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Original Research Article

A study of effectiveness of tendon transfers in upper extremity in the management of spastic hemiplegia

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ABSTRACT

Background: Over the years, most often the surgical management of cerebral palsy (CP) has focused only on lower extremities wherein surgeries are performed regularly for sitting, standing and ambulation. Upper extremity surgery is uncommonly done to improve the functions of the hand.
Objective: To study effectiveness of tendon transfers in upper extremity in the management of spastic hemiplegia
Materials and Methods: This was a prospective study, which included 24 patients with spastic hemiplegia, of either sex between the ages of 5 and 25 years. All the patients were admitted and evaluated in detail. Pre-operative functional assessment of the upper limb was done according to the House et al functional classification and recorded. IQ evaluation of all the patients was done. All the patients were subjected to the three surgical procedures.
Results: Majority (33.33%) belonged to 16–20 years and 66.67% were Females. 15 (62.5%) were having Rt. Sided involvement 20 (83.33%) were having a Normal IQ (>70). The pre-operative score significantly improved from 1.42 to 4.54 after surgery. No one was having excellent improvement but 25% had good improvement while 58.3% had fair improvement. 16.7% had poor improvement. Out of the four cases having Mild MR, majority, 3 (75%), showed Poor observed improvement scores. Out of the 20 cases having Normal IQ, majority, 13 (65%), showed Fair observed improvement scores.
Conclusion: The appearance of the hand improved in all the 24 cases (100%) making improvement in the appearance of the hand a very important functional and psychological goal for surgical management even in severe cases

1. Introduction

Cerebral Palsy (CP) is a clinical entity characterized by a three-part definition: a disorder of movement and posture; caused by a non-progressive injury; to the immature brain.[1] The distinctive characteristic of these syndromes is the change in muscle tone and posture; both at rest and with voluntary activity. The definition of CP implies that the underlying pathologic process in the brain does not progress, and occurred during early development of the brain. The first year or two of life is included in most definitions, although it is unclear what the upper age limit is of a post-neonatal brain insult. The definition of CP is being reviewed at present.[1]

CP is one of the most common disabilities affecting children.[2] The reported incidence varies but is approximately 2 to 3 per 1000 live births.[1] There were hopes that recent improvements in neonatal care would

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decrease the incidence of CP, but this decrease has been transient. CP prevalence in full term infants has remained relatively constant. The improved neonatal survival has decreased the risk of CP for neonates weighing more than 2500 grams. Despite improved neonatal outcomes in general, the survival of these low-birth weight (<2500 grams) and very low-birth weight (<1500 grams) infants with higher CP risk has kept the prevalence of CP in childhood relatively constant.[1]

It has been estimated that around 30-40% of the children having spastic type of CP, have spastic hemiplegia. The typical posture of the child with spastic hemiplegia consists of the equinus of the foot and ankle, flexion of the elbow, wrist and fingers and an adducted thumb. Most of these children begin independent walking between the ages of 18 and 21 months, gain independence in activities of daily living (ADL), are able to talk, can participate in peer group activities and attend regular school. Their greatest handicap can be mental retardation, behavioral problems or a late onset convulsive disorder.[3,4]

Over the years, most often the surgical management of CP has focused only on lower extremities wherein surgeries are performed regularly for sitting, standing and ambulation.[5]

Upper extremity surgery is uncommonly done to improve the functions of the hand. Therefore, the need for this study was felt, wherein the main aim was to determine the efficacy of tendon transfers in upper extremity in the management of CP as very few papers have been published in literature on surgical management of upper extremity in CP.

2. Materials and Methods

This study was conducted at All India Institute of Physical Medicine and Rehabilitation (AIIPMR), Mumbai for a period of 32 months. This was a prospective study, which included 24 patients with spastic hemiplegia, of either sex between the ages of 5 and 25 years.

