, though he did not admit superiority even here.

On the other hand, the method has found a number of ardent friends and supporters, although all of them point out that the time has been rather short to arrive at any definite conclusions.

The claims of superiority of the method have been based chiefly on two factors:

1. The possibility of exact dosage, and
2. The reduction of danger of recurrence.

1. Most surgeons who report their experiences with the operation agree with Stoffel in that the amount of power to be reduced can be estimated with a great deal of exactness, which is not so with tenotomy.

From my personal experience I believe that the dosage can be made fairly exact, indeed, for the muscles of the calf and the back of the thigh, whereas in other regions the difficulties are much greater. But fortunately the conditions in practice are such that dosage is best possible where it is most required, and where it is difficult, it is of no avail anyway. Cases with spastic contracture of the pronator and flexor muscles of the hand and forearm do not often require operative interference unless they are very severe, and then one need not be too cautious. In a case I have operated upon for contraction of the pronators I have removed all fibres from the pronator teres, the flexor carpi radialis and the palmaris longus and there is still a certain amount of pronator spasm present, probably due to the pronator quadratus. I am planning to operate again on this patient for resection of the fibres of the pronator quadratus and some of the long flexors of the fingers. In a case like this it seems to me that the question of dosage is not so very important; after seemingly everything has been removed, one finds that there is still something left.

Conditions are somewhat different in the leg. Here a moderate amount of spastic equinus contracture may be very annoying in walking and at the same time may be strong enough to interfere with the action or even development of the extensor muscles of the foot and toes. My first case belongs to this class. The contracture was not very severe and could be corrected by a moderately strong passive dorsal flexion. Nevertheless, the child walked with a marked equinus and had no active control whatsoever over the extensor muscles. Her mother had always considered the toes to be entirely paralyzed in regard to dorsal flexion, and was greatly surprised to see life return to those muscles some time after the operation.
At the time of the operation I considered this case a slight or moderate one and, following Stoffel's advice, resected about one-third of the motor supply of the gastrocnemius. This was evidently not enough, and in a similar case in future I should be more radical. Evidently the question of dosage is one that requires much experience and good judgment. But I cannot quite agree with Lorenz when he denies the opportunity of dosage and states an inferiority of Stoffel's method compared with tenotomy in this particular respect.

There is a certain danger of underdosing as well as overdosing the amount of motor supply to be resected. Underdosing leads to an insufficient effect of the operation and, sooner or later, to recurrence. The danger of overdosing does not appear so great, after all, as it might seem at the first glance. Guradze has noticed that after a partial resection of the motor nerves for the flexors of the fingers the extensors were at first not sufficiently counterbalanced by the weakened flexor muscles, but he adds that, after several weeks, the symptoms of paralysis had disappeared and then a correct balance was noted. This is the only remark about overdosing I have been able to find in the literature, and, as it seems, there was no lasting damage reported as resulting from it. In the future I feel inclined to be rather more radical than too cautious.

2. The other factor in which a superiority of Stoffel's operation has been claimed to exist as compared with the tenotomy is the diminished danger of recurrence. It is this factor which has led us to try Stoffel's method. In observing cases which came to the Out-Patient Clinic after having undergone a tenotomy or tendon lengthening for spastic contracture, I was struck by the frequency of recurrence. In one of my four-month out-patient services I counted five consecutive cases of such type showing a partial or total recurrence. In all of these cases the tenotomy had been performed in our clinic and the after-treatment had been done with the usual care and precautions. Similar observations have been made by Hohmann and others who have later adopted Stoffel's method. Hohmann has made a partial resection of the motor nerves in a case where tenotomy had been done three times without lasting result. The explanation of the recurrence in such cases does not seem to be difficult. As Biesalski points out quite rightly, we have to distinguish two elements: a mechanical and a nervous element, and it depends on the individual case which element prevails. If the nervous element prevails, the disposal of the mechanical element, as done by the tenotomy, will often not suffice. The spastic power remains and soon finds an opportunity to work again as the tendon heals very quickly. We admit, how-
ever, that by a long-continued fixation in an over-corrected position the danger of recurrence may be considerably reduced. How easily the tenotomy will lead to an actual deformity, such as pes calcaneus, I am not able to say; friends of Stoffel's operation have pointed towards this danger, but others, especially Lorenz, say that it can be easily avoided.

