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CP Upper Limb Treatment and Assessment

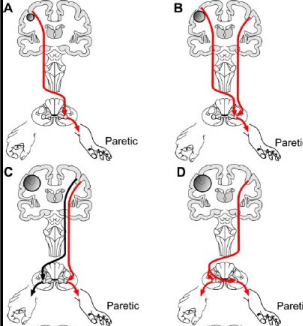
Eva Pontén MD, PhD, Associate Prof
Specialist in Orthopaedic Surgery and Hand Surgery
Astrid Lindgren Children's Hospital
Karolinska University Hospital, Stockholm, Sweden

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Large brain lesions result in control of the hand from the same side of the brain → Bad grip




- A: Good grip
- B: Moderately impaired grip
- C: Bad grip
- D: Intense mirror movements

- **This we cannot change with surgery.**
- **The brain plasticity potential differs between patients.**

Transcranial magnetic stimulation from thesis by Vandermeeren 2003

Cerebral Palsy= Motor impairment due to a lesion of the developing brain

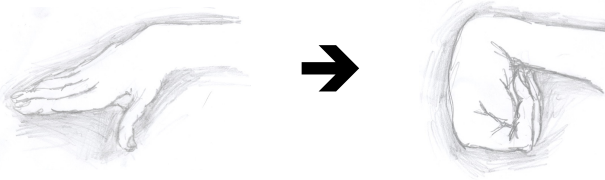
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Poor muscle control results in unbalanced forces across joints

- Flexors are larger than extensors (*Loren et al. 1996*), and thus take overhand
- => flexed position of elbow, wrist and fingers
- Can be treated with tendon transfers etc !



Nann Ellermann 2022-03-02 3

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Hand surgery for a balanced position of the hand



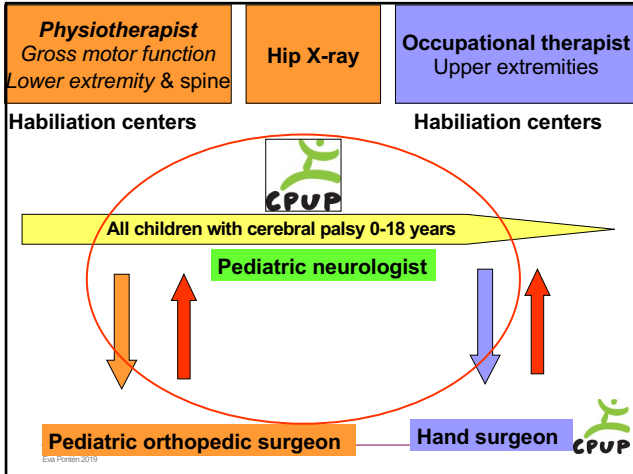
Release, Augment, Stabilize



- Divide (release) tendon and muscle
- Lengthen tendon
- Release aponeurosis and tendon inside muscle
- Tendon transfer
→ Difficult to predict in spastic dystonia
- Fusion of joints

Eva Pontén 2010

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Hand and arm function in CPUP Occupational therapists at Habilitation Centers Sweden

Manual ability MACS (I-V)

Hand function in each individual hand House (0-8)

- 0 Does not use
- 1-3 Passive assist
- 4-6 Active assist
- 7-8 Spontaneous use

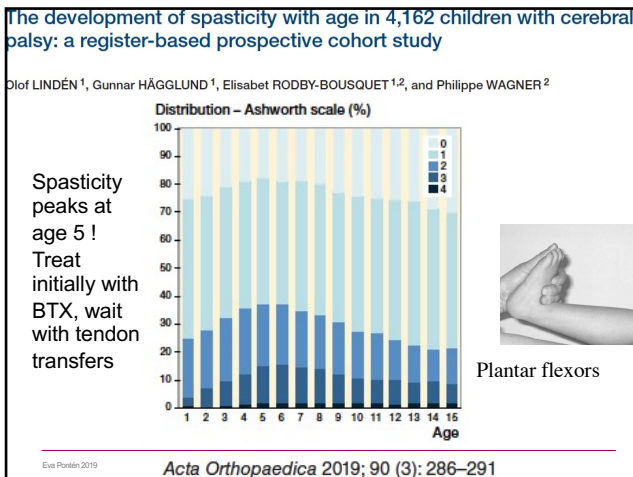
Wrist and finger extension Zancolli (I, IIA, IIB, III)

Thumb-in-palm House (0-IV)

