AN ANALYSIS OF THE RESULTS OF DORSAL ROOT SECTION IN THE TREATMENT OF THE SPASTIC STATE OF CEREBRAL DIPLEGIA.*

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The general text of this article is written by Doctor Clark, but embraces the opinions and the cooperation of the two authors in this special field of neurological surgery. The study is based upon the analysis of forty-one cases including five original cases, from the inception of the operation as performed by Foerster (1908) to the present. Other cases such as multiple sclerosis with spastic paraplegia, hemiplegia, tuberculous cervical spondylitis, etc., have been treated by dorsal root section, but they are omitted from this paper as they are not germane to the title of the essay.

The literature of our subject is in danger of being hopelessly confused, inasmuch as dorsal root section is being urged for the relief of at least three quite distinct conditions, namely, for pain, athetosis, and spasticity. The operation of radiculotomy per se is one thing, and radiculotomy for spasticity in Little's disease is another. The two or three subjects must, therefore, be kept apart, which is at present difficult, as many writers report indiscriminately upon the two conditions at the same time. In a few instances the two states coincide in the same case, as in one of our cases (Taylor's) of painful spasticity in a hemiplegic arm.

The entire subject of radiculectomy¹ is very much

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¹The various types of neuralgia, especially of stump neuralgia, have been so refractory to treatment in many instances that the most radical procedures have been suggested and employed for their relief. Chief among these is section of the posterior spinal roots inside the dura, which naturally necessitates the operation of laminectomy.

The first man, apparently, to do this operation was Bennett, of London, in 1888. He operated for intractable neuralgia—sciatica—by dividing the posterior roots of the four dorsal and first sacral

older than some would have us believe. Thus Chipault did it some years ago for tabetic crises. Probably the operation as now generally applied for the treatment of pain received no small impetus from its anatomicophysiological homologue of so-called physiological extirpation of the Gasserian ganglion by section of the sensory root of the fifth nerve dorsad to the ganglion (Keen and Frazier). However ancient radiculotomy may be as a surgical procedure for the relief of pain, undoubtedly the operation was attained, apparently. The death of the patient soon afterward was not connected with the operation. Bennett employed Horsley's laminectomy technique.

In a paper published in 1890, on surgery of the central nervous system, it appears that Horsley operated twice between 1887 and 1890 in the same fashion—once dividing two (eighth and ninth) dorsal roots for spasm and pain, and once operating on the roots of the brachial plexus. The results were quite satisfactory. The impression prevails in some quarters that Horsley was not responsible for this operation. His omission of dates—although nearly every other case reported has the date of operation fixed—suggests he had no memoranda to determine the exact time.

The next operator in chronological sequence was Chipault, who reported cases in 1895 and 1897 and digested the entire subject in his great work on The Actual Condition of Surgery of the Nervous System, 1895-1903. He awarded credit to Bennett and Horsley, but was not aware of Abbe's work. He had operated four times up to 1896, and once afterward—the case being reported in 1897. Of his five patients one died from the operation, two recovered, and two sustained relapses.

An Italian, Parona, operated on the dorsal roots for intercostal neuralgia, reporting the case in May, 1896. The result was a success.

In 1896 Abbe reported all his material—three cases to date. Since his first operation in 1888 he had performed two others, in 1895 and 1896 respectively. The conditions and operation were similar. He also cited a case of McCosh's in which the fifth and sixth dorsal roots were divided for intercostal neuralgia.

In 1899 Faure reported a case of division of posterior roots for pain of uterine cancer. The operation was a success. It appears, therefore, that this operation was done at least fifteen times before 1900. During that year Giordano operated once with success for sciatica and Mingerlini suggested, but did not execute division of the posterior roots for the gastric pains of tabes.

Chipault, in 1902-3, had not added any cases subsequent to the preceding, but in 1901 Prince reported a case in which the brachial roots were divided for neuritis, Brown-SEQUARD paralysis developed.

Mr. Hinman, who operated for Prince, also had a similar case with the same sequel. He reported both cases in 1894.

The preceding cases do not exhaust the number of rhizotomies described prior to Foerster's time. A few others are known to exist, none having been reported in connection with a trauma of the spine.


dence 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 under ether narcosis. The latter phenomenon is a complex one and not easily understood, 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 functions by offering more or less resistance to extension; they slow 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 is 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 diplegics, nor is there counter-extension 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 supervention of disease of the lateral tracts, internal capsule, etc., does not in-

crease 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, has left much to be desired. The majority of attempts to ameliorate the lot of the spasticities in diplegics have been devoted to correcting the abnormal reflex arc in the spinal cord. The sensory part of the reflex arc is anterior in point of physiological time to that part of the motor mechanism which directly induces the spasticities. This and similar reasons induced Foerster, 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 are collected from the muscle spindles.

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. Hence the posterior sensory roots near the cord, dorsal to the 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 quite 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 the skin immediately overlying the muscles involved. Sufficient data are at hand now to show the operation is of little or no use in any spastic state where sensory defect exists. We may thus exclude all the forms of myelitis and in fact all cord affections per se. The reason for this is not difficult to understand. The sensory defect added by operation is already in evidence in the disease itself before operation.

The indications for the operation lie in those cases of pure pyramidal disease of cortical or subcortical origin. Little's disease is the disorder to which the operation in future must be largely limited. Even cases of infantile hemiplegia seem to offer less prospect of betterment than in diplegia as shown in Foerster's, Gottstein's, and in our own cases. On theoretical grounds it would seem as though removing a part of the inflow of sensory impulses to the hemiplegic cortex might lessen or remove much of the cortical instability, and thus make the operation of use to better the condition of hemiplegic epilepsy, but, as yet, data corroborating this view are not at hand. One of our own patients showed temporary improvement in this regard, but has since relapsed and is now quite as badly off as regards the severity and frequency of epileptic attacks as before operation.

All diplegics showing painful and ineradicable spastic flexures, exhibit good indications for this operation, inasmuch as their spastic state may be easily converted into flaccid palsies of normal anatomical rest. Unfortunately, most of such cases present such a degree of mental impairment that the important after care and training is of little use.

