

From the Clinic for Cerebral Palsy,
The Orthopaedic Hospital, Copenhagen.

SURGERY OF THE HAND IN CEREBRAL PALSY

By

J. MORTENS

Many operative procedures have been suggested to improve the function of the spastic hand. The aim of this paper is to analyse critically the different interferences possible, based upon the literature and upon a limited personal experience.

The Cerebral Palsy Clinic at the Orthopaedic Hospital, Copenhagen, was opened in 1950 and treatment was instituted on a team basis. 1500 patients were seen at the clinic up to 1961, and 290 patients were operated upon by the orthopaedic surgeon of the team with 800 individual operations.—With regard to the hand, 17 patients, and 17 hands, were operated on with 54 individual operations.

When the clinic opened, according to the fashion at that time, few operations were performed. With physiotherapy and braces, instituted early and continuously employed, it was hoped to improve motor function satisfactorily, and only organic contractures in neglected cases and very severe spasticity gave indications for operations—a reaction to the previous period in which training was neglected and the results of operations accordingly were considered unsatisfactory. However, gradually, many of the previous conventional operative procedures came into use again and new types of operations were employed as experience was gained as to what extent physiotherapy and splinting alone were inadequate and to what extent the individual operative procedures were helpful when pre- and postoperative training and many years of observation were possible.

We have adopted a moderate approach to early soft tissue surgery in Cerebral Palsy in order not only to correct deformities but also, to the extent possible for us, to correct the imbalance of muscle pull by surgery in the prevention of recurrences of the deformities, to improve dynamic function and to facilitate the task of training for the physio-

therapists and occupational therapists, and in order to diminish the need for splints and braces.

The reason for this approach is the fact that alteration in muscle lengths and deformed bone growth in the presence of muscle imbalance beset the treatment of the deformity and dysfunction in spastic paralysis as well as in poliomyelitis. If muscle imbalance is not corrected by early soft tissue operations in addition to splinting and physiotherapy it is likely that the deformity and dysfunction will progress to a greater degree in the growing child.

TABLE 1
Orthopaedic Operations to Improve Function of the Hand in 17 Patients.

Myo-tenotomies or	pronator quadratus	2	
Elongation of Tendons	Wrist flexors	7	
	add. poll.-interos. dors. I.	2	
	flex. poll. long.	1	12
Tendon transplantations			
A.	pronator teres to ext. carpi rad.	5	
B.	flex. carpi ulnar.		
	1) dorsal to radius or to ext. carp. rad.	5	
	2) to ext. dig. com.	4	
C.	flex. carpi rad. to		
	1) ext. poll. long.	5	
	2) abd. poll. long.	2	21
Tenodeses	sublimis - interphal. prox.	6	6
Arthrodeses	radio-carpal	11	
	metacarpo-phal. I.	3	
	carpo - metacarpal I.	1	15
Total			54

During the years when we have gradually extended the employment of operative procedures, we have also become increasingly interested in the problem of improving the function of the spastic hand by surgery. But due to the experience gained during the years in the whole field of Cerebral Palsy (*Mortens* 1962, 1965) we are still of the opinion, that only procedures with the most elementary objectives yield consistently

good or fair results. And this attitude we have hitherto also extended to the field of surgery of the spastic hand. Our aim at present, is to stop and take stock of the position: to see whether our attitude is too conservative and to consider if we might be justified in altering our opinion that some suggestions for operative procedures in the literature are rather theoretical.

In our clinic 7 per cent of the individual operations performed have been to improve function of the spastic hand or rather, 6 per cent, if the number of patients operated upon is the basis for the relative frequency of operations on the hand. This frequency varies to some extent in the literature:

Green (1942) reports 10 per cent, *McCarroll* (1949) 13 per cent, *Goldner* (1955) 4 per cent and *Swanson* 4 per cent.

The individual procedures we have used can be seen from Table 1. On all hands more than one individual operation was performed as a combined operation; often several combined operations were performed at the same operative session, or with some months' interval.

