The New Treatment of Spastic Paralysis
By Resection of Posterior Spinal Nerve Roots.*

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With Description of the Surgical Technique.
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There is a twofold motor disturbance in the extremities as a result of damage or destruction of the superior pyramidal tracts, namely, contraction and weakness of various muscles. The character and completeness of the injury of the pyramidal tracts gives us the peculiar type of contraction and paresis of the different muscles. Complete hemiplegia, the result of total destruction of all the pyramidal tract of the opposite side, is rare. As a rule, hemiplegia undergoes some degree of spontaneous cure, but whole series of movements can be performed only

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†The practical and theoretical work which we have undertaken on the treatment of cerebral diplegias by resection of dorsal nerve roots was done independent of Dr. Förster's and Dr. Gottstein's splendid and careful studies along the same lines. It was projected some three years ago, although it is now made public some eighteen months after Förster’s preliminary communications in the Zeitsehrift für orthopädische Chirurgie, 1908. In point of fact, similar plans of surgical treatment must have occurred to not a few neurologists interested in the betterment of spastic palsies.

I wish particularly to thank Dr. Joseph Fraenkel for the many valuable suggestions he has given me while the theoretical portion of the work was under advisement. The work as a whole rests upon the still unsettled physiology of muscle tonus and its disorders. It is hoped our piece of work may be considered as a practical effort to solve some of the unsatisfactory points of the last mentioned problem.

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with incompleteness and difficulty. Thus in the leg the movement of dorsal flexion of the foot is most difficult of execution. In general, flexion, abduction, and outward rotation are more difficult of execution than the opposite movements.

When the pathway of excitability of muscles from the cortex by way of the pyramidal tracts is destroyed or severely damaged, the irritability of the muscles from the periphery, as the result of sensory impressions, is not only preserved but is more or less increased. The pyramidal path not only transmits impulses originating in the cortex but also inhibits the lower spinal reflex, and, in the lessened control, permits an insubordinate activity of the lower spinal centres. The objective evidence of the enhanced reflex irritability in the lower arc is shown in the spastic syndrome of increased knee jerk, ankle clonus, Babinski reflex, etc. If the pyramidal tracts of both sides are diseased the spastic syndrome is highly apparent and characteristic. Often by merely stroking the sole of the foot we may produce violent tonic contraction of the flexors of both legs, spreading to the muscles of the trunk, arms, and head. As a rule the greater the absence of voluntary motion, the greater the reflex activity. Aside from the involuntary associated movements in the diplegics, itself an evidence of the increased activity of lower reflex centres in the cord, we have a more or less late—but permanent—muscular contraction which does not disappear on ether narcosis. The latter phenomenon is a complex one and not easily understandable, but nevertheless one to be reckoned with in curing the spasticity of cerebral diplegics. It is not to be explained as a severer form of spasticity, as the two may be coincident in adjacent muscle groups.

Spastic muscle contractures prevent motor func-
tions by offering more or less resistance to extension: it slows the movement, and the movement once performed has a tendency to persist beyond voluntary desire. A sort of physiological myotonus obtains as a result of the approximation of the two points of muscular insertion.

The inhibiting function of the pyramidal tracts is independent throughout of the function producing spasticity, for numerous cases are in evidence in which the first function is not damaged while the latter is severely affected. The reverse also holds true, but much more rarely. This fact may be explained upon the grounds that the inhibitory function is almost always attacked earlier and more severely, while the pyramidal tracts sustain a gradually increasing injury. The muscle tonus function which is largely of peripheral origin is increased later and more slowly. Thus, when the seat of entry of the posterior or sensory roots are diseased, as in tabes, the reflexes are abolished. If the insertion points of the muscles are approximated in the last-mentioned disease there is no active stress on the muscles as in diplegias, nor is there countertension when they are stretched. In health the cortical inhibition checks the spinal reflex by holding in check the influx of sensory impulse. As is well known, in pyramidal tract disease a supervening tabes abolishes all reflex symptoms. In tabes, furthermore, the supervision of disease of the lateral tracts, internal capsule, etc., does not increase the reflexes, and the spastic syndrome does not develop.

