Original Article

Flexion Deformities of the Wrist and Fingers in Spastic Cerebral Palsy: A Protocol of Management

Abstract

Background: Literature is confusing regarding grading and treatment of flexion deformities of wrist and fingers in spastic cerebral palsy (CP). The most established classification is that described by Zancolli; unfortunately, it has its shortcomings which we experienced in the beginning of our approach to manage this rather difficult deformity. We thus modified Zancolli's classification and developed a classification system and treatment protocol. **Materials and Methods:** Thirty patients with spastic CP were operated upon due to flexion deformity of the wrist and fingers and were included in this study. Age ranged from 4 to 14 years, average 7 years. There were twenty boys and ten girls. **Results:** The average followup was 18 months (range 9 months - 3 years). The power of wrist dorsiflexion, the "House's classification of upper extremity functional use" and the clinical assessment of hand function were used for evaluation; they improved in all patients and this improvement was statistically significant. In all patients, cosmetic appearance improved without any residual flexion deformity. **Conclusion:** This study introduces a new grading system for flexion deformity of wrist and fingers in spastic CP that correlates with severity of the condition and allows a treatment protocol to be established.

Keywords: *Flexion deformity, wrist, fingers, cerebral palsy, spastic, classification*

MeSH terms: *Cerebral palsy, spastic diplegia, spastic quadriplegia, botulinum toxins*

Tarek Hassan Abdelaziz, Shady Samir Elbeshry, Mahmoud Mahran, Ahmad Saeed Aly

Department of Orthopaedic Surgery, Faculty of Medicine, Ain Shams University, Cairo, Egypt

Introduction

Cerebral palsy (CP) is a nonprogressive, nonhereditary encephalopathy that occurs in the perinatal period. The hand is involved in almost all types of CP with wrist and finger flexion being the most common deformity. Surgery, when appropriately applied, can improve function and appearance of the involved hand.[1] The literature is confusing regarding the grading of flexion deformities of the wrist and fingers in spastic CP and hence more confusing regarding the treatment. The most established classification is that described by Zancolli.[2]

Zancolli's classification

Group I

The patient can actively extend completely the fingers with <30° of wrist flexion.

Group II

The patient can actively extend the fingers but only with >30° of wrist flexion. In severe cases in Group II, the wrist needs to flex completely to permit complete or partial finger extension.

Group III

Patient cannot actively extend the fingers, even with maximal flexion of the wrist.

This classification is confusing due to several facts such as defining Group II as needing >30° wrist flexion to allow active finger extension then adding "severe" cases that need complete wrist flexion to permit active finger extension (nothing defines the degree of severity). When the treatment protocol is suggested based on this classification[2] further confusion arises; in GII, multiple fractional lengthening of the forearm flexors (MFLFF) is added to flexor aponeurotic release (FAR) if >70° of wrist flexion is needed for active finger extension; in GIII, MFLFF is recommended, but if insufficient, flexor digitorum profundus (FDP) to flexor digitorum superficialis (FDS) transfer is done (practically FDP to FDS transfer cannot be done after fractional lengthening (FL) of these tendons). The aim of this study is (a) to introduce a new grading system for flexion deformity of the wrist and fingers in spastic CP that correlates with the severity of the condition

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Address for correspondence:
Dr. Shady Samir Elbeshry, 74, Rabae Eladawya Biuldings, Nasr City, Cairo, Egypt.
E-mail: shady_elbeshry@yahoo.com

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and allows a treatment protocol to be set, and (b) to evaluate the medium term results of the various surgical techniques used to treat this challenging problem.

Materials and Methods

Thirty children with spastic CP were operated upon due to flexion deformity of the wrist and fingers between April 2010 and May 2014. As we found the Zancolli classification and treatment recommendations confusing as explained above, we decided to modify the existing Zancolli classification and propose a new classification system.

The procedures in this study were in accordance with the ethical standards of the responsible committee on human experimentation, and procedures were done with an informed consent of the patients.

Proposed cerebral palsy hand classification:

- G I: Complete active finger extension with the wrist flexed <30°
- G II: Complete active finger extension with the wrist flexed >30°, but < full flexion
- G III: Complete active finger extension only with full wrist flexion
- G IV: Incomplete active finger extension with full wrist flexion.
- G V: No active/passive finger extension even with wrist completely flexed.