The age of the patients when operated varied between 12 and 23 years.

The type of Cerebral Palsy was in most cases spastic hemiplegia, but three had a spastic tetraplegia, one of these mixed with athetosis.

The deformity and dysfunction to be corrected in order to improve function can be grouped under three headings: 1) the pronation contracture of the arm and hand, 2) the flexion contracture of the wrist and the imbalance between finger flexors and extensors and 3) the adducted and flexed position of the thumb.

ad 1) We have employed myotendotomy of the pronator quadratus and transposition of the pronator teres to the radial wrist extensors—directly, or indirectly through the interosseous membrane round the ulnar side of the radius—in the hope of abolishing pronation contracture. A strong spastic ulnar wrist flexor was also transferred dorsally to the radial wrist extensors or, if a wrist fusion was performed dorsally to the radius. The immediate results after the removal of the plaster in full supination were good but all but one have had recurrence of the pronation deformity. *Green* (1942) and *McCarroll* (1949) report somewhat better results, but the length of their observation time are not known. *Phelps* (1957) has found as a late result of soft tissue surgery for pronation contractures recurrences in all cases; he advocates the use of a derotation osteotomy on the radius as it gives a lasting correction. However, we do not find such an operation indicated as the pro-

nated position is to be preferred to the danger of a permanent supination contracture.

ad 2) To improve upon the flexion contracture of the wrist simple tenotomies on the wrist flexors were of no value in our hands, as we operated on only rather severer contractures. In a few cases of mild flexion contractures of the wrist *Swanson* (1960) did such tenotomy or elongation of the wrist flexors, although in most instances he carried out the transposition of these muscles dorsally—in a similar way as described below—or performed a fusion of the wrist. To abolish flexion contracture of the wrist we transferred the strong and shortened wrist flexors either to the radial wrist extensors, the long thumb abductor and/or to the long finger extensors—in order not only to correct the flexion contracture of the wrist but also if indicated to improve upon a pronation contracture or weakened finger extensors. These procedures have been of little value and confirmation of this opinion is to be found in the literature: F. inst. *Heyman* (1939) reports bad results with all these procedures; when applying transposition of the wrist flexors to the finger extensors he has even produced severe secondary contractures with ulnar deviation of the hand.

Green & Banks (1962) on the other hand report improvement of dorsi-flexion of the wrist with additional improvement of supination by transposing the flexor carpi ulnaris to one of the radial wrist extensors.—However, they only obtain improvement on a very selective indication: milder cases with good control of finger movements.

The best results we have had in correcting the marked flexion deformity of the wrist and improving function of the hand followed a wrist fusion, either with or without additional transposition of the flexors as above outlined; and there is full confirmation in the literature of this opinion.

A fusion of the wrist is never done unless there is some active power in the finger flexors. Always, preoperatively, we splint the wrist in neutral—or in slight volar flexion¹; passive stretching or the finger flexors and exercises of the finger extensors are pursued at the same time. In some instances extension of the fingers and active opening of the hand are only possible by simultaneous maximal volar flexion in the wrist. A wrist fusion can result in a permanent clenched fist, although the fusion may have been performed in a neutral position, and activation of the finger extensors in addition, performed by the best possible tendon transpositions.

See foot-note page 447.

*Fig. 1.*

The technique we use for the fusion shortens the lengths of the bones. The distal end of the ulna is resected and the radio-carpal fusion is performed very simply by forcing the tapered end of the radius down into a frontal slide in the carpal bones. Fusion has always occurred (Fig. 1). By this shortening of the bones the long finger flexors and extensors are relatively elongated and this sometimes produces as fair a muscle balance as one can hope for. Therefore the wrist flexors are not always employed to reinforce extension of the fingers.

It is worth while mentioning that a procedure used by *White* (1962)—a muscle sliding operation such as described by *Scaglietti* for use on Volkmann's contractures, done before the wrist fusion—has the similar aim of elongating the spastic flexors and diminishing the spastic pull.

