

# Comprehensive Upper Limb Motion Analysis for Treatment Planning & Outcome Documentation in Cerebral Palsy & Traumatic Brain Injury



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## Introduction

Individuals with cerebral palsy (CP), and traumatic brain injury (TBI) sustained before two years of age, have complex multi-system impairments that contribute to hand dysfunction and disability. Orthopaedic surgical procedures, performed to improve upper limb (UL) function, are difficult to plan. Reports of surgical efficacy contain limited outcome measures. A comprehensive evaluation tool was developed to assist with specific surgical planning, as well as documentation of outcomes after intervention. We hypothesized that surgery would improve UL function.

## Methods

Pre-operative Comprehensive Upper Limb Motion Analysis (CULMA), included impairment measures, kinematics, electromyography (EMG), Jebson-Taylor Test of Hand Function, video, Pediatric Evaluation of Disability Inventory (PEDI) self-care domain, and individual goal setting.

36 individuals with CP (32), TBI (4): 27 males, 9 females (ages 4 – 69)

- > 30 w/ hemiplegia (17 right; 13 left hemiplegia)
- > 6 w/ quadriplegia with asymmetric UL function (3 R; 3 L)

Surgical planning worksheet completed based on CULMA findings:

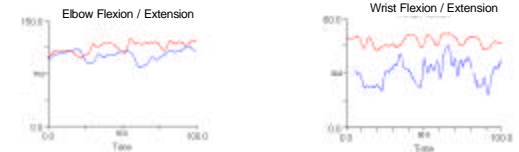
To Enhance Active Elbow Extension	To Enhance Active Forearm Supination	To Enhance Active Wrist Extension	To Enhance Active Finger Function	To Enhance Active Thumb Function
<b>Soft Tissue Releases / Lengthenings (fractional or "z")</b>				
<input type="checkbox"/> Biceps lengthening	<input type="checkbox"/> PT lengthening	<input type="checkbox"/> FCU lengthening	<input type="checkbox"/> FDS lengthening	<input type="checkbox"/> 1 <sup>st</sup> web Z-plasty
<input type="checkbox"/> Biceps release	<input type="checkbox"/> PT release	<input type="checkbox"/> Flexor pronator slide	<input type="checkbox"/> FDP lengthening	<input type="checkbox"/> AP lengthening
<input type="checkbox"/> Lacertus fibrosus rel.	<input type="checkbox"/> Flexor pronator slide	<input type="checkbox"/> FCR lengthening	<input type="checkbox"/> Flexor pronator slide	<input type="checkbox"/> AP release
<input type="checkbox"/> Brachialis lengthening	<input type="checkbox"/> Biceps aponeurosis release	<input type="checkbox"/> FDS/ FDP slide	<input type="checkbox"/> 1 <sup>st</sup> dorsal interosseus release	
<input type="checkbox"/> Brachialis release	<input type="checkbox"/> PQ release	<input type="checkbox"/> PL release	<input type="checkbox"/> Lumbrical lengthening	<input type="checkbox"/> FPL lengthening
<input type="checkbox"/> Brachioradialis length	<input type="checkbox"/> Brachioradialis release	<input type="checkbox"/> FCR release	<input type="checkbox"/> FDS release	<input type="checkbox"/> FPB release
<b>Tendon Transfers / Re-Routings</b>				
<input type="checkbox"/> PT re-routing	<input type="checkbox"/> FCU to ECRBL	<input type="checkbox"/> FCU to EDC	<input type="checkbox"/> BR to APL	
	<input type="checkbox"/> PT to ECRBL	<input type="checkbox"/> BR to EDC	<input type="checkbox"/> FCR to APL	
	<input type="checkbox"/> BR to ECRBL	<input type="checkbox"/> FDS tenodesis	<input type="checkbox"/> PL to APL	
	<input type="checkbox"/> ECU to ECRBL	<input type="checkbox"/> Lateral band re-routing	<input type="checkbox"/> BR to EPB	
	<input type="checkbox"/> FCR to ECRBL	<input type="checkbox"/> Lateral band tenodesis	<input type="checkbox"/> FCR to EPB	
		<input type="checkbox"/> Extensor tendon tenotomy w/ pinning of PIP joints	<input type="checkbox"/> BR to EPL	
		<input type="checkbox"/> SCRL	<input type="checkbox"/> FCR to EPL	
		<input type="checkbox"/> FDS to FDP (S/TP)	<input type="checkbox"/> PL to EPL	
		<input type="checkbox"/> Intrinsic muscle slide	<input type="checkbox"/> EPL re-routing	
		<input type="checkbox"/> Resection of ulnar-nerve (motor branch in Guyon's canal)	<input type="checkbox"/> FPL abductorplasty	
			<input type="checkbox"/> Accessory ms. of APL to EPB (limbrication)	
<b>Bone / Joint Stabilization</b>				
<input type="checkbox"/> Rotational osteotomy	<input type="checkbox"/> Wrist fusion w/ PRC	<input type="checkbox"/> Palmar plate	<input type="checkbox"/> MCP fusion	
	<input type="checkbox"/> PRC	<input type="checkbox"/> PIP fusion	<input type="checkbox"/> MCP capsulodesis	
		<input type="checkbox"/> DIP fusion	<input type="checkbox"/> IP fusion	