2.1. Exclusion criteria

1. Patients with fixed contractures and deformities.
2. Patients having involuntary movements like chorea, dystonia, etc.
3. Patients with moderate, severe or profound mental retardation (according to WHO Classification).
4. Patients with history of repeated convulsions.
5. Patients who are unfit for anesthesia.
6. Patients not willing for surgery.

All the patients were admitted in AIIPMR and were evaluated in detail and the pre-operative functional assessment of the upper limb was done according to the House et al. functional classification and recorded. IQ evaluation of all the patients was done by using one of the following tests depending upon the age of the patient.

2.2. Kamat's test of intelligence

It is a verbal test used to test adaptation of Binet Simon scales of intelligence. It is available in major Indian languages. It is particularly appropriate for younger age group, 3-11 years, even though it can be used up to 22 years.

2.3. Bhatia's battery of intelligence tests.

Is a non-verbal performance test. Consists of five sub tests, namely; Koh's block design; Alexander's pass along test; Pattern drawing test; immediate memory span and Picture completion test. Particularly appropriate for age above 11 years. The patient's IQ was then graded as per the WHO classification as: mild MR: 50-69; Moderate MR: 35-49; Severe MR: 25-34; Profound MR: <25. Only patients with either normal IQ or mild MR were then included in the study.

All the patients were then subjected to following three surgical procedures in either one stage or multiple stages, Fractional lengthening of the long flexors; Transfer of FCU to ECRB (Green's transfer); Release of contractures for thumb-in-palm deformity.

After the surgery, the upper limb was maintained in corrected position by applying an above elbow POP cast with elbow in 15 to 20 of flexion, forearm in maximum possible supination, wrist in 15 to 20 degree of extension and thumb out of palm for 6 weeks. Suture removal was done after 2 weeks.

After 6 weeks of post-operative immobilization, the POP cast was removed. All the patients were then put on a post-operative rehabilitation program, which included:

1. Mobilization of stiff joints; Stretching exercises for the spastic muscles;
2. Strengthening exercises for the wrist extensors, thumb abductors and extensors and intrinsic muscles of the hand;
3. Training of the transferred tendon by re-education of the muscle using bio-feedback;
4. Hand function training for prehensile functions (both gross and fine);
5. Training for use of the hand for ADL purposes, especially for bilateral tasks;
6. Positioning of the hand using splints (at night and during no activity phase).

The following splints were used in all the patients: Cock-up Splint; A.E Cock-up Splint; Long oppenens Splint; Short oppenens Splint. This post-operative rehabilitation usually lasted for 6-8 weeks.

Regular post-operative functional assessment of the hand was done according to House et al. functional classification, every 3 months (12 weeks) during the first year after surgery. Depending upon the pre-operative and the final post-operative functional scores as per the House et al. functional

classification, observed improvement score was calculated. Observed improvement score was then arbitrarily classified as follows for better understanding and analysis: Excellent: >80%; Good: 60-79%; Fair: 40-59%; Poor: <40%.

2.4. Surgical procedures

All the patients were subjected to the following three surgical procedures in one stage or multiple stages under Regional anesthesia (Brachial Plexus Block).

2.5. Release of contractures/myotomy for thumb-in-palm deformity

Palmar incision taken bordering the thenar crease and care is taken to avoid damage to the recurrent branch of the median nerve or the innervation of the adductor pollicis. The long flexors of the fingers are retracted and the origin of the adductor pollicis from the third metacarpal is released. Then the origin of the first dorsal interosseous from the first metacarpal is released. The incision is then sutured appropriately.

2.6. Fractional lengthening of the long flexors

A curved volar incision is taken over the forearm about 3 cm proximal to the volar wrist crease and is proximally extended for about 6cm. FCR tendon is then identified and dissected proximally to the musculotendinous junction. Fractional lengthening of the FCR tendon is done by making transverse cuts in the aponeurosis proximal to the musculotendinous junction. Then Palmaris longus, FDS and FDP tendons are identified and fractional lengthening is done in the same manner. The incision is then sutured appropriately.