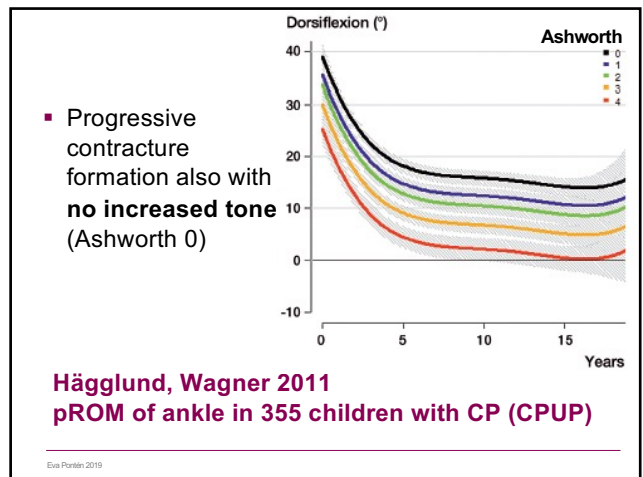
Passive range of motion shoulder to hand (goniometry)

Treatments: Orthoses, Hand therapy, Bot toxin inj, Hand surgery

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DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY ORIGINAL ARTICLE

Upper-limb contracture development in children with cerebral palsy: a population-based study

JENNY HEDBERG-GRAFF^{1,2} | FREDRIK GRANSTRÖM² | MARIANNE ARNER^{3,4} | LENA KRUMLINDE-SUNDHOLM¹

¹ Department of Women's and Children's Health, Karolinska Institutet, Stockholm; ² Centre for Clinical Research Sörmland, Uppsala University, Eskilstuna; ³ Department of Clinical Science and Education, Karolinska Institutet, Stockholm; ⁴ Department of Hand Surgery, Södersjukhuset, Stockholm, Sweden.

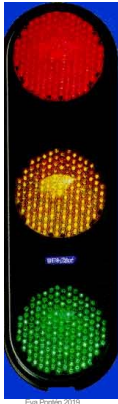
What this paper adds

- In a population-based sample of 771 children with cerebral palsy, 34% developed an upper-limb contracture.
- Contracture development started at preschool age.
- The first affected movements were wrist extension and supination.
- Passive range of motion decreased with age.
- High Manual Ability Classification System level was the most important predictor of contractures.

Eva Pontén 2019

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"Traffic lights" for passive joint movement



Red = an established contracture

Yellow = check and/or treat (e.g. with stretching programs, orthoses, BtxA, surgical muscle / tendon release)

Green = normal

Karolinska Institutet CPUP

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DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY ORIGINAL ARTICLE

Upper-limb contracture development in children with cerebral palsy: a population-based study

JENNY HEDBERG-GRAFF^{1,2} | FREDRIK GRANSTRÖM² | MARIANNE ARNER^{3,4} | LENA KRUMLINDE-SUNDHOLM¹

Progressive contractures

771 children



Supination

PT, PQ <80°

<45°

1-3 4-6 7-9 10-12 13-15 16-18

Age, y (3y interval)

Wrist extension with flexed fingers

>60°

FCU, FCR, PL

<60°

<0°

1-3 4-6 7-9 10-12 13-15 16-18

Age, y (3y interval)

Wrist extension with extended fingers

FDS, FDP

<60°

1-3 4-6 7-9 10-12 13-15 16-18

Age, y (3y interval)

Elbow extension

<-10°

Bic, Brach, BR

<-30°

>-30°

1-3 4-6 7-9 10-12 13-15 16-18

Age, y (3y interval)

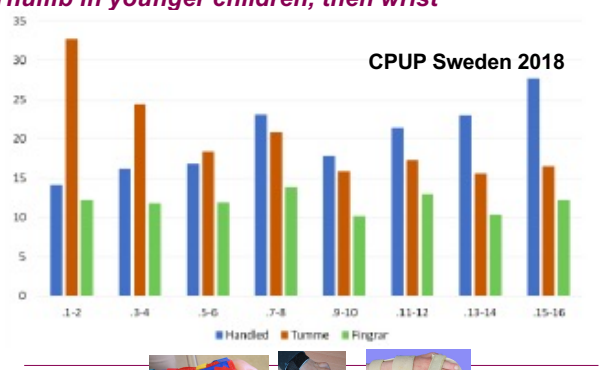
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% of children with orthosis for wrist, thumb and fingers, related to age.