Many surgical procedures have been undertaken to restore the normal balance in the spinal reflex arc in diplegics. Early operation on the pyramidal tracts, even at their inception in the cortex, have left much to be desired. Cushing's revival of the operation of removal of brain clots has not been largely
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successful in restoring that degree of cerebral control sufficient to avoid the spastic palsies of later life. It seems more than likely that the subcortical destruction, throughout the white matter, is too diffuse and severe for surgical removal by this operation. However this may be, the majority of attempts to ameliorate the lot of the spasticities in diplegias have been devoted to correcting the abnormal reflex arc in the spinal cord. It is aside from the present purpose of this paper to discuss the many admirable and helpful methods of tendon, muscle, and nerve adjustments which are practised by orthopedists in this special field. Suffice it to say that the results have left us still searching for other methods of treatment of the spastic palsies.

In a review of the different plans of surgical relief for these motor defects, one is struck at once with the almost unanimous point of attack to which surgeons have heretofore addressed themselves: They have endeavored to reduce the excess of motor pull on the spastic muscles by reducing some part of the motor apparatus either in nerves, muscles, or tendons. We have already seen how this position fails of logical deduction when we note the true origin of normal and increased muscle tonus. The sensory part of the reflex arc is anterior in point of physiologic time to that part of the motor mechanism which directly induces the spasticities. This and similar reasons induced Förster, of Breslau, to come to the same conclusion which we have here stated.

It is freely admitted that the degree of muscle tone in an extremity is determined by the sensory impression from the parts, and especially from the muscles. Tonic spasm may therefore be regarded as an augmented degree of this state due to various causes. The impulses arising in the periphery arc
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...are collected from the muscle spindles. These long, narrow, hollow, structures are well adapted for giving the organism excellent information concerning various states of tension in muscles. Sherrington has proved the structural integrity of the muscle spindles with those of the sensory roots.

The motor part of the reflex arc is obviously beyond attack, for while the contraction would be temporarily relieved, a complete palsy of the muscles involved would result. Neurectomy in the peripheral nerves proper could not be employed, as these consist alike of sensory and motor nerves. Even alcoholic injection in "muscle group isolation" by Schwab does not seem to be permanent or fully adequate. Hence the posterior sensory roots near the cord, dorsad to their individual ganglion, is the point of operation if one seeks to attack the sensory side of the arc. Even though ataxia and loss of reflex irritability should supervene in the operation, this state is much to be preferred to the spastic condition which it relieves. However, sufficient data are now at hand to show that neither mishap obtains in the new operation.

Just what part and how much of the sensory stimuli may be removed to gain the desired amount of flaccidity is even yet not clear. It is reasonable to suppose that the sensory supply of the spastic muscles is approximately from those nerves which also originate from the zonal areas of skin immediately overlying the muscles involved, and the best point of attack on these sensory nerves is in the spinal canal, dorsad to their ganglion. Dr. Taylor, therefore, at my suggestion, operated at this point. Before citing our own cases I desire to briefly summarize the work of Förster and Tietze, and Gottstein.

Förster's first communication reports on four
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cases treated. Case I was that of a boy nine years old suffering from congenital spastic paraplegia with imbecility. The knees were in marked flexion. Incoercible contracture of the plantar flexors was present with firm contraction of the two extensors of the knees. There was lively patella and Babinski reflexes, ankle clonus, etc. The second, third, and fifth lumbar and second sacral posterior roots were chosen for resection. Operation was done by Professor Tietze, June 11, 1907. Case II was a spinal case, and Cases III and IV (fatal) are only briefly considered. To return to Case I, the patient operated upon in June showed great improvement as early as the following September. He had learned to use his legs, could rise up from the dorsal posture, could also stand, and could walk a few paces. Anxiety appeared to inhibit his ability. He walked well if held by the hand, or if he had two canes. He walked wide and slowly. Since operation he received considerable collateral orthopaedic treatment. Sensibility in the operated areas never returned, although sense of heat and cold pressure and passive motion remained intact. The chief benefit of the operation lay in the fact that the contractures were overcome, as well as the involuntary movements of the muscles with the return of some voluntary movements.