One should be very careful to reinforce the finger extensors. We do it with the help of the ulnar wrist flexor—using the radial wrist flexor for the purpose of improving function of the thumb—a topic to be dealt with later.

It can be very difficult to estimate in a spastic dystonic hand the power of the *profundi* and the *sublimes*. And I believe this—in addition to the dysfunction inherent in the disease—is the reason why reports in the literature are controversial.

In a few of our cases, with transposition of the ulnar wrist flexor to all finger extensors including the thumb, we have had some slight improvement, but not in all. However, we have had no severe overcorrection of the muscle balance, on the selective indications employed. *Heyman* (1939) reports no improvement of finger extension activation by use of both wrist flexors, and *Goldner* (1955) has produced overcorrection with the use of one wrist flexor, which had produced a swan-neck

deformity he had to reoperate upon secondarily. *Swanson* (1960) also uses a wrist flexor for extensor activation, but prefers to use the sublimes if the profundis are of sufficient power; he then also performs a tenodesis of the proximal interphalangeal joints using the remnants of the sublimis tendons in order to prevent any secondary deformity by the reinforcement. We have had no personal experience with this suggestion by *Swanson*, but theoretically there is a good argument for using it: he is employing a deforming factor for the correction—an established principle in work with paralytic deformities. The argument against it is what has already been stressed: the difficulties in estimating the finger flexors power in a spastic dystonic hand.

It should perhaps be mentioned that *Swanson*, in some of the milder cases he finds indication to operate upon, has used a wrist extensor for the finger extension reinforcement, and left a wrist flexor intact, so that the effect is one of a tenodesis.

Goldner (1955) like *Swanson* uses the sublimis for finger extension activation but in a rather fanciful way: he reinforces the extensors to the third, fourth and fifth finger by the ulnar wrist flexor, but uses a split sublimis tendon from the fourth or fifth finger to reinforce extension of the second finger: one snip subcutaneously to the tendon of the first dorsal interosseous muscle, the other through the lumbrical canal to the extensor aponeurosis. He might gain some abduction stability of the second finger—although I have never met with a case in need of it; but the recommendation to use the sublimis of the fifth finger does not appeal to me, as this tendon usually is very tiny with not much power.

Before leaving the subject of extrinsic imbalance of the fingers and in order to make the quotation from the literature complete I shall mention that *Goldner* seems to have seen cases with hyperextension deformities of the distal interphalangeal joints, which needed repair by reinforcing the profundis by the sublimis, using an “en bloc” suture of all tendons. These deformities I would think were very rare in the spastic hand. *Goldner* also has found indication for fusing the proximal interphalangeal joints of the fingers for severe flexion deformities of these joints. We have not tackled so severe cases in this manner—only done a wrist fusion with reinforcement of the digital extensors, gaining cosmetic improvement but not always functional improvement of the fingers.

We have tried in a few instances to repair the intrinsic-plus deformity or the swan-neck deformity after the manner described by *Swanson*

(1960). His analysis of the extensor mechanism in the spastic hand is excellent, and I believe he is right in supposing that it is the spastic pull of the extrinsic muscles and not spasticity in the intrinsic muscles which is dominant in producing the deformity. *Swanson's* remedy is very simple: a tenodesis of the sublimes, anchoring these tendons to the proximal phalanges with the proximal interphalangeal joints in some flexion, without severing the tendons. But in our hands the results—very promising to begin with—are not very good; there is an obvious tendency to recurrence of the hyperextension deformity.—When the profundus are weak and the sublimes cannot be spared, *Swanson* employs the usual anterior capsulorhaphia.

Burman (1938) and *Goldner* (1955) cut the lateral bands as they are of the opinion that spasticity in the intrinsic muscles is responsible for the deformity. It is difficult from their articles to estimate their results.

