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Research Article

Evaluation of Surgical Treatment Disfigured Forearm Pronation and Wrist Fold Contraction - Hand in Children with Cerebral Palsy

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Abstract

Background: Cerebral palsy is the musculoskeletal manifestation of a nonprogressive central nervous system lesion that usually occurs due to a perinatal insult to the brain. We noted that the retraction of the wrist-hand fold, forearm pronation, and thumb closing are common upper limb deformities in cerebral palsy patients and these deformities can be partially improved by physiotherapy and surgery. However, the treatment does not have a harmonious combination between surgery, rehabilitation, postoperative care, and affordable payment. At some hospitals, the rate of surgical treatment and postoperative rehabilitation for upper limb deformities is low. This study describes the clinical characteristics of forearm pronation deformity and retraction of the wrist-hand fold and indications for surgical treatment, and it assessed and monitored the results of handling, pronation, and postoperative rehabilitation.

Methods: A prospective study was carried out in 50 cerebral palsy patients with forearm pronation deformity and retraction of the wrist-hand fold in the Orthopedics and Rehabilitation Hospital Ho Chi Minh City from 2011 to 2018. Results: One year postoperatively, two patients (4%) had a disfigured wrist fold; two patients (4%) had no improvement in hand function. Hand function after surgery increased from 3.13 to 5.38 (an increase of 2.25); 69.6% of patients still had forearm pronation deformity. No severe deformity was present in any patients; 32 (69.6%) and 10 patients (21.7%) had good and moderate points, respectively.

Conclusion: Surgery for forearm pronation deformity and retraction of the wrist- hand fold in children with cerebral palsy is easy to implement. Stretching muscle bundles from muscle units has minimal effects following fasciectomy. The direction of traction when moving seems to not change from that normally seen when transferring the extensor carpi ulnaris to the extensor carpi radialis. This is very important when selecting which tendon transfer to perform. Moreover, it does not cause weakness of the wrist fold, unlike when using the ulnar wrist fold tendon. The release of round bowed tendon points facilitates the balance of pronating muscles.

Keywords: Forearm Pronation Deformity; The Retraction of Wrist-Hand Fold; Children with Cerebral Palsy

Introduction

Cerebral palsy is a musculoskeletal manifestation of a nonprogressive central nervous system lesion that usually occurs due to a perinatal insult to the brain. In children with cerebral palsy, wrist posture and movement play an important role in some simple activities, such as practicing movements, and help performing some routine activities and a few more complex activities more easily, such as carrying a bowl and putting on clothes, and some more complicated movements, such as combing hair and holding things. We noted that the retraction of the wrist-hand fold, forearm pronation, and thumb closing are common upper limb deformities in cerebral palsy patients and these deformities can be partially improved following physiotherapy and surgery. However, the treatment does not have a harmonious combination between surgeon, rehabilitation, and establishments providing postoperative care for cerebral palsy patients, and more importantly, affordable costs for patients' family. Therefore, it is much more difficult to treat from initial diagnosis to adulthood. At some hospitals, orthopedic surgery has been implemented to treat cerebral palsy, but primarily focuses on addressing deformations in the lower limbs, while surgical treatment and postoperative rehabilitation for upper limb deformities are rare.

Based on those factors, we decided to assess Evaluation of surgical treatment disfigured forearm pronation and wrist fold contraction - hand in children with cerebral palsy.

Research objectives

- Describe the clinical characteristics of forearm pronation deformity and the retraction of the wrist-hand fold and indications for surgical treatment.
- Assessment and monitoring of the results of handling, pronation, and postoperative rehabilitation.

Research Subjects and Methods

We recruited cerebral palsy patients with forearm pronation deformity and retraction of the wrist-hand fold at the Department of Orthopedic Surgery, Orthopedic and Rehabilitation Hospital Ho Chi Minh City from 2011 to 2018.

Exclusion criteria

- Patients have a degree of muscle spasm ≥3 on the modified Ashworth scale.
- Patients have assessment level V on the Gross Motor Function Classification System (GMFCS).
- The mental and emotional capacity of the patient was unstable.
- Family members and the patient did not cooperate with treatment.