The question of recurrence after Stoffel's operation depends on (1) the amount of motor nerves to be resected, and (2) the possibility of regeneration.

1. The first point has been already discussed.

2. The possibility of regeneration exists very definitely and several surgeons—Stein, Plagemann and Stoffel himself—have tried to avert it by implanting the central, as well as the distal end of the resected nerves, into the subcutaneous fat tissue. The majority of surgeons who report on Stoffel's operation say that they have not seen any signs of recurrence as yet, though they admit that the time of observation has been too short to warrant any definite conclusions. Biesalski has seen recurrences as well as successful cases. Vulpius has examined several of Stoffel's first cases some time after the operation and has found that the results were "partially preserved" in those cases where a complete resection of the motor supply of the spastic muscles had been done, as in cases of pronator spasm, whereas in cases where a partial resection of nerves had been done, recurrence was found "almost without exception." These findings of Vulpius lend further weight to the statement made above that we should not be too cautious.

The method of operation has been described so well by Stoffel himself that I do not need to take your time with repetitions. I will only say that it is a very interesting operation which requires a most painstaking accuracy. One operates on fine nerve filaments which are surrounded by numerous veins, opening of which must be carefully avoided as infiltration with blood causes further difficulty in finding the nerves. The use of an electric needle is a great help for the beginner to differentiate motor and sensory nerves.

In doing the operation for the first time it came to my mind to dispose of the nerves by implanting the central ends into those bundles of the common peroneal nerve which supply the anterior tibial and long extensors of the toes. I have later found out that this had been done before and has even been mentioned by Stoffel himself, although he does not consider this transplantation of any great value and believes that any result seen in such a case may be solely explained by the resection. On the upper extremity I shall not attempt the transplantation of parts
of the medial nerve into the radial nerve because of the great anatomical difficulties which are out of proportion to the uncertain value.

I may just add that the wound must be closed very accurately and that in sewing care must be taken not to tie any of the sensory nerves. Several authors have reported neuralgic pains some weeks after the operation in a few cases; we have not had such experiences. Hohmann and others advise to remove the stitches rather late. I believe when we sew the tissues in various layers there is no danger of secondary opening after one week. I have done the operation five times on four patients; two cases of infantile hemiplegia, one arm, and one calf; one case of spastic-ataxic paraplegia in an adult; and one case of Little’s disease—both calves. In the first two cases a definite result has been obtained, though not complete enough. The third and fourth cases have been failures on account of insufficient selection; both these cases should not have been operated upon.

**Indications.**

Turning our attention now to the indications for the partial resection of the motor nerves, we find a large dissention of opinion in regard to regions of the body as well as clinical affections. A number of authors consider this method unnecessary for the lower extremity and want it reserved chiefly for the pronators and flexor spasm of the hand and fingers. Lorenz says that even in such cases he is just as much satisfied with tenotomies, but he admits that this is one region of the body where Stoffel’s method is able to compete with the older methods. Kölliker and others, however, give the operation on the nerves preference to that on the tendons for the forearm contractures because of the greater simplicity of the former. Moreover, Kölliker wants to have Stoffel’s operation reserved for the cases of hemiplegia, whereas in Little’s disease he believes Foerster’s resection of the posterior roots to be more valuable, at least in the severe type. In light and medium cases of this disease, tenotomies will generally suffice. From my own experience and judgment I rather agree with Köllicker in that hemiplegia furnishes better opportunities for Stoffel’s method. Here the spasms are usually more localized and one or two operations may accomplish a great deal. In Little’s disease, if the case is at all severe, a large number of operations on the motor nerves would be required to bring the patient to a condition suitable for exercise treatment. Stoffel reports a case of Little’s disease which was greatly benefited by his method, but to accomplish a good result, he had to do no less than seven operations. And
each of these is a major operation, though perhaps none quite so difficult and dangerous as Foerster’s method.