However, in diplegics of moderate intelligence with "scissors" gait or even "crossed leg progression," the operation is of the greatest value. The value of the operation does not stop at a better gait for the little patient. The hope of further mental development in the diplegic and feeble minded patient is in no small degree bound up in the freedom of movements of the extremities, which is made possible after such an operation as here proposed. The increased opportunity of use of the extremities after operation carries with it all the sanction which warrants industrial and manual training at the hands of medicopedagogists. Two of our patients have shown what this line of betterment promises.

It must be borne in mind that in Little's disease all the spinal segments are spastic and not the extremities alone, and, as Frankel has pointed out, the whole trunk is employed not a little in normal walking. Hence the importance of not confining the after training to a use of the legs and arms alone.

In nearly all the cases of Little's disease selected for dorsal root sections, so far, the patients have been too old to show the best results from the operation. In the ideal conditions the operation should be done between the fourth and seventh year of age, as soon as the balancing and walking principles are well inculcated in the child. Then, too, this early we may avoid the trophic and deformity defects of later life.

Having determined more or less definitely that pure lesions of the pyramidal tracts such as that of cerebral diplegia is the lesion par excellence for the operation, we may consider to what extent resection may be undertaken. The extremities showing the greatest spasticities should be first considered. As a general principle one should determine whether the spasticity is simple or complicated by permanent shortening of muscles, by placing the patient under ether narcosis before the operation. A few manipulations of the spastic state is thus possible and the trophic alterations in muscles, joints, and bones may then be exactly studied. It is still a much mooted question whether orthopedic corrections by tenotomies on the irreducible contractures should be undertaken before or after dorsal root section. How-
Clark and Taylor: Cerebral Diplegia

ever the matter may be decided, it would seem that the fullest cooperation of the surgeon and orthopedist is absolutely necessary if permanent benefit is to follow any surgical interference to restore lost functions in these diplegics. Foerster has carefully worked out the following table for determining the roots to be resected in any given state in the extremities.

Table showing which roots should be resected for the correction of muscle spasticity in the muscles of the lower extremity.²

<table>
<thead>
<tr>
<th>Flexors of the thigh:</th>
<th>Psoas iliacus, L₁₁₂₃₄₅, S₁;</th>
<th>Gastrocnemius, peroneus longus, flexor digitorum c. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abductors of the thigh:</td>
<td>Gastrocnemius, peroneus longus, flexor digitorum c. 1</td>
<td>Tensor fascia, (L₄) L₅, S₁, Ex-</td>
</tr>
<tr>
<td>Glutaeus maximus, LₛS₂</td>
<td>Glutaeus maximus, LₛS₂</td>
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In brachial spasticities perhaps the best and completest results follow resection of the fourth, fifth, seventh, eighth cervical, and first dorsal roots. It should be borne in mind that a part of the spastic conditions should be left as a physiological brace for the paretic muscles.

Immediately after operation, and for some weeks after, patients complain of pains and muscle soreness and cause not a little resistance to passive motion, stretching, etc. This is due to tenderness alone and has no connection with spasticity per se. The tenderness is, moreover, due to irritation caused by severing the root and putting the parts through long disused movements. In the course of five or six weeks it disappears; it tends to vanish closely as passive motion is continued. The position of the legs, originally the abnormal rest position, rapidly becomes normal. Occasionally some trophic disturbances follow in muscle and skin; however, these are usually slight and transitory and the renewed power of voluntary motion makes up in stimulus to the parts which may have been lost through radiculotomy. If Sherrington's law is observed of not more than three consecutive roots to be divided, anesthesias and trophic disturbances should not occur. In almost all cases some ataxia results, but it is speedily discounted as physical training progresses. In a few cases the condition has persisted in a small degree. At all events the ataxy should be accepted as a trivial disorder as compared to the spasticity which it replaces. In individual cases (Foerster's) some temporary urinary retention has been noted immediately after operation. We have noted it in none of our series. In one of Foerster's cases urinary retention persisted for several weeks, due to unintentional injury to the lower sacral roots. Later it entirely disappeared. In some of the cases reported abroad erections were noted after operation. An associated injury of the lowermost sacral roots can hardly be responsible for this mishap, as it still
Cerebral Diplegia. Persist three years after the radiculotomy. Probably the loss of part of the roots of the sacral plexus, more particularly the second sacral, induces an increased irritability of the lowermost sacral nuclei. Foerster even suggests that dorsal root section of the second sacral might be undertaken for deficient erections. After operation the hand or foot can usually be bent in any direction without involuntary flexion of the forearm or leg. The practical benefit accruing in most cases from return of power to execute isolated movements is best seen in the patient's gait. They can usually flex the foot both two ways to full amplitude, flex and extend the legs normally, raise the limbs high up, abduct and adduct and rotate in and outwardly. The apparent gain in power after operation; is but the releasing of the corticogenic excitability of certain muscles bound down previously by spasticity. It hardly seems probable, as Foerster contends, that some voluntary motion is added, for the first time, after operation. With the removal of contractures and restoration of an approximately normal breadth of excursion of movements of limb segments, and the elimination of the very perturbing defensive flexor reflex, 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 developing standing and walking in our diplegic patients. Even at this point the child must go through a very elaborate education in using the extremities. At first it collapses. First the patients stand with bilateral, then unilateral support, then they learn to walk with a cane, and finally to go alone.

The after care treatment must be prolonged. There can be no doubt that the after care and training of cases treated by dorsal root section is the most important part of the whole procedure as far as the enduring results go, once the root section is made. At the risk of laying down trite and commonplace rules I shall detail at length some general rules which I have practically deduced in the last three years of observations on the after care of these spastic cases, assisted by the faithful efforts of Miss Baker.

Even while the little patients are in bed, the first few days after operation, diligent daily exercises of the legs should be given. These exercises should be undertaken even though some of the pain on movement still remains. The painful soreness is aided by the treatment too. The exercises should be undertaken several times daily. If the limbs do not return to the normal rest position after the operation, removable plaster sheaths should be applied. This treatment should gain the maximum extension abduction and external rotation in the hip joint, maximum extension of the knees, dorsal flexion or medium position of the foot, etc. In slighter grade of postoperative deformity sand bags may be used. All this apparatus should be used while the patient is bedridden and while he is not undergoing active treatment in exercises, and especially during the night. Foerster considers these sheaths or external corrections of abnormal positions necessary during several years. He recommends in extreme flexure contractures at the hip, that a cushion be slipped underneath the sacrum of the recumbent patient.