- **Study design:** Prospective study
- **Study sample size:** A sample size of 35 patients was calculated according to the formula

$$n = \frac{Z(1\text{-}\alpha/2) \times p(1-p)}{d^2}$$

in which Z(1-α/2) is the percentile of the normal distribution at 1-α/2, for the Z score corresponding to the desired ratio (Z = 1.96), α is the confidence level of 95% (α = 0.05), d is the permissible error of 0.1% (d = 0.1), p is the estimated ratio, which was 90% here (p = 0.9) [1].

Thus, within this study, with a permissible error of 5%, a confidence level of 95% and an estimated p ratio of 90%.

- Data processing: SPSS 16.0 software was used for statistical analyses.

Classifications used in the study

Retraction of the wrist fold was classified as per Zancolli E.A.; pronation deformity was classified according to Gschwind and Tonkin; and hand function was classified according to House J.H.

Results

From April 2011 to October 2018, at the Department of Orthopedic Surgery, Orthopedic and Rehabilitation Hospital, Ho Chi Minh City, we performed surgery for 52 patients and completed follow-up visits for 50 patients with forearm pronation deformity and retraction of the wrist- hand fold (two patients did not return for postoperative follow-up). The results of the statistical analysis are as follows

Assessment of retraction of the wrist-hand fold per the zancolli classification

Among the 52 surgical cases, six cases (11.5%) were type IIA and 46 cases were type IIB (88.5%). As a result, we can see that weakness of the wrist muscles is quite common in retraction of the wrist-hand fold deformity in children with cerebral palsy.

Assessment of the motor activity of hands

Spasticity and weakness of the wrist flexors and weakness were quite common in those with Zancolli type II retraction of the wrist-hand fold deformities.

Assessment of the spasticity of the wrist and abdominal flexors using the Ashworth scale.

Type / Movement		IIA	IIB	Total	Rate (%)
Grasp hand (n = 52)	Complete	6	25	31	59.62
	Incomplete	0	21	21	40.38
Open hand (n = 52)	Complete	5	24	29	55.77
	Incomplete	1	22	23	44.23

Table 1: Ability to actively grasp and open hands (n = 52).

Spasticity / Muscle		No apparentincrease in hypertonia		Apparent increase in hypertonia		Total
		IIA	IIB	IIA	IIB	
Pronator teres muscle	N	4	7	2	39	52
	%	7.7%	13.5%	3.8%	75.0%	100%
Flexor carpi ulnaris	N	4	12	2	36	52
	%	7.7%	23.1%	3.8%	69.2%	100%
Flexor carpi radialis	N	6	27	0	19	52
	%	11.5%	51.9%	0%	36.5%	100%
Palmaris longus muscle	N	6	25	0	21	52
	%	11.5%	48.1%	0%	40.4%	100%
Flexor digitorum superficialis	N	5	39	1	7	52
	%	9.6%	75%	1.9%	13.5%	100%
Flexor digitorum profundus	N	5	37	1	9	52
	%	9.6%	71.2%	1.9%	17.3%	100%

Table 2: Spasticity of the wrist flexor and pronator teres muscle.

In our study, spasticity was predominantly seen in the fold muscular group, and most patients with forearm pronation deformity had spasticity of the pronator teres muscle. We found that retraction of the wrist-hand fold deformity in children with cerebral palsy is associated with spasticity of the wrist flexor group.

Assessment of upper limb coordination deformities

We found that the forearm pronation deformity appears in most patients with cerebral palsy. Forearm pronation deformity was related to and aggravated the retraction of the wrist-hand fold ($p = 0.011$; Chi-squared test).

Wrist fold / Forearm pronation		Type IIA	Type IIB	Total	Rate (%)
Deformed	Type 1	2	13	46	88.5%
	Type 2	1	13		
	Type 3	0	17		
	Type 4	0	0		
Undeformed		3	3	6	11.5%
Total		6	46	52	100%

Table 3: Proportion of forearm pronation deformity per the Gschwind and Tonkin classification (n = 52).