In Förster’s second communication, a year later, the symptoms of the patient in Case I did not noticeably differ from earlier reported results. Improvement to some extent was noted in the general absence of tendency of spastic rigidity, resistance, and associated movements. There was a progress in recovery of the power of voluntary motion. The final results regarding sensation, locomotion, etc., were as stated in the earlier paper. He walked fairly well with a cane, and especially when held by
the hand. He climbed stairs well with the aid of a baluster.

The patient of Case II was a boy of nine with Little's disease who could neither sit, stand, nor walk. Bilateral resection of L,L,S was undertaken. The final results were similar to those in Case I. Of theoretical improvement there was every evidence, but when we come to such subjects as standing and walking we find that neither can be affected alone. This the author ascribed in part to absence of facilities for after treatment, the obliquity of the pelvis from congenital dislocation being also a factor. Case III was omitted as it was one of tuberculous spondylitis. Case IV, the fatal case, due to multiple sclerosis need not be given as there was no chance to observe results. Case V was one of right sided hemiplegia. The arm was the seat of operation for spasticity. There was resection of C,C,C roots. Voluntary movements before operation were very limited. Immediately after operation the entire arm became flaccid. After some weeks return of voluntary motion was noticed in the flexors of fingers and pronation of hand. Extension of the forearm was very well and strongly performed. By the eighth week there was some return of power in the adductors and inward rotators. The flexors of forearm and adductors of upper arm gradually regained their power. However, the definitive results were not especially good. The position remained poor, the fingers were strongly flexed in the fist, and numerous associated movements were in evidence. The sensibility was normal save on the edge of the little finger.

If we survey the results obtained in individual cases, the first three may be considered together. In all notable improvement was secured. All exhibited severe (one might say extreme) spastic
paraplegia of the legs, and the operation either removed the spastic condition or noticeably diminished it. The best results was in Case I in which four roots were resected, and normal passive motion was restored in all joints. In the other operation but three roots were resected, and the results were not so favorable.

Gottstein, a colleague of Förster's, has operated in two cases. The first one was a case of cerebral paraplegia from meningoencephalitis in a man twenty-four years old. The condition of high degree of contracture at the hip, knee, and ankle joints had existed ten years before operation. The posterior roots of the L1, L2, S1 were resected. The spastic state yielded soon after operation. Sensibility was fully retained. The legs could be actively and passively moved, but range of motion was slight because of contractures of joints, atrophy and shortening of muscles. Some weeks later the flexors of knees were tenotomized. The patient thereafter did poorly owing to lack of after orthopedic care and training, and was unwilling to submit to after treatment.

Case II of Gottstein's was in a girl of nineteen. It was one of right sided spastic hemiplegia with epilepsy. The roots of L1, L2, L3, and S1 were resected. On day following operation the leg was found flaccid and could be moved freely, but patient was unable to move it. A syphilitic reaction was obtained in the patient and specific treatment was given. A few days later the patient could move the limb freely.

The work of Förster and Gottstein proves one certain fact, that spasticity is relieved permanently by this operation. Now we may analyze briefly our own data.