The form of passive exercises in detail for the patient during the bedridden period may be said to consist in having the patient make, 1, resistive hip extension and flexion and passive stretching of hip extensors; 2, resistive hip abduction and passive stretching of hip abductors; 3, resistive outward hip rotation; 4, passive flexion and extension of the foot and resistive movement in the same manner; 5, resistive foot inversion; 6, with bent knees resistive knee separation; 7, sitting hip and knee flexion and extension; 8, coordination of standing by placing foot forward and sideways on com-
mand; 9, hands on hips and practicing rising and sitting on command; 10, sitting with feet on floor and practicing foot in dorsal flexion, each foot separately. In brief, the foregoing may be considered as some of the literal and specific trainings these cases may follow through.

A tendency to reproduction of the original flexion contracture asserts itself especially in the presence of any pathological sensory irritation at the legs, such as wounds, bed sores, subsequent operative interventions on muscles or tendons, accidental traumatism such as articular contusions, etc. Maintenance of the extension is especially important under these conditions, to prevent a renewal of the tension on the part of the flexor muscles. In case another muscle group shows a tendency toward contracture, after the operation, the position must be modified accordingly. In a given case, the position should therefore be governed by the spastic tendencies of muscle groups, which call for permanent control by counter position.

The evolution of active motility should be furthered by systematic gymnastic exercises, and the power of locomotion be acquired. For the first few days after the operation, the work is limited to some passive movements in the individual joints, possibly with those attempts at voluntary motility. But as soon as possible, the patient should be made to perform systematic active movements in all joints, laying special stress, from the very start, upon the isolated movements of each individual leg, and the individual segments of the leg. What cannot be done actively at first, is to be supplemented by passive motion. These bed exercises are preferably made several times daily; immediately afterward, the legs are replaced in the plaster sheaths, in the prescribed position. Further strengthening of the muscles, by massage and faradization, may be indicated. Later on, medico-mechanical exercises are well adapted to this purpose. Some weeks after the operation, it is time to begin with exercises in sitting up or down, lying down, and turning over. In sitting and rising, it must be seen to that the back is well straightened out, that the legs do not curve in, or fly into the air. In lying down, the legs have a tendency to rise, and the patient must be made to press them firmly against the support. After a few more weeks, when the spine is expected to be firm enough, standing and walking exercises should be begun and be repeated several times daily, if possible; first in a perambulator running on casters, later on held by the two hands, then one hand and a stick, then two sticks, one stick, and at last free, if possible.

In the locomotion exercises, the marked disturbance of the equilibrium is at first very striking. The legs often refuse altogether to support the body, in the first attempts at standing; the trouble being due to a genuine disturbance of coordination. In the first place, the children must be made to understand that the knee should be extended; this is usually accomplished without trouble, and later on comes to be done involuntarily. In the second place, an endeavor must be made to straighten the pelvis, and with it the upper half of the body, upon the legs. The proper lateral fixation in the hip joint must be attended to at the same time. It is common for one hip to be deviated, the other half of the body hanging over on the opposite side. After the individual body segments have come to be properly adjusted in a general way, the finer equilibrium must be practised, and this is done by progressively diminishing the external assistance, as stated above.

Analogous considerations apply to the walking exercises. Suitable gymnastic exercises must be kept up for years, in order to obtain and maintain good locomotion. How absolutely indispensable they are for a functionally useful outcome is well illustrated by the case of Little's disease, in a girl operated on by Tietze, and previously reported by Foerster. The child was taken away by the par-
ents, before the standing and walking exercises could be started, and is now absolutely unable to walk or stand, although the spasms are permanently controlled and there is excellent voluntary motility of the legs (three and one half years after the operation). The patient failed to learn locomotion of her own accord. In two cases of Little’s disease, operated in by Kuettner, the exercises were not begun until six and nine months later, respectively, with very good practical results. The value of systematic exercises was recently pointed out, especially by us, showing that the prognosis in congenital spastic paralysis, or Little’s disease, is worse for the reason that the children have never learned how to walk or stand.

Any existing atrophy contractures of individual muscles should be subsequently relieved by plastic operations. The root resection is, naturally, unable to remove the secondary contractures, due to atrophy of the muscular connective tissue of the tendons and ligaments. Whenever these are found, after the removal of the spastic contractures, it is necessary to proceed to the elongation, division, or plastic operation of the tendons or muscles themselves.

The root resection is thus seen to require later supplementing, in several respects. It is merely the basis for further procedures, but that it is possible to obtain very satisfactory practical results upon this basis, even in grave cases, under appropriate after treatment, is illustrated in our opinion, by the entire series of cases operated in in the past.

A summary of the results obtained in most of the operations of dorsal root section is as follows:

1. Relief of spastic contractures, 2, normal defense flexion reflex, 3, diminution of the increased tendon reflexes, and, 4, improved spontaneous motility.

We believe the operation in future should be largely confined to Little’s disease and that it should be looked upon, not as a cure, but as one of the best therapeutic procedures for the betterment of the cerebral spasticities brought forward in recent years.

We will now consider some of the results of dorsal root section in detail.

Spasticity is more or less completely removed at once by the operation in all cases of Little’s disease. The degree of flaccidity that succeeds, depends upon the extent and completeness of resection. In not a few cases a partial return of spasticity has undoubtedly taken place. The anatomicophysiological mechanism by which such relapse occurs is hard to understand. The relapse was particularly noted in Klapp’s and Göbel’s cases. It is urged that the excessive flaccidity immediately after operation is only apparent and not real, and is due to local shock, from nerve irritation or even from general shock of loss of blood and spinal fluid and the anesthetic. This explanation would hardly seem justified in that the return of spasticity is noted in only a few cases, and even then in many of those of the less severe operations. It may be just possible that the establishment of new reflex paths from the remaining sensory roots may gradually recharge the adjacent centres in the gray matter, especially in the absence of cortical inhibition. It hardly seems possible that any actual regeneration in the roots really takes place, in view of the general acceptance of the experimental fact that a section of a spinal nerve root dorsad to its ganglion has never been known to be followed by regeneration. Some definite investigations of this whole problem of regeneration after section of dorsal roots needs to be made under control by more modern technique than that employed by Lugaro and Raimann several years ago.