Classification	0	1	2	3	4	5	6	7	8	Total
Type IIA	0	0	0	1	1	3	1	0	0	6
Type IIB	0	1	16	20	4	4	1	0	0	46
Total	0	1	16	21	5	7	2	0	0	52
Rate (%)	0	1.9%	30.8%	40.4%	9.6%	13.5%	3.8%	0	0	100%
x = 3.13 (SD = 1.17)										

Table 4: Assessment of preoperative hand function per the House classification (n = 52).

Assessment on preoperative hand function

We found that the pre-operative hand function of patients was limited to holding light objects in their palm.

Treatment results

Results after 3 months

Results of forearm pronation deformity treatment

Wrist fold / Forearm pronation		Type IIA	Type IIB	Total	Rate (%)
Deformed	Type 1	2 (4.3%)	14 (30.4%)	36	78.26%
	Type 2	0	19 (41.3%)		
	Type 3	0	1 (2.2%)		
	Type 4	0	0		
Undeformed		1 (2.2%)	9 (19.6%)	10	21.74%

Table 5: Result of forearm pronation deformity recovery after 3 months (the Gschwind and Tonkin classification).

Of the 46 patients with forearm pronation deformity, 3 months post operation, we found that there was no statistically significant change in pronator or supinator status ($p = 0.47$; Chi- squared test).

Assessment on hand function per the House classification after 3 months

The average hand function level at this time was 3.98 (SD = 1.04). There was a significant increase in hand function 3 months' postoperatively from that seen preoperatively (0.8, SD = 0.833, $p < 0.01$; t-test).

Results after 6 months

After 6 months, we only re-examined 50 patients (96.15%); including six patients with type IIA (12%) and 44 patients (88%) with type IIB wrist fold deformity.

Forearm pronation deformity recovery after 6 months

Wrist fold / Forearm pronation		Type IIA	Type IIB	Total	Rate (%)
Deformed	Type 1	0	23 (50%)	33	71.74%
	Type 2	0	10 (21.74%)		
	Type 3	0	0		
	Type 4	0	0		
Undeformed		3 (6.52%)	10 (21.74%)	13	28.26%
Total		3	43	46	100%

Table 7: Forearm pronation deformity recovery 6 months post operation per the Gschwind and Tonkin classification (n = 46).

Among the 46 patients with forearm pronation deformity, no patient had severe deformity 6 months post operation. We found a change in the pronator and supinator state (forearm pronation deformity) that was associated with the surgery to release the attachment point of the pronator teres ($p = 0.017$; Chi-squared test).

Assessment of hand function per the House classification after 6 months

Classification	0	1	2	3	4	5	6	7	8	Total
Type IIA	0	0	0	0	0	2	2	2	0	6
Type IIB	0	0	2	4	15	13	9	1	0	44
Total	0	0	2	4	15	15	11	3	0	50
Rate (%)	0	0	4.0%	8.0%	30.0%	30.0%	22.0%	6.0%	0	100
x = 4.76 (SD = 1.18)										

Table 8: Assessment of hand function per the House classification after 6 months (n = 50).

The average hand function level at 6 months post operation was 4.76 (SD = 1.18) (Table 8). Patients' mean hand function had increased significantly by 0.78 (SD = 0.789, $p < 0.01$; t-test) from that at 3 months post operation (Table 4).

Study results

Results of forearm pronation deformity treatment

At this time the patients' average forearm supination level was x = 45.98° (SD = 38.39); preoperatively, most patients could not recline the forearm to a neutral position (x = -23.69°, SD = 52.34). Using the t-test, we found that the change in forearm supination following surgery to release the attachment point of the pronator teres tendon related to the forearm pronation deformity in children with cerebral palsy was statistically significant ($p < 0.01$).

Results of retraction of wrist-hand fold treatment

Wrist fold / Forearm pronation		Type IIA	Type IIB	Total	Rate (%)
Deformed	Type 1	0	22 (47.8%)	32	69.6%
	Type 2	0	10 (27.1%)		
	Type 3	0	0		
	Type 4	0	0		
Undeformed		3 (6.5%)	11 (23.9%)	14	30.4%
Total		3	43	46	100%

Table 9: Results of recovery from forearm pronation deformity per the Gschwind C. R JH classification (n = 46).