**Contraindications.**

Stoffel’s operation is contraindicated when the disease causing the spasticity has a progressive character. We have come to this opinion by the observations on a single case only, and I am not sure, so far, that I would not try the method again under more favorable conditions. The interesting observations made on this patient warrant a brief description of the case.

T. N., 39 years of age, a skilled mechanic, had noticed increasing weakness, unsteadiness and later almost complete loss of function of his legs for six years. When seen at the hospital he showed a typical marked spastic-ataxic gait; Romberg markedly positive. Marked limitations of dorsiflexion of both feet, worse on the right. Knee and hip motions somewhat restricted by muscle spasm. After careful examination and consultation with Dr. E. W. Taylor, I decided to operate on the right leg. About four-fifths of the motor supply of the gastrocnemius was resected, the proximal end being buried in the peroneal nerve. The leg with the foot was placed on a splint. The wound healed primarily and the stitches were removed on the eighth day. Three days after the operation the patient told me that he could dorsiflex his foot, which he had not been able to do for over a year. So far so good, but the puzzling thing was that he could also move his left foot, which was not touched at all, not even bandaged. After getting up, the patient was treated for six weeks—too short a time—at the Medico-Mechanical department, and left the hospital somewhat improved, according to his own statement, though he still had a typical spastic-ataxic gait. In spite of the large amount of motor fibres resected, the power of the calf muscles was still good and strong. The difficulty in this case is the lack of knowledge of what we have really accomplished. Why did the left leg react sympathetically with the other? This case, however puzzling it was, taught me at least one thing: That we must under all circumstances become thoroughly acquainted with the condition before we operate.

2. Permanent contractures form another contraindication if they cannot be stretched out even under an anesthetic. This applies for contractures of the muscle itself which is to be weakened by partial resection of the motor supply, but also for muscles nearby, as e.g., the hamstring muscles and tendons, when the nerves of the gastrocnemius are to be resected. I have done this in a case of severe Little’s disease and admit that it was a mistake. In planning for Stoffel’s operation we must see
the way clear before us. When we do a tenotomy and a nerve operation at the same time we deprive ourselves of sufficient judgment. In future, therefore, I would do first the tenotomy, and later would add Stoffel's operation if a markedly defective balance still exists.

3. Furthermore, the nerve resection would be contraindicated when marked paresis of the spastic muscles exists—not to speak of an actual paralysis. I have come to this conclusion by the observation of a case of Little's disease which I may just briefly describe.

E. W., girl now nineteen years old, who came to the hospital five years ago with a very severe contracture in both hips, knees and ankles. Tenotomies were done of the adductors, hamstrings and Achilles tendon, and the patient was markedly improved, so much so that she learned to walk even without caliper splints. Four years later she returned with a total recurrence of the deformity of the feet. Although I was looking at that time for suitable cases for Stoffel's operation, I decided to do a sliding teno-myotomia of the gastrocnemius according to Vulpian's advice. In exposing the muscle I was struck by its gray-yellowish color, such as we see in degenerated paralytic muscles. In such a case removal of the mechanical element is indicated only, and a resection of motor nerves would not seem to be rational.

4. Stoffel's operation is contraindicated in cases with marked mental deficiency, in cases showing choreiform movement, or in cases of hydrocephalus. I would also rather advise against it in children of too young age, in patients with marked physical weakness or pronounced anemia, and in the presence of social or other factors which exclude or may handicap a careful and thorough after-treatment with systematic developmental exercise. I want to make this point quite clear and may just add that this is also the outspoken idea of Stoffel himself, that the partial resection of the motor nerves is intended to bring the patient's limbs into a condition suitable for exercise treatment, not merely for function on his own accord, but for treatment. There are possibly cases which will enjoy benefit from the operation even without sufficient after-care, as Kofman reports from his clinic, but the full value cannot be derived from this method unless by long-continued, patient and intelligent training of the nerves and muscles. When this is possible we believe that Stoffel's operation is a very useful method.