In finishing the description of the various methods employed for the intrinsic-plus deformity wish to mention that *Swanson* recommends the usual flexion osteotomy on the metacarpals—the procedure in use for the rheumatoid hand—when volar dislocation of the fingers has taken place; however, I have never seen such a deformity in a spastic hand.

In concluding the discussion of the swan-neck deformity, I should like to say, that I am somewhat amazed at all the work done in repairing it. In my opinion, this deformity is mostly a cosmetic problem, and I do not believe a successful repair adds much to the function of the clumsy dystonic spastic hand.

ad 3) When the thumb is permanently adducted or lying in the palm of the hand making an active opening of the hand for grip impossible, the first thing we do—when a wrist arthrodesis is called for, which usually is the case—is to perform the radio-carpal arthrodesis in marked ulnar deviation¹ as recommended by *Cooper* (1952); when the thumb cannot be brought away from the hand, the hand can be brought away from the thumb (Fig. 1). In some instances this is helpful but far from always. Then the tendon of the long extensor of the thumb is cut and rerouted in a radio-volar direction and the radial wrist flexor

¹ This position is chosen primarily to relax the spastic over-pull of the finger flexors. But as we fuse the wrist not only in neutral between flexion and extension but also in ulnar deviation, we obtain the wrist position for "power grip" (*Napier*). The "precision grip" has the wrist in dorsiflexion and in neutral between radial- and ulnar deviation. Our aim must in most instances be the "powerful grip", as improvement by surgery of finer movements is seldom possible in the spastic hand, in which stereognosis—apart from the motor impairment—often is poor.

is transposed to it, a procedure also used with advantage by *Goldner* and *Swanson*. This will lead to hyperextension deformity of the metacarpo-phalangeal joint of the thumb (Fig. 1) and a fusion of this joint is always performed. *Swanson* also does this fusion as a routine procedure, but *Goldner* not always. We usually do a myotenotomy of the first dorsal interosseous muscle and of the adductor pollicis at the same time as the fusion—a procedure also employed by *Goldner* and in a modified manner by *Burman*, *Leo Meyer* (1938) and *Swanson*.

Goldner sometimes adds the usual sublimis transfer to induce opposition power to the thumb, a procedure we do not think we have yet had any indication to employ in a spastic hand.

If the above procedures we use—reinforcement of abduction pull by the mentioned tendon transfer in combination with fusion of the metacarpo-phalangeal joint—do not bring the thumb sufficiently far out from the palm, we have in a single instance also fused the carpometacarpal joint as recommended by *Steindler* (1952), also employed by *Swanson*. There is an additional intermetacarpal osteoplastic procedure as recommended by *Phelps* (1957) and *Swanson* which I am sure is worth using in very bad cases, although the thumb is converted to a rigid strut: we have not tackled such a severe case by this triple procedure.

In one case a severe flexion deformity of the interphalangeal joint occurred after the above-mentioned operations, and we did an elongation of the long flexor to the thumb with a satisfactory result. This has also been performed by *Swanson*.

CONCLUSIONS

To answer the question under consideration, whether we have been too conservative and omitted the use of some valuable additional procedures suggested in the literature, I think it is appropriate to state, that the interventions we have employed, the frequency with which we have employed them and the results we have obtained by them, display an approach to surgery of the spastic hand which is in accordance with many of the authors' views.

A few have employed some procedures we have not found use for, the reason probably in most instances being that they also wanted to improve upon a spastic hand not very badly damaged by the Cerebral Palsy. However, many of these various procedures have been used in series of cases not large enough to draw any definite conclusions with

regard to the results which can be expected. Further, some overcorrections have been seen, making reoperation necessary.

I, personally, would only add to my "mental armament" of *possible* procedures to apply upon the spastic hand, the use of the sublimis for finger extension reinforcement (*Swanson*) and perhaps also the use of the conventional sublimis transfer for opposition of the paralytic thumb (*Goldner*), on a very selected indication; finally the use also in the very bad hand of the triple arthrodesis procedure on the thumb, and of fusion of proximal interphalangeal joints, when these are permanently flexed.