Wrist posture Group	Wrist flexed >20°	Wrist flexed between 20° nd 0°	Wrist extended ≥0°	Total	x
IIA	0	0	6 (100%)	6 (100%)	28.33°(SD = 7.52)
IIB	2 (4.5%)	22 (50%)	20 (45.5%)	46 (100%)	11.74°(SD = 1.98)
Total	2 (4%)	23 (44%)	27 (52%)	50 (100%)	13.80°(SD = 1.96)

Table 10: Results of wrist extension recovery when stretching fingers (n = 50).

Prior to surgery, patients could not extend their wrists when the fingers were fully extended. After surgery, most patients were observed to have an improvement in wrist extension activity. A significant correlation was observed between wrist extension recovery with extended fingers and surgical intervention (p = 0.043; Chi-squared test).

The limitation in wrist joint movement was evident among the group with type IIB deformity after undergoing enhanced tendon transfer for wrist extension at a rate of 43.48% (p = 0.041; chi-squared test).

Wrist posture / Group	Wrist flexion >20°	Wrist fold <20°	Total	x
IIA	6	0	6	37.5° (SD = 6.12)
IIB	25	19	44	25.72° (SD = 1.43)
Total	31	19	50	26.68° (SD = 1.39)

Table 11: Results of active wrist folding when stretching fingers (n = 50).

Classification	0	1	2	3	4	5	6	7	8	Total
Type IIA	0	0	0	0	0	1	0	3	2	6
Type IIB	0	0	1	1	9	14	15	2	2	44
Total	0	0	1	1	9	15	15	5	4	50
Rate (%)	0	0	2.0%	2.0%	18%	30%	30%	10%	8.0%	100
x = 5.46 (SD = 1.29)										

Table 12: Assessment of hand function per the House classification after 1 year.

The increase in the hand function of children with cerebral palsy according to our research was related to the surgery and was statistically significant (p = 0.023; chi-squared test). Using the t-test to compare the average hand function of 50 patients 1 year after surgery (x = 5.46 [SD = 1.29]) and that at 3 months after surgery (Table 4) (x= 3.98 [SD = 1.04]), we found a significant increase in patients' hand function of 1.48 (SD = 0.838, p < 0.01); when compared to the pre- operation value, the increase in function was 2.28 (SD = 1.031, p < 0.01).

Age (years)	3-4	4-8	>8
Average improvement of hand function according to House's classification	1.5 (SD = 0.71)	2.07 (SD = 0.91)	2.38 (SD = 1.07)

Table 13: Comparison of treatment results by age at surgery (n = 50).

The increase in postoperative scores in the ≤4 years group was lower than that in the other two groups. The average increase in children's hand function post operation was $\bar{x}$ = 2.26 (SD = 1.026). However, using the t-test (p = 0.366), we found that the treatment results were not significantly different between different age groups.

Discussion

The average age in our study population was 10.54 years (range, 4-16 years). The male/female ratio was 1.36/1; there was no difference in the average age between the two sex groups (p = 0.94). The most common age group in our study was ≥8 years, accounting for 69.2% of cases, while the age group of ≤4 years was the smallest.

Compared to the report of Le Nghi Thanh Nhan [2], where the average age was 10.57, the largest age group in the study population was >8 years (61.22%).

Reports from Keat S., Miller G.A., Van Heest E.A., and Skoff H. [4,5,10] all agreed that the most suitable age for upper limb surgery varies between 4 and 8 years, when the imbalance between muscles, joint deformities, and other deformities is not too severe and children of this age can understand and cooperate well when practicing postoperative rehabilitation.

There was postoperative wrist posture change in 49/50 patients. However, among these 49 patients, there were 23 in whom the wrist posture did not achieve a neutral position. This issue was also raised by Van Heest A.E. (1999) when using the stretching tendon of the elbow wrist to switch to stretching the radial wrist. In Van Heest's study, 42/137 cases underwent stretching tendon of the ulnar wrist to switch to stretching the radial wrist. As a result, 41/42 patients had postural changes, in which 20 wrists reached an approximately neutral level. The cause given by the authors was that the tendon suture did not achieve the required tension. The position of the transfer of the tendon suture was too high and slack so it did not create a straight axis following the paralyzed muscle, meaning that the traction was insufficient to maintain the wrist posture, and the technique in stitching the tendon was not good. On the other hand, the force of contraction that had not been adequately released was the cause of the recurrence of deformation.