GI – GIV is each group is subdivided into A and B depending on active wrist dorsiflexion, with subgroup A able to actively extend the wrist "with fingers flexed" at least Grade 3 (against gravity) according to "Medical Research Council (MRC) grading system" and subgroup B unable to extend it [Figure 1].

The reproducibility of the new grading system used in this study was good, with kappa values for intraobserver and interobserver repeatability of 0.71 and 0.72, respectively. The intraobserver concordance was 82%; whereas the interobserver concordance was 78%.[3] According to this classification, thirty patients were included in this study [Table 1]. Two patients were type Ia, four were type Ib, three were type IIa, four were type IIb, three were type IIIa, four were type IIIb, three were type IVa, one was type IVb, and six were type V. Age ranged from 4 to 14 years, average 7 years. There were twenty boys and ten girls. Only children ≥4 years with spastic CP were included in the study as this was considered to be the youngest age at which rehabilitation could start postoperatively.

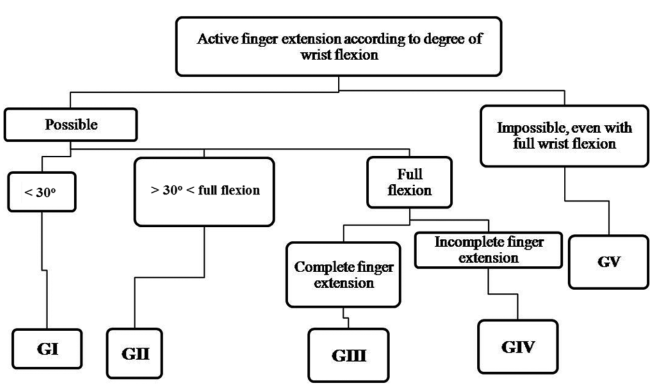

Figure 1: Flowchart summarizing proposed cerebral palsy hand classification; each grade is further subdivided into "A" and "B," with "A" meaning active wrist extension ≥G3 (Medical Research Council grading system)

Any child <4 years, with athetosis or dystonia or with stiff wrist and finger joints was not included in our study. We set our protocol of management based on this classification as follows:

- G IA: Fractional lengthening (FL) of flexor carpi ulnaris (FCU)
- G IB: Transfer of FCU to extensor carpi radialis brevis (ECRB)
- GIIA: FAR
- G IIB: FAR + transfer of FCU to ECRB single stage
- G IIIA: FAR + MFLFF
- G IIIB: FAR + MFLFF + transfer of FCU to ECRB (single stage)

Table 1: Patients' demographics and results

Pt No	Age	CP type	Proposed Grade	DF, Pre-op	DF, PO	HF, Pre-op	HF, PO	House Pre-op	House PO
1	4	H	Ia	3	4	F	G	5	8
2	6	H	IIb	2	4	F	G	4	7
3	5	H	Ib	2	4	F	G	4	7
4	5	H	IIIa	3	4	P	G	3	7
5	6	H	IIa	4	4	F	G	5	7
6	7	H	Ib	2	4	F	G	4	8
7	5	H	IIb	2	4	F	G	4	7
8	6	H	IIIb	1	3	P	F	2	6
9	7	H	IIa	3	4	F	G	4	7
10	6	H	Iva	3	4	P	F	2	5
11	4	H	IIIb	1	3	P	F	2	6
12	8	D	V	0	2	NF	F	0	4
13	6	H	IIIa	3	4	P	G	2	7
14	6	H	Ia	4	4	F	G	5	8
15	13	Q	V	0	2	NF	F	0	6
16	5	H	IVa	3	4	P	F	2	4
17	5	H	IIb	2	4	F	G	4	7
18	6	H	Ib	2	4	F	G	4	8
19	11	Q	V	0	2	NF	P	0	2
20	12	Q	V	0	2	NF	P	0	2
21	9	H	IIIb	1	3	P	F	2	6
22	14	D	V	0	2	NF	P	0	2
23	4	H	IVb	1	3	NF	F	1	6
24	6	H	Ib	2	4	F	G	4	8
25	5	H	IVa	3	4	P	F	2	6
26	5	H	IIa	4	4	F	G	5	7
27	6	H	IIIa	3	4	P	G	3	7
28	13	D	V	0	2	NF	F	0	6
29	6	H	IIb	2	4	F	G	4	6
30	7	H	IIIb	1	3	P	F	2	6