Anesthesia: In none of the operations in which Sherrington’s law has been observed, namely, not more than two consecutive roots are cut, has there been any anesthesia. It must be left an open question, at present, whether or not certain sensory
disturbances are to be invariably anticipated after more extensive resection. Two of our original cases are contributions to the fact that it may not be greatly disturbed though a more extensive resection be undertaken.

Ataxia: In almost all cases some degree of ataxia succeeds extensive resection of dorsal roots in the lumbar region. The ataxia, however, is not great or lasting, as the heightened reflexes from a pyramidal disease supplies an element wanting in the somewhat analogous ataxia of the disease of tabes. Moreover, as Foerster justly remarks, an ataxic gait is decidedly to be preferred to inability to stand or walk.

Atrophy: In none of the cases has this mishap befallen the operation. According to experimental data at hand, atrophy would not be expected to occur as the peripheral nerve has its trophic centre, the ganglion, intact. (See Raymond's Experiments, Revue de l'Académie de Médecine, p. 374, 1890.) The slight modification of lessened muscular tonus ought not to be of great moment in inducing atrophy, as disuse of the muscular parts are not produced by the operation. Again, the increased tonus in the diplegias rarely produces an hypertrophy. Even though mild atrophy should ultimately show itself, the advantages of the operation should outweigh this mishap.

Reflexes: 1. Ankle clonus is usually abolished at once, permanently in all cases. Foerster believes that either S₁ or S₂ can maintain the ankle clonus as in the very few cases where ankle clonus has persisted, one or the other of these roots was not resected.

2. Patellar reflexes were abolished in all cases of Foerster, but not in others, notably our own and those of Göbell's.

3. Babinski's reflex persists in all reported cases except in one reported by Kotzenberg.

4. Oppenheim's tibial reflex persists in some cases and disappears in others.

The Achilles reflex is lost or markedly diminished in all the typical resections, that is, L₃, L₄, L₅, and S₁. In two cases in which ankle clonus persisted the Achilles reflex was also present. The effect, however, of radiculotomy is of theoretical rather than of practical interest.

The abolition, or at least marked reduction, of the defensive flexion reflex in all cases, is absolutely necessary and has been obtained in nearly all cases. Its marked continuance indicates a failure in the operation. A pathological increase of this reflex causes the irrepressible flexor cramps in diplegics. They are extremely annoying and often painful to the little patients. If no other causes were in evidence, this one alone would prevent walking and standing in the vast majority of cases.

The associated movements disappear entirely, or are diminished to such an extent that children can raise themselves from the recumbent position to the sitting posture without help.

Varying degrees of voluntary movements are re-established in all cases. Unfortunately no one can tell just how much of the paretic element is present in a given case until the spastic element is removed by operation. In those cases retaining the most corticospinal fibres the greatest motility is restored. The ideal case is one in which normal locomotion is present before the development of the disease. In congenital cases—those usually encountered—other central nerve lesions are more often in evidence than those of the pyramidal tracts, especially those of cerebellar or frontal injuries, and in such we encounter ataxias at the start. A longer and more painstaking after training is necessary. The striking advantages of the withdrawal of the associated movements by dorsal root section is at once obvious. The ultimate results in all cases operated upon will rest in no small degree upon whether the muscular contractions are due to the direct influence of trophic changes in the muscles and increased reflexes and the persistence of the after
training. Decided trophic changes in muscles, joints, and bones make for a poor prognosis even with the most intensive form of training. In other words, the ideal case for radiculotomy is one without contractures and atrophies in early life (five to eight years of age), without much mental deficit, and one in which the paretic component is at a minimum. It is precisely in mild types of Little's disease that these conditions are fulfilled. A digest of the literature of the subject, combining short abstracts of cases operated on, is here appended and is the more warranted as the operation is still on trial and is but a few years old.

Surgical Considerations (Taylor), and Case Histories (Clark and Taylor).

The surgical technique employed in the cases to be reported was described and discussed in the Annals of Surgery for April, 1910, although there have been a few modifications in the instruments used for the removal of bone.

Through a unilateral laminectomy properly performed, the roots of both sides may readily be divided without in any way injuring the cord substance. In most of the lower extremity cases a portion of all the roots involved has been divided instead of dividing two consecutive roots completely and then skipping one, as is so frequently advised. An objection has been raised, that in dividing a part of the root the remainder would be traumatized, but this objection is largely theoretical because the posterior roots leave the cord in a series of little bundles and any proportion of these bundles may be cut without injury to those remaining.

Case I. G. D., a boy eleven years old, whose history was negative except for 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 materially to help him. The extremities were cold and blue. Sensory disturbances were absent. Operation, August 23, 1909; ether.

Left unilateral laminectomy was done, involving the vertebrae from D10 to L1 inclusive, which exposed the lumbar enlargement and the upper part of the cauda equina, after the dura was opened. In this first case there was some confusion as to the exact nerve section, but the posterior roots of the twelfth dorsal and the first and second lumbar were divided completely, and segments were removed from the next three roots, all on the left side. The dura was sewed tight with a fine continuous catgut, and the remainder of the wound closed tightly by layer chromic sutures, with a silk suture for the skin.

Primary union resulted, and he was allowed up on the sixteenth day.

There was marked relief from the spasticity at once in the left limb, especially about the hip and thigh. He was able voluntarily to separate his knees twelve to sixteen cm. The reflexes were lessened on the operated side. After a course of instruction by Miss Margaret R. Baker, he was able to walk without his crutches for the first time in his life. The gait was somewhat awkward, but the knees were held well apart and he could shuffle along at fair speed. As a secondary result there was marked improvement in both his mental and physical condition. There were no sensory or trophic disturbances at any time.

On June 22, 1911, the dura was opened through the old wound and the right posterior roots were divided, D10, and L1, and L2 completely, and one half of L3 to S1 inclusive. The wound was closed as before, and primary union resulted. The previously marked spasticity on the right side was replaced by considerable faciidity.