Thumb in younger children, then wrist

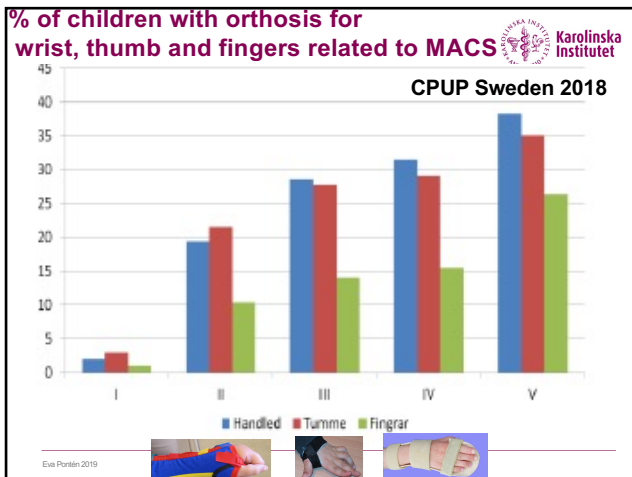
CPUP Sweden 2018



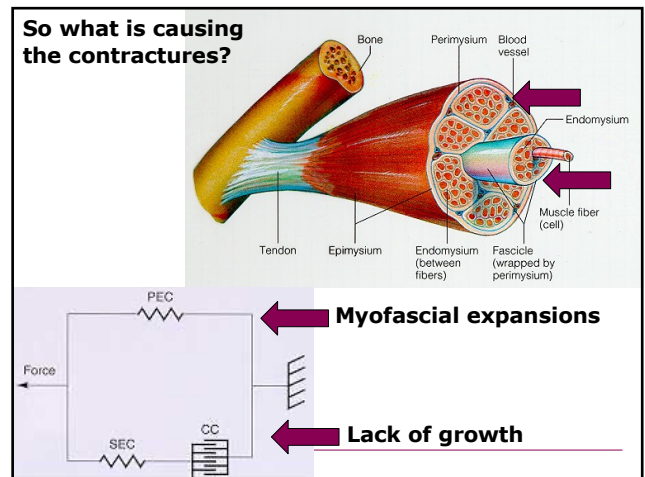
Age (y interval)	Handled (%)	Tumme (%)	Fingrar (%)
1-2	14	32	12
3-4	16	24	12
5-6	17	18	12
7-8	23	21	14
9-10	18	16	10
11-12	21	17	13
13-14	23	15	10
15-16	28	16	12

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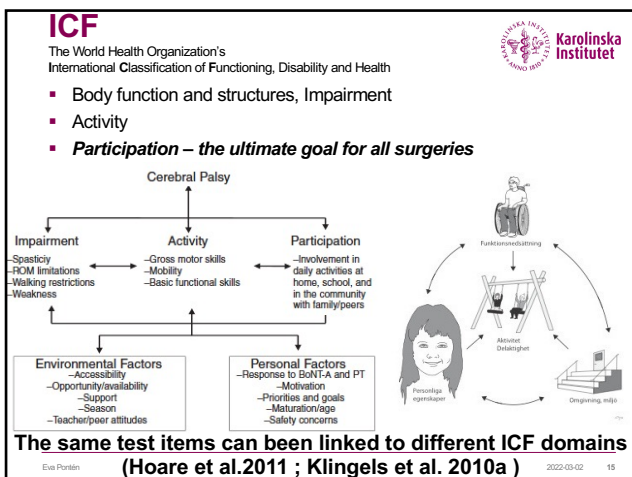
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Assessments

A single universal instrument does not exist!

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Tests for Body function and Structure

- Spasticity, Modified Ashworth Scale
- Strength
- Range of Motion, active and passive

Classifications

- Zancolli I, IIA, IIB, III (Zancolli et al. 1983)

Wrist (> -20°) and finger extension

I: Wrist can extend with flexed fingers
 IIA: Wrist can extend with flexed fingers
 IIB: Fingers can extend with flexed wrist
 III: (Illustration of thumb-in-palm)

Thumb-in-palm House (0-IV)

(House et al. 1981)

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ICF Activity Hand function House (0-8)

How much the affected hand is used when the child is observed

Funktionsklass	Observation	Quality
0	Does not use	Does not use
1	Passive assist	Stabilizes without grasp
2		Poor passive grasp
3		Good passive grasp
4	Active assist	Poor active grasp
5		Fair active grasp
6	Spontaneous use	Good active grasp
7		Reduced dexterity
8		No limitation