H=Hemiparesis, D=Diplegia, Q=Quadriparesis, DF=Dorsiflexion, HF=Hand function, G=Good, F=Fair, P=Poor, NF=Non-functioning

- G IVA: Complete flexor pronator release (FPR)
- G IVB: Complete FPR + transfer of FCU to ECRB (staged, 6 weeks interval)
- G V: Complete FPR + MFLFF + transfer of FCU to ECRB (staged, 6 weeks interval).

Nineteen patients had additional surgery as required, 16 had thumb abductorplasty (transfer of palmaris longus to abductor pollicis longus and extensor pollicis brevis), 7 had biceps Z-plasty, and 9 had pronator teres rerouting).

Operative procedure

Flexor aponeurotic release

A curved incision around the medial epicondyle is used, and a transverse incision of the aponeurotic sheath surrounding the common flexor origin is made around the whole muscular mass. The muscle bellies are left intact.[2]

Multiple fractional lengthening of the forearm flexors

A longitudinal midline incision is made in the forearm; the incision is extended to include the middle two-fourths of the forearm. The separate FDS tendons are identified superficially, and the conjoined FDP tendons are identified in the deep aspect of the wound. The ulnar nerve is protected ulnarly, and the median nerve is protected between the FDS and the FDP. FL of the FDS and the FDP is performed with two transverse incisions in the tendinous portion of the musculotendinous junction. If the FPL is short (child has thumb-in-palm deformity), it can be addressed in a similar fashion.[4]

Complete flexor pronator release

A curved incision around the medial epicondyle that is extended obliquely toward the junction of proximal and middle thirds of the ulna is used. The entire flexor pronator origin (FPO) is released from the medial epicondyle, the medial intermuscular septum, the upper third of the ulna, and the interosseous membrane and then allowed to slide distally till wrist and fingers full extend.[5]

Flexor digitorum superficialis to flexor digitorum profundus transfer

A 15 cm volar incision is made from the proximal forearm to the distal thenar crease.

The palmaris longus, flexor carpi radialis, and FCU tendons are identified and released. The median nerve is identified and protected. The FDS tendons are isolated and sutured together distally in the forearm. The tendons are transected distal to the suture and dissected proximally. The FDP tendons are next sutured together in the proximal forearm and transected.

The FDS is then sutured to the FDP en masse while holding the wrist and fingers in fully extend.[6]

Postoperative management and followup

Above elbow double slabs (volar and dorsal) were applied with the wrist held in 30° extension, full finger extension, forearm in supination, and thumb in abduction. Patients were reviewed at 2, 4, and 6 weeks postoperatively and then were reviewed monthly for 3 months, at 3 months intervals for 1 year than at 6 months intervals. Patients who underwent staged procedures had this at 6-week post operative and had the cast removed intraoperatively. Six weeks after surgery, a removable splint was used, and physiotherapy started with the arm out of splint. This was continued for 6 months with the splint remaining in place between exercise periods. After that, a night brace was worn at night time till skeletal maturity. Our assessment was performed using the "House's"[7] classification of upper extremity functional use; this includes 8 classes with "0" equivalent to a totally useless limb and "8" equivalent to a totally normal one as well as the "clinical assessment of hand function" described by Tonkin and Gschwind,[8] this grades the hand function as good, fair, poor, and nonfunctioning. The power of wrist dorsiflexion was also assessed using the MRC grading, in which G3 meant active wrist dorsiflexion against gravity. Statistical significance was set at $P \leq 0.05$. Chi-square test was used to compare the preoperative and postoperative grades of hand function according to both the "House classification" and the "Clinical assessment of hand function." Wilcoxon signed-rank test was used to compare the preoperative and postoperative grades of power of wrist dorsiflexion.