Note, two and one half years after the first operation, and seven months after the second operation: From inability to walk at all (patient completely collapsed on attempting the same two weeks after the second operation) he is now able to take steps normal in length, unaided in any way. There is still some shuffling in walking. There is no actual loss of sensation anywhere in the lower extremity. Both legs are capable of segmental movements about one half normal range, the right leg being a fist in this respect. The knee jerks are absent. The left knee, left big toe, and internal malleolus still
show some slight tendency to ulcerations as the result of slight traumatism in getting about. Babinski and Oppenheim reflexes are present about as before operation. There is no clonus. Now that this patient is able to go to school regularly, a remarkable improvement in intellectual development is noticed by all. The all around betterment in this case is most gratifying.

Case II. 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 the hand flexed at more than a right angle at the wrist. The fingers were in extension, and could just be moved. The whole extremity was in a "birdwing" contracture, and spastic. Patient was feeble minded.

November 8, 1909, operation. A left unilateral laminectomy was done under ether. The intention was to divide the left posterior C₆, C₇, C₈, and D₁, but for reasons not worth explaining at length, the final result consisted in the division of the posterior roots of the left side from the C₂ to the D₃ inclusive. The wound was closed by layer suture as in the preceding case. Primary union resulted, and the sutures were removed on the seventh day. The day following operation the spasticity was very greatly diminished, and the arm was moved with great freedom.

February 14, 1910, there was anesthesia of the inner aspect of the forearm and hand, which had persisted since operation. There was also an eruption, somewhat like pemphigus, on the hand and forearm, which had been present for about a month. Many of the sores had healed, and the trouble entirely disappeared later. The spine was normal in contour and flexibility in every way.

The final results were excellent. He gained nearly all the ordinary uses of his arm, but the hand remained paretic, yet able to grasp and hold objects placed in it by the other one.

Case III. The third case operated in was one of infantile cerebral hemiplegia, in M. K., eighteen years old. Right side paralyzed from birth. He had 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.

November 15, 1909, operation under ether. Right unilateral laminectomy was done with division of the C₆, C₇, C₈, and C₉ posterior roots. When the dura was first punctured in this case the fluid spurted upward nearly eight cm.

The wound was closed as in the preceding cases. Primary union resulted. The spasticity largely disappeared immediately after the operation. Two weeks after operation, sores like those described in the preceding case appeared on the extremity from the fingers up to the elbow. They healed slowly.

At present, some two years and two months after operation, patient's epilepsy remains about as before operation. He is too simple minded to be put through a training treatment, yet he has been able to use his arm in dressing and undressing himself much better than before the operation. No further ulceration has occurred since those above cited.

Case IV. Thomas M., fifteen years old, an athetoid diplegic. June 27, 1911, operation under ether. Left unilateral laminectomy was done, and through this one sided exposure the posterior roots of the left C₂, C₇, C₈, and the right C₂, C₇, and C₈ were easily divided. In this case the pia mater was unusually thick and opaque. The wound was closed as usual. Spasticity was greatly improved, but athetosis is unmodified.

Case V. Joseph H., twelve years old; spastic paraplegia. August 14, 1911, operation under ether. Left unilateral laminectomy was done, and about one half of each posterior root from L₁ to S₂ inclusive was divided on both the right and left sides. The wound was closed as in the preceding cases, and primary union resulted.

The release of spasticity noted in all the other cases is not in evidence here. Patient's condition remains practically unchanged. Evidently a partial resection of individual roots is not able to induce the desired flaccidity, as seen in the other cases.

Approximately, some forty-one cases of Little's disease have been subjected to this operation.

Little's Disease: Cases operated in:

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Kiöttner. Held rigidly in adduction and flexion. Myotomy of passive motion unlimited, and voluntary motion not assembled a frog, with arms and legs abducted. Neither voluntary nor passive motion possible in any degree.

1910. Companied by associated movements. The boy can sit without support, and can walk with the aid of two canes.

Contractures as always confined to bed. Passive motion impossible. The child can stand perfectly straight, and walks alone with two canes. A pronounced cerebellar ataxia appears when walking or standing, but this is gradually overcome by systematic exercises. It is also relieved by supporting the child so that he can even stand on one leg when someone holds his hand.

CASE V (Little's disease). Female. Operated upon at the age of three years. Could neither walk nor stand before the operation, but can now walk around when her hand is held.

CASE VI (Little's disease). Male, thirteen years old. Could sit up and stand when supported. Walking impossible. Contractures in extensors of the knee and adductors and inward rotators of the hip joint. Operation one and a half year ago. Following the operation a transitory flaccid paralysis of both legs, persisting in the peronei muscles of the left leg. Nevertheless, he can walk around. Flexion, abduction, and outward rotation now possible. This boy has been going to school for the past few months.

CASE VII (Little's disease). Male, eight years old. Always confined to bed, but active flexion of legs possible in an almost normal degree. Isolated movements impossible. One and three quarters year after the operation, independent voluntary motion. No limitation of active or passive motion in any direction. Walks very well with two canes. Can walk with only one cane, or even without support, but the gait is then ataxic.

CASE VIII (Little's disease). Male, four years old. The child was completely bedridden. The results of the operation were less satisfactory than in the other cases, possibly because a tenotomy was performed to counteract the persisting equinovarus contraction of the flexors of the knee. Nevertheless, the child can now walk alone.

CASE IX (Little's disease and chorea). The spastic contractures ceased after the operation. No further observations were made.

CASE X. Male, twenty-one years old. Always bedridden. Spastic contractures of upper extremities with daily tonic painful spasm of left arm and shoulder. Section of fourth, fifth, sixth, seventh, and eighth cervical roots on left side. Five weeks after the operation spastic contractions had disappeared. The painful spontaneous cramps occurred only in the fingers. Slight shortening of the tendons at the wrist joint remained and might necessitate a plastic operation later on.

Köttner reports the results of Foerster's operation in ten cases of spastic paralysis. Nine of these
patients were unable to walk or stand, and five could not even sit up. A boy of eleven years, who previous to the operation could not turn himself in bed, thirteen and a half months after the operation could walk around with two sticks, and with so much ease that the father wanted to seek employment for him as a shepherd. The functional results were equally startling in another child that had been bedridden, but a pronounced cerebellar ataxia is observed when the child walks. Küttner feels confident that the ataxia symptoms will disappear with systematic exercises.

