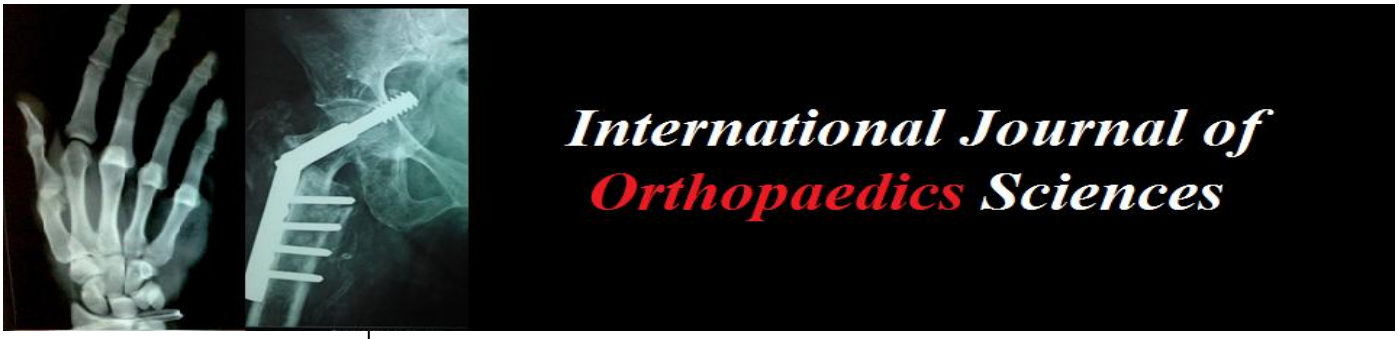

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One stage correction of forearm pronation, wrist flexion and thumb in palm deformity in spastic cerebral palsy

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Abstract
Thirty eight patients, with spastic cerebral palsy hemiplegic aged from 4to16 years with mean of 10 years had surgical procedures for the upper limb to increase functional status of hand. All the patients underwent various surgical procedures depending upon the necessity. IQ of all the patients were more than seventy. 36 patients felt an improvement in function, range of movement in the fore arm and wrist were also increased 74.7% the patients, thumb in palm deformity was completely corrected and resting position towards neutral and stability of hand were also some of the achievements of surgery. There was improvement in different functional grasps. The management of upper limb in cerebral palsy is a challenge, but in properly selected patients there is some improvement in functional status.

Keywords: Cerebral palsy, spasticity, upper extremity surgery, tendon transfers

Introduction
Surgical options for the management of the spastic upper extremity vary with the specific parts; however they are focused around three basic principles: weakening the overactive muscle/tendons, strengthening the underactive muscle/tendons, and stabilizing non-stable joints. Surgical management of the spastic upper limb in cerebral palsy requires meticulous evaluation and planning. It is important to know that upper extremity deformities are secondary manifestations of the cerebral injury. Therefore, in addition to evaluation of upper extremity function, consideration should be given to the intelligence and motivation of the patient, and voluntary use of the upper extremity. These are also important details for the patients and their families, who should know that surgery is aimed at improving the upper extremity deformity, and not the primary disorder. Appropriately indicated surgery can significantly contribute to upper extremity function [1-5].
Neonatal intensive care units are saving more children of lower gestational age and lower birth weight than previously, and these children are more likely to have birth injuries or prenatal defects than other children, thereby increasing the cerebral palsied population [6].
A majority of those with involvement of the upper limb are adequately handled by occupational therapists by developmental therapy and bracing. Probably fewer than 4 % of patients with hands disabled by cerebral palsy can be benefitted by surgery. Typical pattern of spasticity in upper limb includes elbow flexion, pronation of the forearm ulnar deviation and flexion of the wrist with thumb in palm deformity. Each individual case must be carefully evaluated and when indicated surgery can be extremely beneficial. It has been seen that ideal candidate for surgery is a spastic hemiplegic, who is co- operative, IQ more than seventy and has a pattern of grasp and release are so functional that the hand is useful to some extent.
Hoffer *et al.* [7] believed that adequate cognition was important and suggested that patients with IQ less than seventy must be carefully selected. Thometz and Tachjian [8] showed that in patients with IQ less than seventy, improvement in functional capacity was less. The hand should be sensitive, because up to 50%children with cerebral palsy have significant deficit in sensibility. Surgical procedures are selected to improve activities of daily living, to increase the speed of hand flexion and extension, and improvement in the rotational axis of the forearm [1]. The muscle tendon unit is weakened by releasing its origin, detaching at the insertion, or lengthening the unit in the midportion, using Z lengthening or fractional lengthening.