PRC = proximal row carpectomy

## Results

Post-operative CULMA in 4 of 36 individuals resulted in varied functional outcomes.

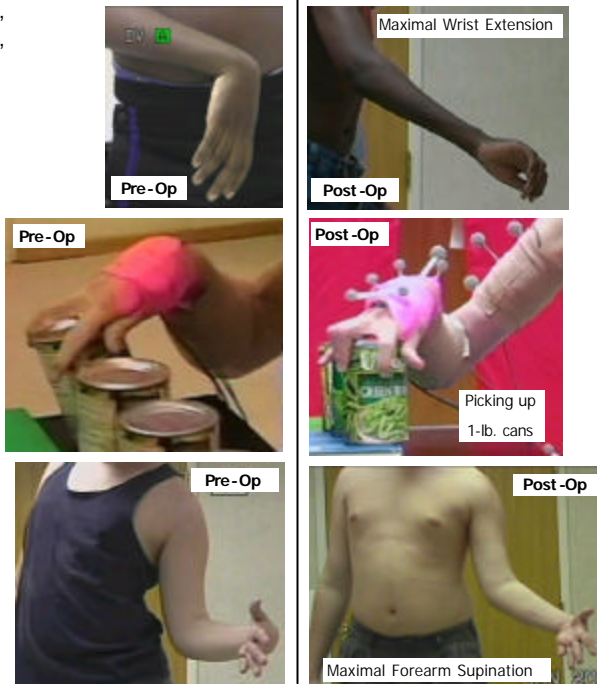
- > Significant improvements in total Jebson time (p=.039)
- > Significant improvements in normalized 3-jaw pinch strength (p=.05)
- > Improvements in PEDI Scaled Scores, and active wrist and elbow extension approached significance
- > Changes in active forearm supination were not significant
- > Goal attainment ranged from 2-10 individual goals attained



Pre-op kinematics in red; post-op in blue using the involved UL during the small objects task of the Jebson-Taylor Test of Hand Function

## Discussion

Orthopaedic surgery to reduce UL impairments is assumed to improve functional abilities. Use of comparative kinematics with synchronized EMG added another dimension to quantify movement. Because we have only evaluated four individuals post-operatively to date, functional outcomes after specific combinations of UL surgery have yet to be defined. Motor control issues and motor relearning strategies will impact surgical outcomes. Including combinations of Constraint-Induced Movement Therapy (CIMT), Neuromuscular Electrical Stimulation (NMES), and botulinum toxin during post-operative rehabilitation may enhance surgical outcomes.



## Conclusions

Early results of post-operative improvements in UL function are promising. By evaluating individuals in a very systematic way pre- and post-operatively using CULMA, true changes in UL abilities were documented. We continue to evaluate the remaining individuals in our case series post-operatively.