Results

Followup ranged from 9 months to 3 years (average 18 months). Power of wrist dorsiflexion improved in all patients [Table 2]. This improvement was statistically significant (SS) ($P = 0.000$, Wilcoxon signed-rank test). The "House's classification" of upper extremity functional use improved in all patients [Figure 2]. This improvement was SS ($P = 0.000$, Chi-square test). The Clinical assessment of hand function improved in all patients [Table 3]. This improvement was SS ($P = 0.000$, Chi-square test). In all patients, cosmetic appearance improved without any residual flexion deformity [Figures 3-5]. All patients and their parents were satisfied with surgery results.

Discussion

Flexion deformity of the wrist and fingers is the most common deformity in spastic CP. As a result of this deformed posture, hand function is poor. Recent studies

Table 2: Improvement in dorsiflexion

DF preoperative *N*=30	DF postoperative *N*=30		
	2	3	4
0 (*n*=6) (20%)	6		
1 (*n*=5) (16.7%)		5	
2 (*n*=8) (26.7%)			8
3 (*n*=8) (26.7%)			8
4 (*n*=3) (10%)			3
Total	6 (20%)	5 (16.7%)	19 (63.3%)

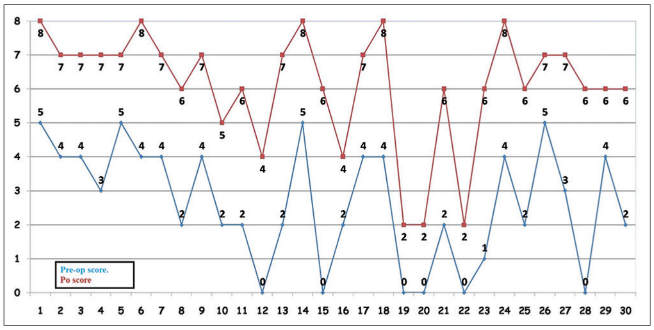

Figure 2: Scatter diagram showing improvement in "House's classification of upper extremity function use" in each individual patient

Figure 3: Clinical photographs of a child with GIIB deformity: (a) Preoperative. (b) After flexor aponeurotic release + flexor carpi ulnaris-to-extensor carpi radialis brevis

Table 3: Improvement in clinical assessment of hand function as described by Gschwind and Tonkin

Hand function preoperative *N*=30	Hand function postoperative *N*=30		
	G	F	*P*
F (*n*=13) (43.3%)	13 (100%)		
P (*n*=10) (33.3%)		4 (57.1%)	3 (42.9%)
NF (*n*=7) (23.3%)	3 (30%)	7 (70%)	
Total	16 (53.3%)	11 (36.7%)	3 (10%)

G=Good, F=Fair, *P*=Poor and NF=Non-functioning

have suggested that surgery yields better results than botulinum toxin injection and ongoing physiotherapy.[9] The contracted flexor muscles prevent extension of the wrist which is essential for a good grip. Because of

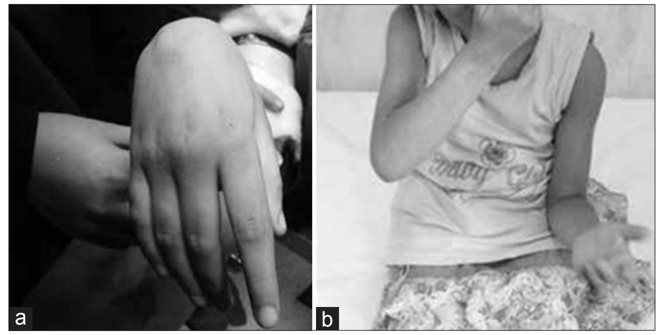

Figure 4: Clinical photographs of a child with GIIIB deformity (full wrist flexion needed for complete finger extension) (a) preoperative. (b) After flexor aponeurotic release + multiple fractional lengthening of the forearm flexors + flexor carpi ulnaris-to-extensor carpi radialis brevis

Figure 5: Clinical photographs of a child with GIVB deformity: In spite of full wrist flexion, fingers are incompletely extended

decreased excursion of the flexors, grasp is inefficient. Although many attempts to correct this deformity have been described in the literature including tenotomy, tendon lengthening, tendon transfer, tenodesis, and arthrodesis and although many studies have reported the results of these procedures; only two studies[2,9] have attempted to establish a protocol of treatment based on the degree of the deformity. In the study by El-Said,[10] Zancolli classification was modified into a four grade classification: (a) active finger extension possible with wrist extended at to neutral, (b) active finger extension possible with wrist flexed <50°, (c) Finger extension only possible with wrist flexed >50°, and (d) severe flexion deformity of wrist and fingers with little/ability to extend them. Treatment was decided based on this classification: (a) FCU transfer and pronator teres release, (b) FCU transfer and FPO release from medial epicondyle, (c) FCU transfer and entire release of FPO, and (d) FCU transfer and entire release of FPO.