Our first case was selected with considerable care.
While we desired to select one as fully representative of spastic palsy we did not want a case in which the practical advantages of the operative treatment could not be shown. The first case and its results are as follows:

CASE I.—It was in a boy eleven years old whose history was negative except a cerebral diplegia secondary to meningoencephalitis induced by a very severe attack of malignant scarlet fever at eleven months of age. The boy's paraplegic syndrome was typical; bilateral exaggerated knee jerks, ankle clonus, Babinski, a tendency to "crossed leg progression" was present. The boy, however, with this spastic handicap, was able to walk by very short steps (about the foot's length) without assistance, but with arms extended. Various orthopedic measures failed to materially help him. Inasmuch as we had at that time no positive guide regarding the amount of resection necessary the dorsal roots of but one side, the left, were resected. They were D_2, L_3, L_4, L_5, L_6, the last dorsal and all the lumbar, six in all. The operation was performed August 23, 1909.

All three cases reported in this paper were operated upon by Dr. Alfred S. Taylor by his own original method of hemilaminectomy. A short description of the operation is herewith given in abstract. A separate and complete report of the surgical technique of dorsal root resection, which was read before the Neurological Society, December 7, 1909, will be published by him in a future number of the Annals of Surgery.

UNILATERAL LAMINECTOMY.

BY A. S. TAYLOR, M. D.

Unilateral laminectomy possesses certain advantages (to be mentioned later) over the bilateral laminectomy universally employed. It is done as follows: The incision is made just to that side of the spinous processes upon which the laminectomy is to be done, and is carried close to the spinous processes down to their bases. Large deep rake re-
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Tractors are used to pull the muscles outward (incidentally stopping the hemorrhage) and a periosteoal elevator is used to denude the laminae, to which the muscles are but loosely attached, until they are exposed as far outward as the articular processes. With a Doyen saw the laminae are divided at the bases of the spinous processes and also externally near the articular processes. With a bone forceps the laminae are then lifted out. One may prefer to remove one lamina by means of the saw and forceps, and then to remove the others by means of special rongeurs. In this way one may obtain spaces 1.8 cm., 1 cm., and 1.5 cm. wide in the cervical, dorsal and lumbar regions respectively. The dura is opened longitudinally, and after the work for which the operation is done is finished, it is completely closed with a continuous catgut suture. The muscles and aponeurosis are closed with chromic gut and the skin with silk. No drainage is used.

By this method I have resected posterior nerve roots three times in the cervical region, the posterior roots on both sides from the seventh to tenth dorsal inclusive without damage to the cord proper, in one case, and the lumbar roots on one side in one case.

These patients have shown practically no shock, and have healed promptly by primary union, even though one of them had a locomotor ataxia of some years' standing. In each of these cases the escape of spinal fluid when the dura was opened was very free but neither then nor afterward was there any appreciable effect noticeable in the patient's condition.

This operation properly performed, gives ample room for any exploratory operation upon the cord, for the removal of many tumors, and in the case of
tumors too large for this route, indicates just which laminae of the opposite side must be removed to render easy the extirpation of the tumor.

In those cases referred to by Dr. Fraenkel, in which an anterior tumor had been found at autopsy after an exploratory bilateral laminectomy had failed to reveal it, this method would give less failures for the exposure is sufficiently lateral to render easy the exploration of the anterior aspect of the cord.

To sum up, the advantages of the method are:
Minimum loss of blood, of bone, of bony protection to the cord. No postoperative deformity of the spine; or loss of flexibility of the spine. Exposure sufficient for all exploratory work, except in certain cases of fracture of the spine; for all nerve root work on one or both sides; for the removal of many tumors; and for minimizing the operative trauma in others by first exposing their exact size and location. Exposure such as to lessen the chance of overlooking an anterior tumor.