2.7. Transfer of FCU to ECRB (Green's Transfer)

A volar longitudinal incision from the flexor crease of the wrist, extending proximally for about 3 cm taken and the insertion of FCU on the pisiform bone exposed. Tendon of FCU detached from the bone and it is dissected proximally. Then silk sutures are introduced into the distal end of the tendon and, by pulling on it gently, outline the course of the muscle proximally. A second incision about five cm distal to the medial epicondyle of the humerus taken which is about 7 to 10 cm long over the belly of the muscle. Lateral margin of the muscle is then defined and an incision is taken through the deep fascia to expose this margin and the deep surface of the muscle. The tendon is then pulled through the proximal incision and the muscle is then further dissected until it passes it straight from its origin across the border of the ulna to the dorsal aspect of the wrist. Care is taken to locate and preserve branches of ulnar nerve to the muscle, which limit the dissection proximally. A third incision then taken on the dorsum of the wrist, extending from the transverse skin crease proximally for about 3 cm over the ECRL and ECRB tendons. Using a tendon passer, the free end of FCU is directed from the proximal incision into the dorsal compartment along the path of the ECRB tendon. A buttonhole incision is made in the ECRB tendon and then the FCU tendon is passed through it and the FCU tendon is then sutured there under tension with forearm in maximal possible supination and the wrist in 15 to 20 degrees of extension. The incisions are then sutured appropriately.

3. Results

Table 1: Distribution of patients according to demographic characteristics

Variables		Number	%
Age (years)	5-9	7	29.2
	10-15	7	29.2
	16-20	8	33.3
	21-25	2	8.33
Sex	Male	8	33.3
	Female	16	66.7
Religion	Hindu	12	50
	Muslim	11	45.8
	Other	01	4.2
Literacy	Illiterate	12	50
	Primary education	9	37.5
	Secondary education	3	12.5

In this series, among age groups, majority of the cases, 8 (33.33%) belonged to 16 – 20 years and were least, 2 (8.33%) in 21 – 25 years group. Out of the 24 cases, 8 (33.33%) were Males and 16 (66.67%) were Females, in the ratio of 1:2. Out of the 24 cases, majority (12, 50%) were Hindus, 11 (45.83%) were Muslims and one (4.17%) belonged to others. Out of the 24 cases, majority of them, 12 (50%) were illiterate (never been to school), nine (37.5%) had attained primary education and three (12.5%) had attained secondary education. (Table 1)

Table 2: Distribution of patients according to side of affection

Side affected	No. of cases	Percentage of total
Rt. Sided	15	62.5
Lt. Sided	9	37.5
Total	24	100

Out of the 24 cases, 15 (62.5%) were having Rt. Sided involvement and nine (37.5%) were having Lt. sided involvement. This is in accordance to the standard literature, which states that Rt. Sided hemiplegia is almost twice as common as Lt. sided hemiplegia. (Table 2)

Out of the 24 cases, 20 (83.33%) were having a Normal IQ (>70) and four cases (16.67%) were having Mild MR (IQ – 50 to 69), as per the WHO classification. (Table 3)

Table 3: Distribution of patients according to their mental status (IQ Level)

IQ level	Number	%
Mentally Sound (Normal IQ)	20	83.33
Mentally Unsound (Mild MR)	4	16.67
Total	24	100

Table 4: Distribution of patients according to their pre-op score, post-op score and observed improvement using House et al. Functional Classification

Pre-Op Score (Mean+ S.D)	Post-OP Score (Mean+ S.D)	t value	p value
1.4166 + 0.88	4.5416 + 1.35	20.663	< 0.0001

The pre-operative score significantly improved from 1.42 to 4.54 after surgery.(Table 4)

Table 5: Distribution of patients according to grading of observed improvement score

	No. of cases	Percentage of Total
Excellent (> 80%)	None	Nil
Good (60-79%)	6	25
Fair (40-59%)	14	58.33
Poor (<40%)	4	16.67
Total	24	100