The least satisfactory results were obtained in the case of a small boy in whom tenotomy was performed before the radiculectomy. Küttner is strongly of the opinion that it is better to wait with the tenotomy until afterwards. He also emphasizes the importance of beginning the after treatment as soon as possible, to counteract the tendency to abnormal position, and as the root section only relieves the spastic contractures, but of course not the secondary retraction of the muscles.

The ultimate results are good, as far as the time allows us to judge. It must be borne in mind that the patients must be taught to coordinate, like little children.

Regarding regeneration, Küttner thinks that it does not take place, but nevertheless he recommends complete resection of the spinal roots, not merely severing them.

In one case of multiple sclerosis the spasticity disappeared immediately after the operation. Two weeks later the child had a sudden attack of paraplegia, of the flaccid type. This second paralysis can in no way be considered a recurrence, but a second stage of the progressive multiple sclerosis. Küttner closes with the remark that Foerster's operation is not to be so readily resorted to in the diffuse progressive cerebrospinal lesions.

Klapp, of Berlin, has performed Foerster's operation in six cases of Little's disease at Bier's clinic. The results were satisfactory on the whole, but he wished to state that the spasm, which disappeared immediately after the operation, returned shortly in more or less pronounced degree (he does not state in how many of his cases). He offers two explanations for this: 1. It may be due to shock, local, from nerve irritation, or general, from loss of blood and spinal fluid or from the anesthetic. 2. Possibly a new reflex route may be formed in the remaining sensory tract.

The next two cases are Foerster's, operated in by Tietze:

Case I (Little's disease). Congenital bilateral atresia of frontal convolution. Male, ten years of age. Examination: Notable deformity of cranium, which was abnormally small in comparison to the massive face. Divergent strabismus. Marked imbecility. Thorax barrel shaped. Arms slightly involved. Spasmodic paraplegia of lower extremities, with following symptoms: Extreme plantar flexion with contractures, rendering any attempt at standing impossible. Ankle clonus and Babinski's reflex on both sides. The flexors and extensors of knee contracted in an equal degree. Only slight passive flexion of knee possible. The thighs were flexed and held in forcible adduction and inward rotation. The only passive motion possible was a slight supplementary flexion. The only voluntary motion possible is a slight flexion of knee and hip, accompanied by dorsal flexion of the big toe and the metatarsal joints on both sides, motions of the arm, flexion of spinal column, and of head upon chest. These secondary movements were more marked and more extensive when the reflex defense contraction was produced, e.g., by pinching the leg. The patient could not sit up nor turn over in bed. The forcible adduction of the thigh was apparently the chief obstacle to active motion. This condition had grown steadily worse during the past two years.

Section of Lp, L4, L5, S3 was performed on June 11, 1907, by Tietze.

The contractions disappeared during the anesthesia, proving their true spastic character. Following the operation, the limbs assumed a normal position. Passive motion normal in all directions. The patient could sit down without spastic contraction of the flexors of the
knee resulting. The Achilles reflex and ankle clonus had disappeared, but patellar reflex was normal. Bilateral Babinski persisted. The defense reflex motions had disappeared almost entirely. Passive motions were somewhat painful during the first five or six weeks, which may have accounted for the unsuccessful attempts at active motion at first. Voluntary motion improved rapidly, so that in September associated muscular movements no longer appeared when he attempted to walk. The left quadriceps remained weak owing to accidental injury to the fourth lumbar during the operation. Sensory disturbances were absent, as far as the low mentality of the child permitted one to determine.

Case II (Little's disease). Female, nine years old. She had never been able to walk or stand. Could only sit up when supported. Disturbance of speech. Imbecility. Bilateral divergent strabismus. Upper extremities showed spastic paralysis. Lower extremities, equinovarus on both sides. Contractures in flexors of the foot, knee, and hip. Passive motion limited in the knee joint. Abduction and outward rotation in hip joint impossible. Passive extension of the thigh accompanied by flexion of both legs and feet. Tonic contractions followed the slightest pressure upon the soft parts, or tickling the sole of the foot, sometimes spreading to the upper extremities, which were held in flexion and abduction with the hand pronated and the fingers extended. Ankle clonus and Babinski present. Patellar and Achilles reflexes exaggerated. Voluntary motion impossible in the foot and restricted to slight flexion and extension in knee and hip, but always accompanied by movements of the other leg, upper extremities, spine, and head. The child could not sit up unsupported, could not raise itself up in bed; standing and walking impossible.

Operation, May 13th and 15th, by Tietze. Bilateral section of third and fifth lumbar and second sacral. Immediately following the operation, passive motions were painful. Babinski persisted. Achilles reflex diminished. Ankle clonus absent. Patellar reflex present on the left side (possibly the fourth lumbar reflex present in both legs, but less marked). No associated movements, except flexion of the knee when leg was raised with patient in recumbent position. Voluntary motion progressed so that at the end of June flexion, extension, abduction and adduction, and inward rotation were possible. The adductors were still contracted, possibly on account of shortening. On July 5th myotomy of Achilles tendon on the left side, and of flexors of knee joint on the right side. In March, 1908, myotomy and adductors, after which thigh was put up in plaster, in abduction for four weeks. Reduction of con-

genital dislocation of the left hip, followed by immobilization in abduction and outward rotation for four months. In October, 1908, the child was discharged. Voluntary motion: Flexion and extension of foot to 90° and of hip to about 60°, abduction to 90°. Adduction with greater ease than before. Slight limitation of outward rotation, but not of inward rotation. No associated movements. The girl could sit up in bed, could not stand alone, walked with crutches.

Göbell reports two cases in which he performed radiculectomy:

Case I (Little's disease). A boy, fifteen years, presenting a typical case of Little's disease. The increase in reflexes was so enormous that tapping the table on which the child lay was sufficient to cause tetanic spasms of the lower limbs. Ankle clonus and Babinski well marked. The second sacral, fifth, third, and second lumbar roots were resected. Following the operation, both legs were flaccid, all muscle and tendon reflexes were abolished, voluntary movements returned so the child could walk around when supported. There were no sensory disturbances. About seven and a half months later the reflexes were markedly increased in the left leg, and the associated movements had also returned in the left leg to a slight extent, but there were no marked sensory disturbances (the boy was not intelligent enough for the finer tests). The Babinski reflex was present. The right leg was flaccid, with absence of muscles and tendon reflexes.