There was no postoperative shock but patient slept only one out of the next twenty-four hours and complained of pain in the left lower extremity. On the following day the pain ceased in the extremity but continued in the spinal and gastric region. On the fifth day after operation, patient was entirely free from pain. A neurological examination one week after the operation showed a greatly reduced spasticity in the whole left leg, there was a great reduction in the reflexes, absence of ankle clonus, and an imperfect production of the Babinski, it could be obtained at irregular intervals only. The crossed leg progression was succeeded by quite a straddling, skating gait. The sensory examination at this time and ever since has shown no defect whatever. On September 9, 1909, seventeen days after the operation, patient was allowed out of bed permanently. Patient had a tendency to collapse in standing alone, like a "jointed doll." After a week's practice he then, as now, stood and walked alone. The steps were long and fairly steady if taken slowly.
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Miss Baker has kindly undertaken the reeducation of our patients after operation. Detailed training and orthopaedic adjustments cannot be overestimated. Analysis of this part of the work will be taken up at another time. After a certain time has elapsed we shall undertake further operation in this case, as it may seem to require. The system of after training which we have followed has been in the main to teach the performances of isolated movements of the limb segments, such as flexion of the foot, adduction, abduction, etc. Even though the relief of spasticity abrogates the defensive flexor reflex movements, the long existent and more or less conscious association of movements of the same side and also of the opposite side render a careful training out process necessary. The incoordinate movements in these cases after operation are no doubt remnants of the former vicious excessive reflex action perpetuated through mental, conscious, or unconscious association. That this conclusion is correct is shown in the rapid manner in which the physical training abolishes them through the method of conscious and purposeful elimination. Fraenkel’s reeducation method for tabetics is adopted in part only as the conditions which we are dealing with are really diametrically opposed; the one a hypertonic state and the other a hypotonic condition. Tabes is not reproduced clinically in this operation though we deal with the same structures anatomically. The sensory disease here added surgically must be something quite different from the neural degeneration of the parasyphilitic affection of the locomotive apparatus as in tabes.

Miss Baker’s report and the scheme of physical training outlined for our patient is as follows:

The patient’s condition when I first saw him on October 11, 1909, was as follows: The left leg was longer
and more flexible than the right. There was hardly any motion in the left ankle and none in the right. He was flat footed, the right foot being more extreme. The hip extensors and adductors were very strong, but the patient was exceedingly weak in hip flexion, abstraction, and outward rotation. There was hardly any motion in the knees. In standing, the patient threw all his weight on the right leg, flexing the left knee. His legs when viewed from the front appeared like inverted commas. In walking the trunk pitched forward and swayed violently sideways. His arms resembled the wings of a windmill. He kept the left knee flexed, and the left foot always pointed in. His gait was wide and shuffling. The incoordination was marked—the head, arms, and trunk participating in all motions of the lower extremities.

My aim in the treatment has been to increase his strength and flexibility, and to give a training in the ordinary movements of everyday life as in standing, walking, sitting, rising, etc. I have striven to develop his sense of rhythm and to increase his coordination. A great hindrance in the work has been his deficient mentality. Now that he is beginning to grasp the idea of the work, his progress is much more rapid. His legs are becoming better equalized in power. The range of motion has very much increased in each joint. The greatest rigidity is in the hip and knee extensors of both legs, and the gastrocnemius and soleus of the right leg. There is some rigidity also in the hip adductors. The hip flexion and abstraction are very much improved. The range of motion when flexing both hips together is much greater than when flexing either separately. The outward rotators are still very weak. Strange to say, the patient was able to flex the knees under resistance before he could do it without. The left knee still flexes in standing, but the sole of the right shoe is to be elevated to counterbalance the shortness of the leg, which will be of the greatest assistance. He is now able to walk with head and trunk erect, keeping his arms by his side. He occasionally points the left foot out or straight in front. He walks with a narrower base than formerly, although the side swaying continues. His gait is much better when walking slowly than when his pace is quickened. The patient's self confidence has greatly increased and his ambition is aroused.