No one was having excellent improvement but 25% had good improvement while 58.3% had fair improvement. 16.7% had poor improvement (Table 5)

Out of the 24 cases, majority of them, 14 (58.33) showed Fair improvement after surgery, while 6 cases (25%) showed Good improvement and 4 cases (16.67%) showed Poor improvement and none of the cases showed Excellent improvement, when graded depending upon the observed improvement scores. Majority of the cases who showed good improvement, 3 (42.86%), were belonging to the age group of 5 – 9 years and the percentage of good improvement score decreased as the age of the patient increased. (Table 6)

Out of the 4 cases having Mild MR, majority, 3 (75%), showed Poor observed improvement scores and only 1 (25%) showed a Fair observed improvement score. Out of the 20 cases having Normal IQ, majority, 13 (65%), showed Fair observed improvement scores, 6 (30%) Good and only 1 (5%) Poor observed improvement scores. (Table 7)

4. Discussion

One of the papers published by Green WT et al[6] described the efficacy of FCU to ECRB in CP way back in 1962. They performed the above procedure in 47 patients with spastic paralysis and concluded that FCU to ECRB is the single best procedure to improve function of the wrist and hand in CP. It aids dorsiflexion and supination and, at the same time, preserves active motion of the wrist.

Later, House JH et al[7] evaluated in the detail the surgical management of thumb-in-palm deformity in CP. They performed 165 different procedures for the correction of thumb deformities in 56 patients with spastic CP. Using various combinations of releases, tendon transfers and joint stabilizations, measurable and predictable improvement in function was achieved in all the 56 patients whose records were analyzed.

Zancolli EA et al[8] described in detail the surgical management of upper extremity in CP. They described the pre-operative evaluation for selection of patients, the various deformities seen in CP, classified the wrist and finger deformities (Zancolli and Zancolli Classification) and advocated various surgical procedures for the correction of these deformities. They later concluded that most of the patients with CP whose upper limbs are affected are not suitable candidates for surgical reconstructive procedures. However, selected patients may be helped by certain surgical procedures. Careful, repetitive examinations, testing and evaluation are of major importance in such selection. The majority of poor surgical results are due to incorrect indications or execution of the surgical procedures.

In our study, we included 24 cases with spastic hemiplegia who were subjected to three surgical procedures either in one stage or to multiple stages. The follow-up period ranged from three to 12 months. House JH et al[7] Functional Classification was used to assess the patients pre-operatively and post operatively. Overall, majority of the cases, 14 (58.33%) showed Fair improvement after surgery, while 6 cases (25%) showed Good improvement and 4 cases (16.67%) showed Poor improvement and none of the cases showed Excellent improvement, when graded depending upon the observed improvement scores. As the duration of follow-up was short, no recurrence was observed in our study.

Smith RJ et al[9] studied the effectiveness of transferring the tendon of FPL to the radial side of the proximal phalanx of the thumb and stabilizing the IP joint in 15 degree of flexion by tenodesis or arthrodesis in 7 seven patients with thumb-in-palm deformity due to spasticity of FPL. He concluded that after the operation, there was improved appearance in the hands of all seven patients. The thumb was no longer held clenched in the palm. Each patient was able to use the operated hand for assistive grasp, however, the ability to use the hand for manipulation of small objects and for pinch was not improved.

Koman A et al[10]concluded that although only a small number of children with CP have indications for surgical treatment of dynamic or structural upper extremity deformities, orthopedic surgery does improve function and appearance of the involved hand, particularly in spastic hemiplegia.