Göbell states that, as both legs were flaccid and tendon and muscle reflexes were absent in both sides following the operation, one can only assume that partial regeneration of the posterior spinal roots on the left side has taken place. To guard against such an occurrence he recommends Bardenheuer's procedure (entwining the cut ends of the nerves).

Case II (Little's disease). Hydrocephalus. Female, five years old. This child had been able to walk, but since its second year had been paralyzed.

Examination: Circumference of head, fifty-eight cm. Movements of the eye were normal. Could walk when supported. Gait ataxic. Equinovarus on the right side. Babinski and ankle clonus present on right side, with increase of tendon reflexes. Reflexes in the right leg only slightly increased, absent in the right arm.

Operation, June 28, 1909. Resection of L4, L5, S1, and S2. On July 29, 1909, this case was demonstrated before the Schleswig-Holstein Medical Society. Spastic condition had disappeared entirely. Voluntary motion in both legs.

*Göbell, XXXIX Congress für Chirurgie, 1910.
No ataxia, no sensory disturbances. No associated movements.

Gottstein gives the two following cases:

CASE I (Little's disease). Female, six years old. Died second day after operation.

CASE II (Little's Disease). Male, seven years old. All voluntary motion absent. Defense flexion reflex present to a marked degree at every attempt to make the child stand, or at tickling of the plantar surface. Spontaneous tonic spasms of lower extremities when he moved the arms, when speaking, and when frightened. Sometimes the opisthotonus was produced by merely touching the toes of one foot. Operation consisted in resection of the second, third, and fifth lumbar and second sacral. Results: The spastic contractions partly disappeared. Voluntary motion was good. One and a half year after operation the patient could sit unsupported, could stand erect with support, and walked with canes. Gait normal and steady. Ataxia and spastic contractions of upper extremities disappeared gradually.

Two cases of Biesalski are as follows:

CASE I (Little's disease). The child died as a result of iodine poisoning shortly after the operation.

CASE II (Little's disease). At the present time the child had recovered nicely from the operation and was put up in plaster in order to overcome a tendency to adduction.

Hildebrand performed intradural root sections seven times, in six patients, for a great variety of reasons, including two cases of Little's disease. These patients were two children of seven years and two and one half years respectively. In the first case the first posterior sacral root, and the fifth, third, and second lumbar roots were divided on both sides. In the younger child, with spastic contractures, a relatively good result attended the operation. The contractures have relaxed, and the child is beginning to stand up, but the full success has not yet become apparent for the reason that the child is not normal psychically. and moreover has a congenital luxation of the hip joint. On account

of its youth, moreover, it could not be given the appropriate after treatment. It is probably the youngest child on whom the Foerster operation has been performed for Little's disease. The child of seven years, on whom the Foerster operation was performed, has likewise done well, but the final outcome cannot yet be stated.

Two cases by Wilms and Kolb are as follows:

CASE I (Little's disease). Intervention on conus medullaris, division of relatively few fibres. Effect positive, although moderate, according to circumstances.

CASE II. Contractures due to athetoid spasms (Little's disease). Although the value of the method was undoubted, the functional result proved unsatisfactory, in view of the complicated features of the case.

An attempt has been made by Wilms to modify Foerster's operation in such a way as to expose the nerves at the conus medullaris, where they emerge from the cord, instead of dividing the sensory roots before their emergence from the spinal canal. The object of the modification is to locate the field of operation higher up, and to diminish its extent. The posterior arches of the twelfth dorsal, first and second lumbar vertebrae are resected, the dura is opened, and the dorsal nerve is traced, drawn forward, and fixed; which causes the spinal cord to become tilted and placed edgewise. There is no difficulty about distinguishing the sensory from the motor fibres. Of the sensory bundles, two respectively were divided, and one was left, passing downward to the extremity of the spinal cord. The outcome was moderately good in the first case operated in (Little's disease). Wilms regards further attempts in this direction as justified.

The next case is reported by Van Gehuchten:

Little's disease treated by modified Foerster operation. The patient was a girl nine and a half years old, in

\[\text{Clark and Taylor: Cerebral Diplegia.}\]
whose case the continued wearing of plaster apparatus had corrected the faulty position of the limbs, but the extension contracture of the thighs on the pelvis, and of the legs on the thighs, prevented all active and passive movements, beside giving rise to extremely severe pain on the slightest attempt at motion. The child had to remain in the horizontal position, sitting being rendered impossible by the involvement of the gluteal muscles in the contraction.

Operation: (Operator, Lerau). Resection of root fibres, in immediate vicinity of cord, was recommended by Van Gehuchten, and the operation consisted in the bilateral resection of three small root bundles, belonging to the posterior roots of the lumbosacral nerves.

On the day following the operation, the child could voluntarily flex and extend the legs on the thighs, and the thighs on the pelvis. Some time was required to give her the courage to walk. She now walks very well when held by one hand and can walk unaided for a distance of about one hundred metres. She flexes the various segments of the two lower limbs voluntarily, sits down on a chair with the greatest ease, and has no trouble in crouching down on her heels and getting up again. But the gait is not normal. It must be kept in mind that the original lesion is not cured by the posterior radiculotomy, which merely aims at diminishing, as well as may be, the harmful results of this lesion, more particularly the muscular hypertonicity.

It is by diminishing the exaggeration of the normal muscular tonus that we succeed in diminishing the obstacle to the exercising of the voluntary motility. The clinical return of voluntary motility, as associated with the diminished spasticity of the muscles, clearly proves what Van Gehuchten has long maintained, namely, that the corticospinal connection, established by the pyramidal tract, takes place through at least two distinct kinds of nerve fibres: fibres concerned with the mechanism of the voluntary motility and fibres which exert an inhibitory action on the tendon reflexes, the inferior cutaneous reflexes, and the normal muscular tonus.