Releasing the tendon at the origin or lengthening at midportion are preferable since they preserve some function, whereas release from the insertion often eliminates function of the muscle. Strengthening the weak muscles is often performed using tendon transfers. Due to the involvement of the central nervous system, re-education after transfer in the cerebral palsy patient is difficult. It is therefore preferable to use a donor tendon that is working "in-phase" with the desired function, which enables active function after surgery without comprehensive reeducation [9].

The examination of the patient should be carried out in a calm setting with familiar people [10]. Serial examinations are preferred, as the spasticity may affect upper extremity movement. The most important observation in the evaluation of the patient is whether the child voluntarily attempts to use the hand during activities. If the child does not use the hand, surgery is not advised. Surgery cannot induce functional activity in a functionally ignored limb, and will be of little benefit to the child [9]. The examination includes documentation of passive and active ranges of motion for the shoulder, elbow, forearm, wrist and fingers; muscle strength of upper limb motors; patterns of deformity; sensibility; functional activities of pinch, grasp, and release; and size measurements of circumference and length of arm, forearm and hand [10].

By using the House Functional Use Classification for overall assessment of upper limb function (Table 1) [11].

Table 1: Upper extremity functional USG classification

S. No	Level Designation	Activity level
1	0 Does not use	Does not use
2	1 Poor passive assist	Uses as stabilizing weight only
3	2 Fair passive assist	Can hold onto object placed in hand
4	3 Good passive assist	Can hold onto object and stabilize it for use by other hand
5	4 Poor active assist	Can actively grasp object and hold it weakly
6	5 Fair active assist	Can actively grasp object and stabilize it well
7	6 Good active assist	Can actively grasp object and manipulate it against other hand
8	7 Spontaneous use partial	Can perform bimanual activities easily and occasionally uses the hand spontaneously
9	8 Spontaneous use, complete	Uses hand completely independently without reference to the other hand

Materials and methods

Thirty eight patients hemiplegic spastic palsy (4-16 years), All patients underwent surgery IQ for them is more70%. Twenty four male and fourteen females, right side (20) and left side (18). From 2010-2015, follow up (1-4) years mean follow up (2.5) years.

Forearm pronation deformity

Both suppuration and pronation movement is essential for adequate hand activity. Dynamic deformity of forearm pronation is corrected according to the severity of pronation classification and treatment options by Gschwind and Tonkin (Table 2) [12]. The surgical method for pronation deformity must aim at restoring active supination movement without compromising the existing pronation movement. The procedures are pronation quadratus release, flexor aponeurosis release pronator terse rerouting, and pronator terse transfer to the wrist extensors. Thirty six Patient were operated via pronator quadratus release, interosseous aponeurosis release, ten pronator teres rerouting and twenty eight patients were operated by pronator teres transfer to wrist extensors to extensor carpiradialis brevis.

Wrist flexion deformity: Is caused by the wrist flexors, flexor carpi ulnaris, flexor carpi radialis, also spastic finger flexors according to the algorithm of test active digital extension with wrist in neutral and test active range of motion in the wrist. Twenty five patients fractional lengthening of myotendinous junction of flexor digitorum superficialis (FDS), flexor digitorum profundus and flexor carpiradialis (FDP). Twenty eight patients, F.C.U. transfer to extensor digitorum. 6 patient F.C.U. transfer to extensor carpiradialis brevis.

Finger flexion deformity: (25) patients had fractional lengthening of FDP, FDS. Four patients had transfer tendons origin of flexor digitorum superficialis to profundus.

Thump in palm deformity (aided by Sakellaridis classification [15] table 3): (18) patient was operated for Z lengthening of flexor pollicis longus. Ten patients had releasing 1st web skin space, dorsal interosseous muscle, releasing of adductor pollicis and myotomy release of flexor pollicis brevis. Eleven patients F.C.R transfer to extensor pollicis longus. Nine patients had palmaris longus transfer to extensor pollicis longus.