Table 6: Distribution of patients according to age in years and grading of observed improvement score

Age in Years	Observed Improvement Score Grading									
	Excellent		Good		Fair		Poor		Total	
	No.	%	No.	%	No.	%	No.	%	No.	% (of Total)
5-9	None	Nil	3	42.86	3	42.86	1	14.29	7	29.17
10-15	None	Nil	2	28.57	4	57.14	1	14.29	7	29.17
16-20	None	Nil	1	12.50	5	62.50	2	25	8	33.33
21-25	None	Nil	None	Nil	2	100	None	Nil	2	8.33

Table 7: Distribution of patients according to mental status and grading of observe improvement score

Mental Status	Observed Improvement Score Grading									
	Excellent		Good		Fair		Poor		Total	
	No.	%	No.	%	No.	%	No.	%	No.	% (of Total)
Normal IQ	None	Nil	6	30	13	65	1	5	20	83.33
Mild MR	None	Nil	None	Nil	1	25	3	75	4	16.67

Gschwind C et al[11] studied in detail the pronation deformity present in children with CP, devised a classification for pronation deformity, and recommended appropriate surgical procedures for correction based upon the classification to improve supination but maintaining pronation and thus improving function of children with CP.

Harilaos T et al[12] studied the surgical management of the unbalanced wrist in 60 children with spasticity due to CP and observed excellent results in 35% of the patients; good results in 40% and fair results in 25% of the patients. They concluded that early recognition of the deformity with accurate conservative therapy and appropriate surgical treatment gave very satisfactory results.

Rayan GM et al[13] studied the effectiveness of a modified technique of EPL tendon rerouting in 14 patients with spastic thumb-in-palm deformities and concluded that EPL tendon rerouting can provide satisfactory correction of severe thumb-in-palm deformities especially when combined with other procedures such as metacarpophalangeal joint arthrodesis and thumb intrinsic muscle release.

van Heest AE et al[14] reviewed 180 operations of upper extremity representing 718 procedures in 134 patients with spastic CP. Comparison of the pre-operative and post-operative 9-level functional use scores showed an average improvement of 2.6 functional levels for all patients.

Upon analyzing the results obtained in our study and the observations made, the following points were highlighted. Firstly, careful selection of the patients for surgical correction is necessary in order to achieve the desired functional results. There is no single procedure, which offers complete reconstruction of the spastic hand and wrist. The various procedures described must be combined either in one or multiple stages, depending upon the severity and the general condition of the patient and the surgical management should be individualized for each patient after careful and repeated pre-operative assessment. In addition, the participation and motivation of the patient him/herself and that of the parents/guardians in the post-operative rehabilitation protocol is equally important in achieving the desired functional results.

Majority of the cases that showed Good improvement, 3 (42.86%) belonged to the younger age group (5-9 years) and it was observed that as the age of the patient increased, the deformity became more severe which included bony changes and hence the results after surgery also declined. This suggests that early surgical intervention in upper extremity in CP is highly desirable.

It was observed that majority of the cases were having Mild MR. 75% showed Poor observed improvement scores. Thus, stressing the fact that the patient must have sufficient intellectual function and emotional stability to comprehend the goals of surgery and to co-operate in the optimum restoration of the hand function post-operatively and hence moderate to severely retarded children and adults will not obtain the desired functional results.

Good results were seen only in 25% cases. 58.33% cases showed fair results. Upon grading of observed improvement scores, the appearance of the hand improved in all the 24 (100%) cases. Thus, suggesting that improvement in the appearance of the hand is a very important functional and psychological goal for surgical management even in severe cases wherein the expected functional results are not that good.

In the end, it must be re-emphasized that despite the monumentus work done on surgical management of CP, very little attention has been laid on the surgical management of upper extremity in CP, when compared to lower limb surgeries. The results of this study certainly argue in favor of surgery in the management of upper extremity in CP, however, it may be noted that further extension of this study is required, both in number of cases and the duration of follow-up, to come to a definitive and statistically analyzable conclusion.

5. Conclusion

Good results were seen only in 25% cases and 58.33% cases showed fair results; upon grading of observed improvement scores as per the House et al Functional Classification. The appearance of the hand improved in all the 24 cases (100%) making improvement in the appearance of the hand a very important functional and psychological goal for surgical management even in severe cases

6. Conflict of Interest

There are no conflicts of interest in this article.

7. Source of Funding

None.

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