Exercises of the patient: Lying, resistive hip flexion; lying, passive stretching of hip extensors;
lying, resistive hip abduction; lying, passive stretching of hip adductors; lying, resistive outward hip rotation; lying, passive foot flexion and extension; lying, resistive foot flexion and extension; lying, resistive foot inversion; lying with bent knees, resistive knee separation; lying with legs hanging over side of bed, passive knee flexion and extension; lying with legs hanging over side of bed, free kicking; sitting, resistive knee flexion and extension; assuming correct standing posture; double arm stretchings sideways and upward while standing correctly; walking with alternately raised knees in marked time; standing on alternate legs with raised knee; foot placings forward and sideways on command; double arm stretchings while retaining former position; hands on hips, practising rapid standing and sitting on command; sitting with feet on floor, foot dorsal flexion; sitting, retaining foot, dorsal flexion position, during counts.—Margaret R. Baker.

Case II is that of E. F., an eighteen year old boy suffering from left hemiplegia from birth. The boy's birth was the termination of a long and tedious labor in which instruments were freely used, and the father says "there was a great dent in the right skull of the child at birth." The child was a "blue baby." It was a crying, irritable child and moved the left arm and leg little from time of birth. In course of time the typical infantile hemiplegic syndrome developed, the arm and leg were moderately undeveloped, the left forearm was contracted on arm at an acute angle and hand flexed at more than a right angle at the wrist. The fingers were in extension, could just be moved. The whole extremity was in a "birdwing" contracture and spastic. Patient is feeble minded. Dr. Taylor resected the dorsal nerve roots from the C, to D, inclusive on November 8, 1909. As soon as the patient recovered sufficiently from the ether narcosis to obtain the normal reflexes on the nonparalyzed side, it was found that all the reflexes were intact in the left upper extremity. Further examination showed anaesthesia in the
lower two thirds of the whole length of the arm. The arm was entirely free from spasticity and if the extremity was free from its permanent contraction it would undoubtedly assume its natural and normal position. Tenotomy, physical training, and orthopedic appliances will be employed at the proper time.

**CASE III.**—The third case operated on was one of infantile cerebral hemiplegia. M. K., eighteen years old. Right side paralyzed from birth. He has had epilepsy since he was eight months old. At first the attacks were truly hemiplegic, beginning in the arm of the affected side. The whole body was affected. In the fit the patient had an epigastric aura. The right arm was spastic in the shoulder, arm, forearm, and hand. Permanent contraction of the adductors of arm, biceps and long flexors of the fingers was present. The shoulder and arm were the seat of a mild grade of athetoid movement. Operation was undertaken November 15, 1909, to overcome the spastic state, also to note the influence of such operations upon the epilepsy and the athetoid movement. Spinal hemilaminectomy was done, and dorsal nerve roots from C₄ to C₇ inclusive were resected. No specific anaesthesia followed the operation. All spasticity was removed but the athetoid movement was worse for ten days after operation, then it entirely disappeared and was still absent on December 22, 1909. A pemphigoid skin disorder of the whole of the back of the right hand followed after operation which is now healing satisfactorily. The permanent contractions remained. For ten days after operation patient lost the little use of the fingers he had before operation. The excursions of former voluntary movement had been fully regained by December 10, 1909. There was a record of forty-one fits in 1907, about equally divided between day and night attacks. In 1908 the patient had 51 fits. In 1909 he had 160 attacks until the date of operation, November 15th. Since then he has had but six attacks to the time of this report, a period of five weeks. The average number of attacks before operation were from twelve to fourteen a month. This curtailment of epileptic attacks for the short period since operation may mean much or little. Soreness and tenderness of the whole limb passed away entirely two weeks after operation. Patient is under physical training and orthopedic care for contraction in flexors of arm, forearm, hand, and adductors of shoulder. All reflexes were preserved after operation, but less active.
Just why there should be full retention of sensibility in Case I and intact reflexes in Cases II and III is not clear. However, the experiments of Sherrington in resecting these roots in the ape has already shown that anesthesia does not result if two or three roots are cut, but it does not explain the absence of sensory loss in so wide a resection six roots as we have undertaken in Case I. No work like this has before been undertaken on man. Bruns and others have expressed the opinion that resection of over three roots would cause anaesthesia. No reflexes should be in evidence in Case II, at least reasoning from previous physiological studies. The data affords much for future analysis and study.