Of the patients in group IIA, 3/6 had forearm pronation deformity, that recovered after surgery and rehabilitation. As noted earlier, these patients had continuous postoperative physical therapy training. However, we were limited in monitoring the training intensity, degree, and habits of patients postoperatively.

As for type IIB patients, compared with preoperatively, we noted that within the study population, most patients still had forearm pronation deformity (32/46 patients) but fell within type 1 and type 2 deformities (69.6%), of which type 1 accounted for the majority (12/32 patients), at 39.1%. The number of patients who achieved fair and good results accounted for 78.2%. The number of patients who achieved average results accounted for 30.4%, and none of the patients had poor results. Compared with the results of some domestic and foreign studies, type 1 and type 2 accounted for 73.2% in Le Nghi Thanh Nhan's study [2], while in Goran C.'s study [11-27], fair and good results accounted for 80% of patients.

Compared with the preoperative results with an average functional level of 3.13 (SD = 1.17), the patients in our study achieved a postoperative level of 5.46 (SD = 1.29). Le Nghi Thanh Nhan [2] reported am average postoperative hand function of 5.20 (SD = 1.44). Compared with foreign results, we found that our results were lower than other authors for the following reasons: inadequate experience in assessing preoperative deformity in the initial phase of the study led to errors in the choice of treatment methods, lack of experience in adjusting the tension of muscles during tendon transfer limited the benefits of treatment, and some patients did not have long-term family support for pre- and postoperative rehabilitation.

Conclusion

On average, after 1 year, among 50 patients, two (4%) still had retraction of the wrist- hand fold as before and 2 (4%) did not have improved hand function. Average postoperative hand function increased from 3.13 to 5.38 (an increase of 2.25).

Fifty patients (96.1%) had improved wrist extension with extended fingers. The average amplitude of wrist flexion with extended fingers was 13° (type IIA: 28°, type IIB: 11°). The average wrist flexing gesture when extending fingers was 27° (type IIA: 37°, type IIB: 25°). Thirty-two patients (69.6%) had type 1 or type 2 forearm pronation.

After surgery, 69.6% of patients had forearm pronation deformity. However, no patients had severe forearm pronation deformity; the number of patients rated as excellent or good was 32 (69.6%), while 10 patients were rated average (21.7%).

Advantages

- Easy-to-implement method.
- Able to elongate muscle mass from muscle fiber units with little effect on the rest with muscle fascia surgery.
- Switch a tendon stretching the ulnar wrist to stretching the radial wrist; this is a tendon that functions to stretch the wrist so patients will quickly adapt to the presence of a new tendon. The orientation and direction of traction when performing activities has almost no change compared to that in the natural state, which is important when choosing the transfer tendon.

Moreover, it will not cause weakness in wrist flexion, operation such as using an ulnar wrist flexing tendon.

- The release of the pronator teres tendon attachment point in patients with forearm pronation deformity facilitates the balance of the pronator and supinator muscles.

Disadvantages

- For muscle fascia surgery, after stretching the muscle fibers, they form a cavity around the incision site, leading to frequent hematoma and swelling.
- For a tendon transfer technique using a tendon that flexes the ulnar wrist to stretching the radial wrist, in the case of retraction of the wrist-hand fold in cerebral palsy, the stretching tendon system is often weakened or paralyzed; moreover, after muscle movement, the tendon will be degraded by one level. Therefore, after switching from stretching of the ulnar wrist to stretching of the radial wrist, the wrist posture only needs to be maintained, and the wrist-stretching effort will not increase compared to that following the transfer of the ulnar wrist flexing tendon to stretching the radial wrist.
- For the method of releasing the pronator teres tendon attachment point: this tendon plays a vital role in forearm pronation. The release of the attachment point will somewhat affect forearm pronation.