CASE of Little's disease (Anschütz).13 Female, thirteen years old. Spastic contractures of muscles of the calf, in the flexors of the hip and kneejoints, and the adductors. Legs held in adduction or inward rotation. Equinovarus. Standing, walking, or sitting up in bed impossible. Operation: Section of L2, L3, L4 and S1.

Results: Immediate disappearance of spastic contractions. No sensory disturbances. After six weeks the legs were held in normal position, except for slight flexion of knee and hip. Walking and daily improvement in gait. Gymnastic exercises.

Case of Little's disease (Kotzenberg).14 Female, four years old. Mentality normal. Lower extremities held in forcible adduction with flexion of hip and kneejoints. Babinski and ankle clonus present. Patellar and Achilles reflexes increased. Contractures most marked in adductors, also present in flexors of hip, outward rotators, and plantar flexors. No voluntary and only slight passive motion possible. Section of L4, L5, and S1. Results: Active and passive flexion and abduction normal. Ankle clonus and Babinski not present. Patellar reflex still exaggerated. The author states that it is yet too early to determine the ultimate results in this case. No mention is made of child walking or standing.

Case of Little's disease (Hevesi)15 The spastic symptoms most marked on the left side. Active and passive motions impossible. Resection of L2, L3, L4, and S1 on the left side and L2, L3, L4, S1 on the right side. Spastic contractures disappeared at once, and passive motion became possible in all directions. Voluntary motion appeared later, so that seven weeks after the operation the child could stand and walk with the aid of two canes. Gait unsteady, but improved daily. No marked sensory disturbances or ataxia.

Frazier's16 personal experience has been limited to one case of Little's disease.

CASE of spastic congenital diplegia (Little's disease). Patient, aged twenty-four years. Resection of fifth, sixth, seventh, and eighth sensory roots of cervical cord.

Results of operation: In eight weeks almost complete disappearance of athetoid movements; spasticity diminished, but not abolished. Voluntary motion and control

13Anschütz, Chirurgische Behandlung der Little'schen Krankheit, Münchener medizinische Wochenchrift, p. 1713, August 17, 1899.
14Kotzenberg, Durchschneidung der hinteren Wurzeln bei Little'scher Krankheit, Zentralblatt für Chirurgie, xxxvi, p. 503, 1909.
15Hevesi, Beitrag zur Operation Behandlung der angeborenen Gliederstarre, Deutsche medizinische Wochenchrift, 1910.
Clark and Taylor: Cerebral Diplegia.

...of both extremities possible to a much greater degree. Individual voluntary movements not restored. Associated movements pronounced. The patient was able to walk with less difficulty. Improvement continued daily.

Frazier is not prepared to say why the results here are disappointing, in regard to spasticity and the associated movements. It may possibly be on account of the cerebral origin, or the section of the roots of the cervical cord may be less beneficial than in the dorsal and lumbar regions, or possibly a mistake was made in the selection of the resected roots.

Case of spastic spinal paraplegia due to sclerosis of lateral strands (Codivilla). The patient was a girl of fifteen years of age, unknown parentage. Disturbances on part of nervous system since tenth year, beginning with some weakness of the lower extremities and limit of motion in walking. Limbs became progressively more rigid and adducted, kneejoints more flexed, until she could walk only with a stick. No results from mercury and iodine treatment.

On examination of the patient in the dorsal position, all the articulations of the lower extremities were found to be flexed; the thighs in the hipjoint, the legs in the kneejoint; the feet in equinus position. Forcible passive abduction or flexion rendered the extremities as well as the trunk rigid and stiff. Unilateral performance of passive motion caused an involvement of the opposite side in the spastic contractions. Active movements were very slight, limited to slight flexion and extension in the knee-joint and slight flexion in the hipjoint; these movements were made slowly and painfully.

Operation: Resection, on right side, of posterior roots, of the second sacral, fifth, and third lumbar; on the left side, on account of its abnormally high origin.

Result of operation: Slight improvement of spasticity. Although the patient's gait still retained its spastic character, the reflex spinal irritability was undoubtedly much diminished. The spontaneous movements were considerably freer, and the patient was better able to control her movements. Spasticity, contractures, and reflex movements were worse on the left than on the right side. The muscular development of the left leg remained stronger, because the resection of the nerves was not so complete as on the right side.

Codivilla is of the opinion that similar results might have been obtained by the ordinary procedures, such as tenontomyotomies, etc. The persistence of the spasticity is certainly referable to the fact that the resection was limited to a small number of nerve roots. The grave and very troublesome contracture of the adductors might have been corrected by resection of the second, beside the third lumbar vertebral arch. In order to lessen the dangers of the intervention (two deaths among sixteen cases operated in), the author recommends the transference of the field of operation from the present lumbar sacral site to the dorsolumbar region, so that instead of the cauda equina, the lowermost portion of the spinal cord is exposed. Orientation would thus be facilitated, and individual bundles of fibres could be resected, instead of the entire roots. Moreover, the skeletal segments are more superficially situated higher up; the injury to the soft parts is less considerable; a resulting hemorrhage is less profuse, and the field of operation is more easily inspected.

In the case described above, the operation was followed at first by spontaneous pain in the extremities, and pain on active or passive movements. There was urinary retention on the first day. The pains subsided entirely by the end of twelve days. Five months after operation, at the time of the report, the spinal irritability was notably diminished, the spontaneous movements were relatively free, and the patient had much better control over her body.

Case of diplegia spastica infantilis or Little's disease (Stiefler). Forster's operation, combined with systematic after treatment, undoubtedly led to very satisfactory results; the spasms were in part removed, in part considerably diminished. Especially, the spontaneous motility increased in strength and scope, so that the patient was enabled to sit upright, unaided, and also to walk with the assistance of the hands.

Codivilla, Ueber die Foerstersche Operation (Resektion der hinteren Nervenwurzeln bei der spinalischen Paralyse), Münchener medizinische Wochenschrift, No. 27, p. 1438, 1910.

Heile reports a cured case of Little's disease in a child of four years of age, after resection of the second, third, and fifth posterior lumbar and second sacral root, to the extent of about two cm.

84 East Fifty-sixth Street.

18Heile, Münchener medizinische Wochenschrift, No. 3, p. 129, January 16, 1912.