It must, however, be emphasized that for some weeks after operations some resistance to passive motion, stretching, etc., can be perceived. This is due to tenderness alone and has no connection with spasticity. The tenderness of muscles and tendons is in turn due to irritation caused by severing the root and putting the parts through long disused movements. This phenomenon is transitory and ends with the degeneration of the divided nerve. It tends to vanish closely as passive motion is continued. The position of the legs, originally the abnormal "rest position," rapidly becomes normal.

The muscles, however, may in part have undergone atrophic changes, and no improvement follows division of the roots. Such conditions are diagnosed by placing patient first in light and then in deep ether narcosis. It is precisely after division of the roots that myotomies and tenotomies—commonly so unsatisfactory—become successful. (Numerous examples of failure of myotomy in ordinary cases without division of nerve roots are everywhere in clinical reports.)
In this connection comes the question of isolated movements of a segment of a limb. This was originally impossible. Since operation, however, the hand can be bent in any direction without involuntary flexion of the forearm or arm, and so on.

The practical benefit accruing from return of power to execute isolated movements is best seen in improvements in gait in Case I. Striking improvement was obtained as to voluntary movement of limbs. The patient's original condition was so improved by operation that he could flex the foot both ways to its full amplitude, flex and extend the leg normally, raise the limb high up, abduct, adduct, and rotate in and outwardly. These movements are all isolated. This kind of improvement is due to removal of spasticity. Division of special roots had overcome muscular resistance. It also appears for the first time that the corticogenic excitability of individual muscles had been to a certain extent retained. We see again clearly the complete independence of the corticogenic impulses to the muscles direct, and the inhibition executed upon the peripherogenous, subcortical excitability, and can understand why the latter can be abolished while the former preserves some integrity. Naturally for the recovery of voluntary motion, some anatomical basis is necessary—a residue of pyramidal fibres. We cannot always expect that such will be present. In the first case, however, such a condition prevailed.

We believe with Förster that the rapid supervision of voluntary movement does not stand or fall entirely with the mechanical resistance of the spastic muscles being removed. Whatever the reason it is certain that division of the root not only removes the spastic element, but restores voluntary motion to a wide extent. In the early days after division voluntary motion is not in evidence; on the contrary.
where it was present before operation it may now be worse. This, however, is the result of tenderness of muscles and handling of the cord in the operative field. Every movement, every tension or stretching is very painful. As this sensitiveness vanishes, power of voluntary motion gradually returns, especially when aided by exercises.

With the removal of contractures and restoration of an approximately normal breadth of excursion in the movements of limb segments, and with the elimination of the very perturbing defensive flexor reflexes and removal of associated movements (associated with voluntary efforts); and finally, last but not least, with the return of voluntary motion, we have a basis for the acts of standing and walking. Obviously, in congenital cases where there has been no experience of this sort, the prognosis is much less favorable.

The child should be taught to exert its muscular force. At first it collapses. The first act to acquire is holding the knee extended, the second, to raise the pelvis and trunk on legs. So on with each individual segment until patient is able to stand with bilateral support. Very gradually then they may be taught to stand with unilateral support—as when led by the hand or held up by a cane. Failure to stand or walk may be due, of course, to some outside factor. Thus cerebellar coordination could be involved, or lesions of the lateral columns might coexist, or multiple sclerosis, etc. Spastic paralysis of purely spinal origin might be the actual condition.

Finally we must remember then the spasticity demanding relief in these cases, particularly in the cerebral type, is one in which the whole spinal segment must be considered, spasticities of the trunk
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must in time receive full attention. While they are not prominently in evidence during consideration of the enormous limb spasticities, yet in the training they demand the same essential attention as the trunk movements have received in the reeducation of tabetics as in Fraenkel's system of training. It is not too fanciful to hope that in time some sort of general lowering of the whole sensory influx to the cord may be undertaken by chemic injection in the spinal canal, inducing a mild but uniform degeneration in the dorsal roots akin to that in tabetic lesion.