We believe this protocol to be inappropriate due to the following facts: (a) it does not differentiate between patients with weak/strong wrist extensors in any of the groups, recommending FCU to ECRB transfer in all patients, group A patients who can actively extend their fingers with the wrist in neutral position usually do not need any sort of tendon lengthening, (b) It combines together Group C and D regarding treatment; this is however practically impossible as Group D will never correct only with FPO release, no matter how extensively it is performed. In all their patients, there was a cosmetic improvement: in group A, grasp and release were restored, in group B, a good hand grasp was restored, but release remained weak; in group C, both grasp and released remained weak and in group D, both grasp and release remained ineffective. Zancolli[2] presented his study on a series of 91 patients with spastic CP, 47 cases were evaluated for their final result. According to the Zancolli classification, the number of patients was: GI, 8 cases GII, 31 cases, and GIII, 8 cases. The results were GI - 7 good and 1 poor; GII - 19 good, 10 fair, and 2 poor; G III - 1fair and 7 poor. As mentioned previously, Zancolli's system has its shortcomings. Another limitation of both of these classifications is the fact that they have not been universally used by other authors to establish a treatment protocol.

Conclusion

This study introduces a new grading system for flexion deformity of wrist and fingers in spastic CP that correlates with severity of the condition and allows a treatment protocol to be set.

It takes into account shortcomings of previous existing classifications and has good reproducibility, with kappa values for intraobserver and interobserver repeatability of 0.71 and 0.72, respectively. The intraobserver concordance was 82%; whereas the interobserver concordance was 78%. Although this study has some limitations; mainly in the small number of patients to whom the proposed classification was applied and the fact that other contributing factors may affect the outcome of surgery, as sensibility, mental status of the child and compliance of the child and parents to postoperative rehabilitation, we hope that our proposed classification system and treatment protocol gradually become implemented by more surgeons who will report their results. Eventually we hope that it becomes accepted as a universal classification that sets a treatment protocol for the confusing issue of flexion deformities of the hand and fingers in spastic CP.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Gulzar SA. Flexor carpi ulnaris transfer to improve function and cosmosis of hand in patients with cerebral palsy. Pak J Med Sci 2007;23:242-4.
2. Zancolli EA. Surgical management of the hand in infantile spastic hemiplegia. Hand Clin 2003;19:609-29.
3. Barnhart HX, Haber M, Song J. Overall concordance correlation coefficient for evaluating agreement among multiple observers. Biometrics 2002;58:1020-7.
4. Zancolli EA, Zancolli ER Jr. Surgical management of the hemiplegic spastic hand in cerebral palsy. Surg Clin North Am 1981;61:395-406.
5. Inglis AE, Cooper W. Release of the flexor-pronator origin for flexion deformities of the hand and wrist in spastic paralysis. A study of eighteen cases. J Bone Joint Surg Am 1966;48:847-57.
6. Braun RM, Vise GT, Roper B. Preliminary experience with superficialis-to-profundus tendon transfer in the hemiplegic upper extremity. J Bone Joint Surg Am 1974;56:466-72.
7. House JH, Gwathmey FW, Fidler MO. A dynamic approach to the thumb-in palm deformity in cerebral palsy. J Bone Joint Surg Am 1981;63:216-25.
8. Tonkin M, Gschwind C. Surgery for cerebral palsy: Part 2. Flexion deformity of the wrist and fingers. J Hand Surg Br 1992;17:396-400.
9. Van Heest AE, Bagley A, Molitor F, James MA. Tendon transfer surgery in upper-extremity cerebral palsy is more effective than botulinum toxin injections or regular, ongoing therapy. J Bone Joint Surg Am 2015;97:529-36.
10. El-Said NS. Selective release of the flexor origin with transfer of flexor carpi ulnaris in cerebral palsy. J Bone Joint Surg Br 2001;83:259-62.