Referens : House J H. et al. A Dynamic Approach to the Thumb-in-Palm Deformity in Cerebral Palsy. The Journal of Bone and Joint Surgery, 1981; 63-A: 2: 216-225. Modifierad av nationella arbetsgruppen cpup-at 2009

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Participation

MACS

Manual Ability Classification System for children with cerebral palsy, 4-18 years

Classifying the children's ability to handle objects in daily life

www.macs.nu

Eliasson AC, Krumlinde Sundholm L, Rösblad B, Beckung E, Arner M, Öhrvall AM, Rosenbaum P. Dev Med Child Neurol. 2006 48:549-554.

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Participation

MACS

- Handles objects easily and successfully
- Handles most objects but with somewhat reduced quality and/or speed of achievement
- Handles objects with difficulty; needs help to prepare and/or modify activities.
- Handles a limited selection of easily managed objects in adapted situations
- Does not handle objects and has severely limited ability to perform even simple actions

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Manual Ability Classification System (MACS) (Eliasson et al. 2006)

- Strong evidence of validity and reliability between therapists and parents ratings (Eliasson et al 2006).
- Stable over time. (Öhrvall et al 2013, 2014)
- Strong predictor of children's independence in self-care activities (Öhrvall et al. 2010).
- Not expected to detect change
 - The exception is in individuals whose ability is close to the border.
- Mini-MACS (< 4 years old) (Eliasson et al. 2017)
- www.MACS.nu

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PROM Questionnaires

ABILHAND-Kids (Arnould et al. 2004)

- CP ages 6–15 years,
- 21 items, unimanual and bimanual tasks,
 - impossible, difficult, easy


ACTIVLIM-CP (Bleyenheuft et al. 2017)

- Global activity performance
- 43 everyday tasks


Online analysis on www.rehab-scales.org/

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Participation



CHEQ

Children's Hand-use Experience Questionnaire

What does the child think is important ?


CHEQ is a questionnaire which captures children's experience of using the affected hand in activities where usually two hands are needed.

For children 6-18 year with unilateral involvement


Sköld, Hermansson. Krumlinde-Sundholm, Eliasson Dev Med Child Neurol. 2011. 23

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www.cheq.se

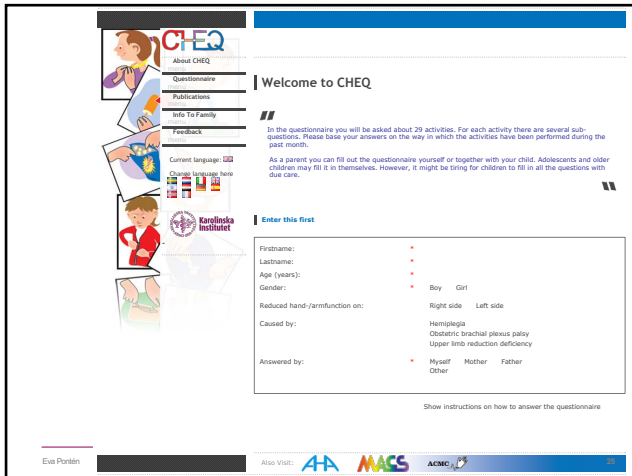


- 29 activities that typically require two hands
 - if the activity is performed independently
 - If one or two hands are used
- 3 subscales
 - effectiveness of the grasp,
 - time consumption,
 - bothered or not
- The be filled in online www.cheq.se, free to use
 - Are suggested to be used at home before the visit on the hospital
 - Results are generated in a pdf file, not saved anywhere

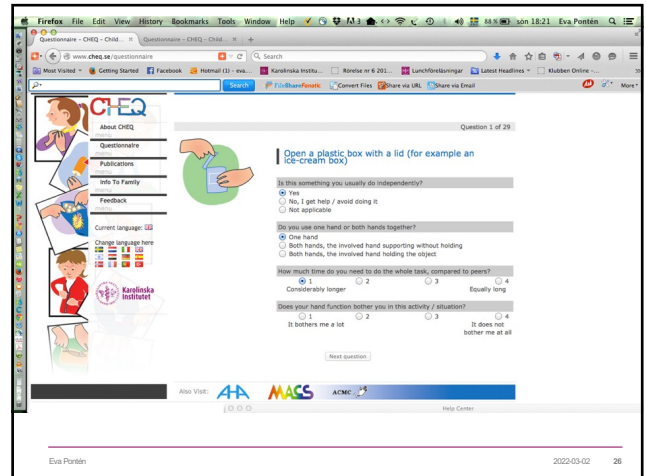
Could be saved by patient. File for research could be sent by patient¹² 24