Table 2: Pronation deformity classification and treatment options by Gschwind and Tonkin

Type	Deformity classification	Treatment options
Type1	Active supination beyond neutral	surgery is unnecessary
Type2	Active supination to less than or to neutral position	Release of flexor aponeurosis and pronator quadratus
Type3	No active supination free passive supination	Transfer pronator teres, brachioradialis rerouting
Type4	No active supination tight passive supination	Release flexor aponeurosis, Transfer pronator teres lengthening, brachioradialis rerouting

Table 3: Sakellaridis classification for thumb in palm deformity treatment [15].

Type	Deformity etiology	Treatment
Type1	Weak EPL	Transferring PL or FCR to EPL
Type2	Spastic or contracted intrinsic muscles of the thumb Thenar muscles	Releasing dorsal interosseous muscle or the carpal Tunnel + releasing the 1 web skin, if contracted
Type3	Weak abductor pollicis longus	Rerouting the abductor round the FCR
Type4	Spastic or contracted FPL	Z lengthening of FPL

Results of operative procedures: (Table 4 & 5).
Upper limb function in USG classification was (9) level of function the modified version to consider into 4 levels: (0) non function limb, (1-3) passive assisting limb, (4-6) active assisting and (7-8) spontaneous use (20). Forearm supination movement correction: (36) cases was operated by different method of correction deformity. (2) Cases unchanged poor result, (36) improved cases, (32) good result and (4) cases fair improved, fair result improved supination range from (0-50) degrees, good result from (50-80) degrees, and full result 90 suppuration.
Wrist extension: (34) cases was operated for improvement and correction flexion wrist deformity, (2) cases no improvement, (6) cases fair result neutral wrist extension, (26) cases good result neutral to 5 degrees wrist extension.
Hand function: Finger grip and grasp and five finger pinch,(2) cases of unchanged of hand function,(4) cases of fair hand function of grasping and pinching,(28) cases good hand function, all cases (34) patient was operated for correction of finger flexion deformity.
Thumb in palm: (20) cases of thumb in palm deformity, (3) cases was fair results. (14) Cases was good results, (3) cases was full function.
Non case was made worse, unchanged cases preoperative as postoperative as in forearm supination were 5.5 % of cases, wrist extension were 5.8 % and finger grasp and grip 6%. MHC was used to classify each patient for upper limb function (2) cases were level 1, (4) cases were level 2, (6) cases were level 3 and (26) cases were level 4.

Table 4: CP operative procedures done for all patients

S. No	Name of Operation	Number
1	interosseous aponeurotic and pronator quaratus release	36
2	Rerouting of pronator teres	10
3	Transfer of pronator teres to ECRB	28
4	Fractional lengthening of flexors of fore arm	25
5	Transfer of FDS to FDP	4
6	Transfer of FCU to ECRB	6
7	Transfer of FCU to ED	28
8	FBL lengthening	18
9	Release of first dorsal interosseous and adductor policis	10
10	Transfer of PL to EPL	9
11	Transfer of FCR to EPL	11

Table 5: results of procedures according to function and region.

Procedures	Unchanged (Level 1)	Fair (Level 2)	Good (Level 3)	Full (Level 4)	Total	Satisfaction	Percentage
Forearm Supination	2	4	32		38	36/38	94.7%
Wrist Extension	2	6	26		34	32/34	94%
Finger grip and grasp	2	4	28		34	32/34	94%
Thumb extension and abduction	-	3	14	3	20	20/20	100%

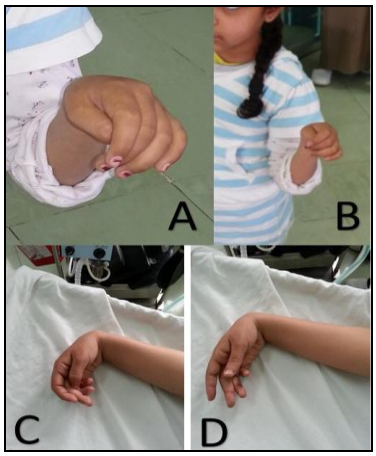

Fig 1: preoperative examination of 7 years old female patient; A & B) examination for supination and pronation; C & D) thumb in palm deformity.