It is to a large degree a matter of temperament to what extent one judges an operation on the spastic hand to be indicated. I still would hesitate to try to improve by surgery a spastic hand which has some skilful abilities; the only possible exception to this rule is the employment of the flexor-carpi ulnaris transposition to the radial wrist extensors to improve upon a moderate flexion—pronation contracture in a hand with fairly good finger control. I think the main indication for surgery is the rather badly damaged hand which at the utmost can be considered a supporting hand. But then, I feel that such a hand can be improved, often more than expected. It is not possible to convert in into a skilful hand; it will still only be a "supporting hand", but a better one.

Whatever kind of "temperamental" attitude towards surgery of the hand one adopts, I believe the following statements are valuable to keep in mind:

Fusion of joints is most reliable because results are fairly predictable by preliminary use of adequate splinting during training.

Tendon transpositions alone are to a large extent unreliable and overcorrection is a danger. Nevertheless, their use is sometimes indicated. If used, however, the tendon transfers should preferably be combined with joint stabilization—arthrodeses or tenodeses—in order to govern and regulate the dynamic of the reinforcement.

Myotomies and elongation of tendons can additionally be of some use, but one must realise that improvement is often lost later if other stabilizing or balancing procedures are not simultaneously employed.

In finishing this report I would like once again to stress that only procedures with the most elementary objectives yield consistently fair results. Remember that in Cerebral Palsy the normal interrelated functions of contiguous articulations in the fingers and hand are profoundly affected, and that whatever one does, one can never obtain a cure—at

the utmost some improvement in a simple specific function to a badly damaged hand.

SUMMARY

Seventeen hands, involving 54 individual operations, from the Clinic for Cerebral Palsy at the Orthopaedic Hospital in Copenhagen, are reported upon.—On all the hands more than one individual operation was performed as a combined operation, and often several combined operations were performed at the same operative session, or with some months' interval. The results are compared with results in the literature. Further, some suggestions from the literature to improve function of the spastic hand by surgery, not personally employed, are discussed. On the basis of a critical analysis of the procedures which we used at our clinic and those rather few additional suggestions in the literature it is concluded that the fairly moderate attitude towards surgery of the spastic hand which we—and many others—have adopted is advantageous: only simple procedures with the most elementary objectives yield consistently good results. One must be very cautious in trying to improve by surgery the function of a spastic hand which has some skilful abilities. The indication for surgery is mainly the badly damaged spastic hand, which at the utmost can be considered a supporting hand. But then, such a hand can often be improved more than expected.

RESUME

Dix-sept mains, comportant 54 opérations individuelles effectuées à la Clinique de paralysie cérébrale de l'Hôpital orthopédique de Copenhague, font l'objet du rapport.

Sur toutes ces mains, plus d'une opération individuelle a été effectuée comme opération combinée; souvent plusieurs opérations combinées ont été pratiquées pendant la même intervention, ou à quelques mois d'intervalle. Les résultats sont comparés à ceux de la littérature. Par ailleurs, il est discuté de certaines suggestions de la littérature pour améliorer la fonction de la main spastique par une chirurgie qui n'a pas été appliquée personnellement par l'auteur. Sur la base d'une analyse critique des méthodes que nous employons dans notre clinique et de quelques suggestions additionnelles tirées de la littérature, il est conclu qu'une position plutôt modérée quant à la chirurgie de la main spastique que nous — et beaucoup d'autres — avons adoptée est à la préférer; seules des méthodes simples, ayant l'objectif le plus élémen-

taire, donnent de bons résultats. Il faut être très prudent quant aux tentatives d'une amélioration par le moyen de la chirurgie de la fonction d'une main spastique qui possède encore une certaine habileté. L'indication de l'intervention chirurgicale doit être principalement la main spastique fortement endommagée qui peut tout au plus être considérée comme une main de support. Mais dans ce cas, l'état d'une telle main peut souvent être amélioré plus que l'on ne s'y attendait.