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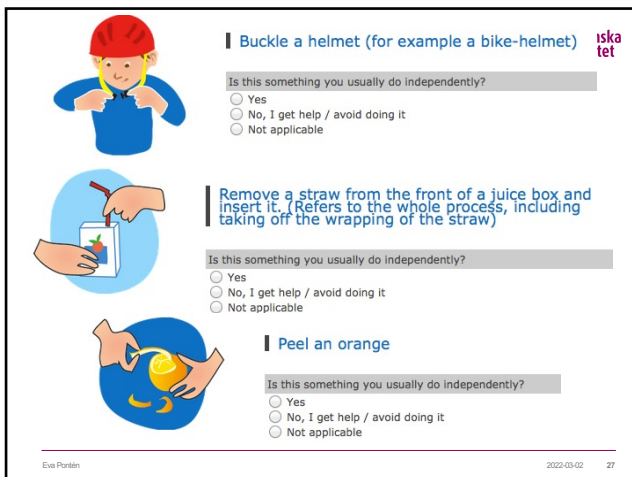
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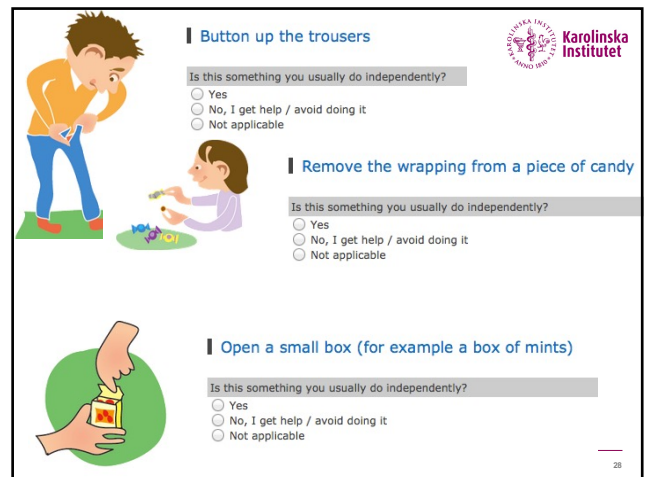
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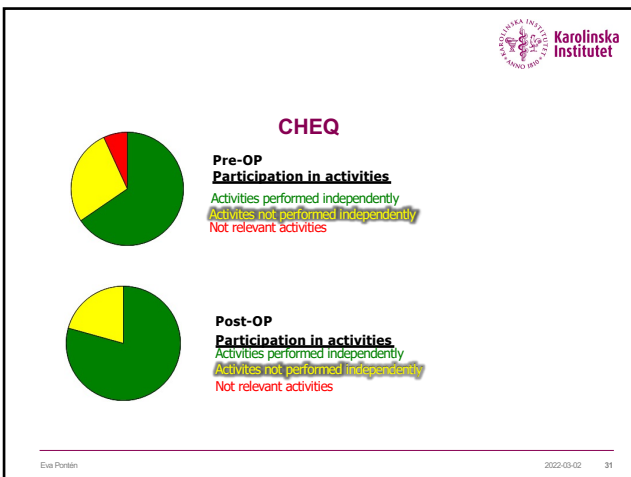
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Choose a test related to the nature and goal for the intervention

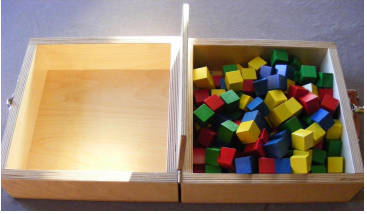
- Match
 - ICF levels with the patient's goals
 - expected effects of intervention.
- Valid and reliable measures for CP
- High test-retest reliability.

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Observation Based Speed and Dexterity Box and Block

- Unilateral gross manual dexterity.
- Number of blocks moved during 60-seconds
- Norm-referenced for ages 6 years to 19 years + adults
 - Mathiowetz et al. 1985a, Jongbloed-Pereboom et al. 2013)




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Quality of Movements Melbourne Assessment 2 (MA2)

- Criterion-referenced Capacity measure of Quality of unilateral upper limb movements
 - (Randall et al.2014)
- 2–15 years of age with CP.
- (1) amount of active ROM at each upper limb joint
- (2) accuracy of reach for, or placement of, an item
- (3) dexterity of finger movements when grasping, releasing, and manipulating objects
- (4) fluency or smoothness of the movement.