Fig 2: intraoperative photos: A & B & C) Forearm correction; D & E) thumb in palm correction; F) two months postoperative.

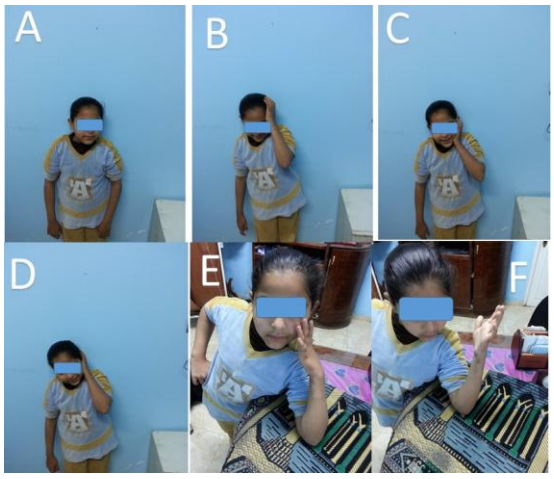

Fig 3; function one year postoperative.

Discussion

It is important to know that upper extremity deformities are secondary manifestations of the cerebral injury. Therefore, in addition to evaluation of upper extremity function, consideration should be given to the intelligence and motivation of the patient, and voluntary use of the upper extremity. Prior to surgery, the overall level of function needs to be considered. This is also important for the patients and their families, who should know that surgery is aimed at improving the upper extremity deformity, and not the primary disorder [7].
If we recognize that some improvement of hand function may aid the patients to a marked degree in ADL, then the correct place of surgery will be established [1].
Typical pattern of spasticity in upper limb includes elbow flexion, pronation of the fore arm ulnar deviation and flexion

of the wrist with thumb in palm deformity. Each individual case must be carefully evaluated and when indicated surgery can be extremely beneficial. It has been seen that ideal candidate for surgery is a spastic hemiplegic, who is co-operative, IQ more than seventy and has a pattern of grasp and release are so functional that the hand is useful to some extent [7]. Reconstructive surgery of the spastic upper extremity in cerebral palsy can be a most challenge one. Techniques and principles for the various procedures are established [13-15].

In our series' most patients were of hemiplegic type. Most patients showed improvement of hand function which were maintained up to six months to four years. Thumb in palm deformity was completely corrected in most of the patients. Position of thumb was reinforced by transfer of FCR and palmaris longus to abductor pollicis longus tendon. The results were compared with that of L.B Dahlin *et al.* and results were found to be comparable [16].

Flexion wrist and pronation deformity is not only a functional disability but also cosmetically displeasing. We have done lengthening flexors, rerouting of pronator teres, flexion aponeurotic release and transfer of flexor carpi ulnaris to ECRB which improves elbow extension, active supination and dorsiflexion of wrist. Rerouting of pronator teres was also used to improve supination. Supination gain was compared with that of Sakellarides *et al.* [15]. ROM of wrist was compared with that of L.B Dahlin *et al.* and T.M Wolf *et al.* Correction of pronation increased two handed activities, because forearm pronation interferes with the ability to get the palms together [16, 18].

The level of intelligence may affect a patient cooperation, training and motivation. Patients with lQ seventy or more were selected for surgery by Hoffer *et al.* [19]. After his study he concluded that adequate cognition was important and lQ less than seventy must be carefully selected. So we have not tried the procedures in cases having less than seventy is also very difficult to get the co-operation of due to lack of education and low mental status. Frequent visit on long duration stay in hospital is necessary. So, family counseling and mental status of child should be assessed thoroughly in our country before under taking the procedures [19].

Though any appropriate age is not selected for surgery, still it is reasonable to wait until the child can actively participate in post-operative therapy. Green and Banks [13] recommended that surgery should not be done below the age of seven. But, it is patient dependent. Our youngest patient was of four years old. But it is reasonable to wait until the child actively participate in postoperative therapy.

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