Bibliography

1. Duc BV. "Orthopedic Injuries of the Upper Limbs" 1.385 (2010): 484-508.
2. Nhan LNT. "Study of clinical features and assessment of results of surgery to treat forearm and hand deformities due to sequelae of cerebral palsy" (2010).
3. Zancolli E. "Structural and dynamic bases of hand surgery. 2nd edition. Philadelphia: Lippincott (1979): 263-283.
4. Miller F. "Cerebral palsy. 1st edition". Wilmington (USA): Springer Publishers (2005).
5. Van Heest EA., *et al*. "Upper extremity surgical treatment of cerebral". *Journal of Hand Surgery (American Volume)* 24A (1999): 323-330.
6. Gschwind C and Tonkin M. "Surgery for cerebral palsy: Part 1: Classification and operative procedures for pronation deformity". *Journal of Hand Surgery (British Volume)* 17 (1992): 391-395.
7. Cobeljic G., *et al*. "The results of surgical treatment for pronation deformities of the forearm in cerebral palsy after a mean follow up of 17.5 years". *Journal of Orthopaedic Surgery and Research* 10 (2015): 106.
8. Ozkan T and Tuncer S. "Upper extremity surgery in spastic cerebral palsy" (2012): 43-54.
9. Strecker WB., *et al*. "Comparison of pronator tenotomy and pronator rerouting in children with spastic cerebral palsy". *Journal of Hand Surgery* (1988).
10. Baratz ME., *et al*. "Section VI.10 The Wrist Joint: The Pediatric Wrist, Chapter 61: Tendon Transfer for Wrist Extension. In: *Wrist Surgery: Tricks of the Trade* (2006): 178-180.
11. National Institute of Neurological Disorders and Stroke. Cerebral Palsy: Hope Through Research (2013).
12. National Institute of Neurological Disorders and Stroke. Cerebral Palsy: Overview (2014).
13. Blair E and Stanley FJ. " Intrapartum asphyxia: a rare cause of cerebral palsy". *The Journal of Pediatrics* 113 (1988): 420.
14. Panteliadis C., *et al*. "Hallmarks in the history of cerebral palsy: from antiquity to mid-20th century". *Brain and Development* 35 (2013): 285-292.
15. Oskoui M., *et al*. "An update on the prevalence of cerebral palsy: a systematic review and meta-analysis". *Developmental Medicine and Child Neurology* 55 (2013): 509-519.
16. Panteliadis C., *et al*. "Hallmarks in the history of cerebral palsy: from antiquity to mid-20th century". *Brain and Development* 35 (2013): 285-292.
17. House JH., *et al*. "A dynamic approach to the thumb-in-palm deformity in cerebral palsy: Evaluation and results in fifty-six patients". *Journal of Hand Surgery (American Volume)* 63 (1981): 216-225.

18. McConnell K., *et al*. "Upper limb function and deformity in cerebral palsy: A review of classification systems". *Developmental Medicine and Child Neurology* 53 (2011): 799-805.

19. House JH., *et al*. "A dynamic approach to the thumb-in-palm deformity in cerebral palsy: Evaluation and results in fifty-six patients". *Journal of Hand Surgery (American Volume)* 63 (1981): 216-225.

20. Green WT and Banks HH. "Flexor carpi ulnaris transplant and its use in cerebral palsy". *Journal of Hand Surgery (American Volume)* 44 (1962): 1343-1352.

21. Samilson RL and Morris JM. "Surgical improvement of the cerebral-palsied upper limb: Electromyographic studies and results of 128 operations". *Journal of Hand Surgery (American Volume)* 46 (1964): 1203-1216.

22. Manske PR. "Cerebral palsy of the upper extremity". *Hand Clinics* 6 (1990): 697-709.

23. Tonkin MA. "The growing hand. In: Gupta A, Kay SPJ, Scheker LR, editors. The upper limb in cerebral palsy. London: Mosby (2000): 447-459.

24. Carlson MG and Brooks C. The effect of altered hand position and motor skills on stereognosis". *Journal of Hand Surgery (American Volume)* 34 (2009): 896-899.

25. Tonkin M. "The upper limb in cerebral palsy". *Current Orthopaedic* 9 (1955): 149-155.

26. Gschwind C and Tonkin M. " Surgery for cerebral palsy: Part 1: Classification and operative procedures for pronation deformity". *Journal of Hand Surgery (British Volume)* 17 (1992): 391-395.

27. Bhardwaj P and Raja Sabapathy S. "Assessment of the hand in cerebral palsy" (2011).