The hope of future mental development in the diplegic in whom the movements of the extremities are once released by this operation, carries with it all the sanction which industrial training has received at the hands of medicopædagogists. Two of our cases have already shown what this betterment promises. The one hemiplegic-epileptic in which the upper extremity is released shows decided modification of his epilepsy. It seems reasonable to suppose that better results in this regard may be expected in treating such cases if the operation is performed much earlier than heretofore, before the epileptic habit becomes so definitely fixed. It is well known that hemiplegic epilepsy has, in many instances, a tendency to assume a close clinical resemblance to that of the idiopathic type when existent for several years.

Regarding the indication for this surgical operation: it is to be recommended for consideration in treating all degenerative lesions per se of the pyramidal system, attended by severe spastic palsy, cerebral as well as spinal. One needs, however, to study each case closely and adapt the operation to the particular case with full knowledge of the ends
sought. The relation of the spastic and paretic elements in each case needs to be thoroughly studied.  

**ABSTRACT OF DISCUSSION**

In discussing the paper, Dr. Ogilvy said when the patient of Case I first passed through his orthopaedic service he had intended to have him use braces and crutches, so severe and extreme had the spasticity seemed to him. The second case (not shown in person) had absolutely no spasticity after operation, and the contracture in the biceps and long flexors of the hand could not be readily corrected.

Dr. Fraenkel approved of the practical outcome of the theoretical idea. He had been at work upon the latter for some ten years. In his studies, he had proved that the loss of motor function in spastic palsies was in direct ratio to the residual spasticity. It appeared rational to him to add sensory disease whenever the loss of motor function in the spasticities was considerable. He had hesitated, however, to put the theory to practical test on account of the uncertainty of the outcome and the difficulty in finding a quantitative gauge to the amount of sensory withdrawal.

At his suggestion Dr. Beer had shown a temporary flaccid gait in a cerebral diplegic by intraspinal injections of stovaine. To him the value of this operation would be two fold: First, to change painful, ineradicable spastic flexures into flaccid states.

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*I have purposely omitted making a historical sketch of the manner in which several neurologists and surgeons have been led to undertake these operations for spastic palsies. The omission will be supplied in a subsequent paper. As so commonly happens in other fields of scientific inquiry, different investigators almost simultaneously arrive at certain conclusions, working quite independently of each other. There seems little doubt, however, that this operation in one form or another has been smouldering in the minds of several neurologists for years. As previously stated, the genesis of our present conception of spasticity and the effective methods of overcoming it will be set forth in a final paper when our whole series of cases are published and analyzed. Due credit will then be given to each worker in this special field.*
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of normal anatomic rest. Second, to remove the spasticities of subcortical, pure pyramidal disease, to which latter condition the operation as a remedial factor ought to be very largely limited.

Dr. Gibney spoke of the excellent promise of this operation. There was no such final promise in the ordinary procedure of orthopaedic surgery today.

Dr. Fisher, thought the removal of irritative impulses to the brain was as much of moment in this operation as correcting the spasticity. There were also good reasons for thinking the hemiplegic epilepsy might also be improved by this operation. Dr. F. Halstead Meyers believed tenotomies on the contractures ought to be done first.

Dr. Lloyd, on theoretical grounds, thought the advantages of Dr. Taylor's hemilaminectomy were not so great as one might at first be led to suppose. The hemorrhage and deformity of the old operation were not great.

In closing, Dr. Clark called attention again to the fact that section of the dorsal roots posterior to their ganglion made sure of permanent degeneration and still preserved the ganglion to the periphery of the nerve, thus avoiding all dystrophy.

Dr. Taylor emphasized the great danger of the operation as performed by Teitze which the latter surgeon constantly reiterated in his work. The celerity and sureness, and conservative exposure of the field by hemilaminectomy certainly met successfully all the old dangers of bilateral laminectomy.

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