ZUSAMMENFASSUNG

Über siebzehn Hände mit 54 Einzeloperationen aus der Klinik für Cerebrallähmung des orthopädischen Krankenhauses in Kopenhagen wird berichtet. An allen Händen wurde mehr als eine Einzeloperation in Form einer Kombinierten Operation ausgeführt, und oft wurden mehrere kombinierte Operationen in derselben Sitzung oder mit mehrmonatlichem Intervall ausgeführt. Die Ergebnisse werden mit den Ergebnissen der Literatur verglichen. Weiterhin werden einige Vorschläge aus der Literatur zur Verbesserung der Funktion der spastischen Hand mittels des chirurgischen Eingriffes, die jedoch persönlich nicht verwendet wurden, besprochen. Auf Grund einer kritischen Analyse der Verfahren, die wir an unserer Klinik anwenden und jenen ziemlich sparsamen Vorschlägen in der Literatur, schliessen wir, dass die ziemlich bescheidene Einstellung, die wir gegenüber der Chirurgie der spastischen Hand eingenommen haben, vorteilhaft ist: Nur einfaches Vorgehen mit elementarster Zielsetzung ergibt dauernd gute Resultate. Bei dem Versuche die Funktion einer spastischen Hand, die von vornherein eine gewisse Geschicklichkeit besitzt, zu verbessern, muss man sehr vorsichtig sein. Operationsanzeige ist meist die schwer beschädigte spastische Hand, die höchstens als eine unterstützende Hand angesehen werden kann. Aber solch eine Hand kann über alle Erwartungen hinaus verbessert werden.

REFERENCES

- Burman, M. S.*: The spastic Hand. *J. Bone Jt Surg.* 20: 133, 1938.
Cooper, W.: Surgery of the Upper Extremity in Spastic Paralysis. *Quart. Rev. Pediat.* 7: 139, 1952.
Goldner, J. L.: Reconstructive Surgery of the Hand in Cerebral Palsy. *J. Bone Jt Surg.* 37-A: 1141, 1955.
Green, W. T.: Tendon Transplantation of the flexor Carpi Ulnaris ... *Surg. Gynec. Obstet.* 75: 337, 1942.
Green, W. T. & Banks, H. H.: Flexor Carpi ulnaris Transplant and its use in Cerebral Palsy. *J. Bone Jt Surg.* 44-A: 1343, 1962.

- Heyman, C. H.*: Surgical Treatment of Spastic Paralysis. Surg. Gynec. Obstet. 68: 792, 1939.
- McCarroll, H. R.*: Surgical Treatment of Spastic Paralysis. Instructional Course Lectures 6: 138, 1949. Ann. Arbor, J. W. Edwards.
- Mortens, J.*: Surgery of the Spastic Hand. J. Bone Jt Surg. 44-B: 247, 1962.
- Mortens, J.*: Orthopaedic Operations in the Treatment of Children with Cerebral Palsy. Danish Medical Bulletin 12: 22, 1965.
- Napier, J. R.*: - quoted by Flatt, A. F.: Kinesiology of the Hand. Instructional Course Lecture 18: 266, 1961. Ann. Arbor, J. W. Edwards.
- Phelps, W. M.*: Long-term Results of Orthopaedic Surgery in Cerebral Palsy. J. Bone Jt Surg. 39-A: 53, 1957.
- Steindler, A.*: Pathokinetics of Cerebral Palsy. Instructional Course Lectures 9: 118, 1952. Ann. Arbor, J. W. Edwards.
- Swanson, A. B.*: Surgery of the Hand in Cerebral Palsy and the Swan-neck-deformity. J. Bone Jt Surg. 42-A: 951, 1960.
- White, W.*: Surgery of the Spastic Hand. J. Bone Jt Surg. 44-B: 246, 1962.