The responsiveness of the scale is not yet reported.



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Activity SHUEE

Shriners Hospital for Children Upper Extremitry Evaluation
Davids et al, 2006 J Bone Joint Surg Am

- Quick, 20 minutes for the OT
- Easy to score
- (i) the spontaneous functional use (SFA),
- (ii) the dynamic positional alignment (DPA), and
- (iii) grasp/release abilities of the affected hand in three distinct wrist positions.
- Taking money out of wallet
- Folding paper
- Open a bottle
- Putting disks on a string
- Play-Doh into jar
- Throw and put sticker on large ball "High five"
- Accept coins
- Accept bills
- Pick up cracker to mouth
- Touch ear on contralateral side

CP ages 3– 18 years

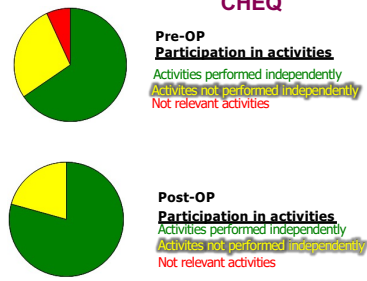
If you want to know how the operated hand is used



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CHEQ




Pre-OP Participation in activities
Activities performed independently
Activities not performed independently
Not relevant activities

Post-OP Participation in activities
Activities performed independently
Activities not performed independently
Not relevant activities

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AA Activity Assisting Hand Assessment


If you want to know how **effectively** the affected hand is used in **bimanual** activities.

- Intended for children with unilateral disability
 - Unilateral CP
 - Brachial plexus palsy
- Semi-structured play session with toys requiring bimanual use
- 22 items and a 4-point rating scale
- Rasch build assessment
- Responsive for change

Krumlinde-Sundholm, Eliasson, Holmefur 2003, 2007, 2009.
More information www.ahanetwork.se

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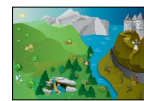
The Assisting Hand Assessment

- validated for children with unilateral disabilities
- use of the affected hand in bimanual tasks

A video-recorded, 10-15 minutes, standardized play session

Scored on 20 items on a 4 point rating scale

Raw scores converted to an interval scale, 0-100 AHA-units


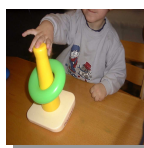
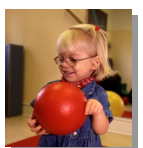
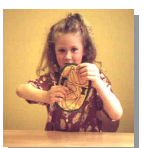
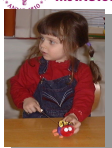




Small-Kids AHA 18 months-5 years
School-Kids AHA 6- 12 years
Ad-AHA for adolescents 13- 18 years
Hand Assessment for Infants (HAI)

(Krumlinde-Sundholm & Eliasson 2003, Krumlinde-Sundholm et al 2007, Holmefur et al 2007, 2009)

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Usefulness of assisting hand

Low ability


- Approaches objects
- Holds
- Stabilizes by weight
- Changes strategies
- Proceeds
- Initiates use
- Moves upper arm
- Moves fingers
- Coordinates
- Reaches
- Releases
- Orients objects
- Flow in task performance
- Stabilizes by grip
- Chooses AH
- Calibrates
- Moves forearm
- Varies type of grasp

High ability

- Grasp
- Readjusts grips
- Manipulates
- Puts down

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Results from patient-reported measures (perceived ability) often differ from observation based measures (observed ability),

- Both aspects should be reported
- Helps the family to identify problem areas
- Guides the surgeon to possible interventions

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Outcome of hand surgery in children with spasticity, a 9-year follow-up study.


Pontén E, von Walden F, Lenke-Ekholm C, Zethraeus BM, Eliasson AC. *J Pediatr Orthop B*. 2019

- 34 children had been operated on at least 10 years ago
- 2 children declined to participate in the follow up
- 2 children had spina bifida + CP and were excluded
- 15 children did not have AHA evaluation before surgery and were therefore excluded

- => 15 children were included in the study**
 - 11 had CP
 - 2 had had a stroke at 2 years and 9 year of age, respectively
 - 1 had had a traumatic brain injury at age 10
 - 1 was operated for a brain tumor at age 9

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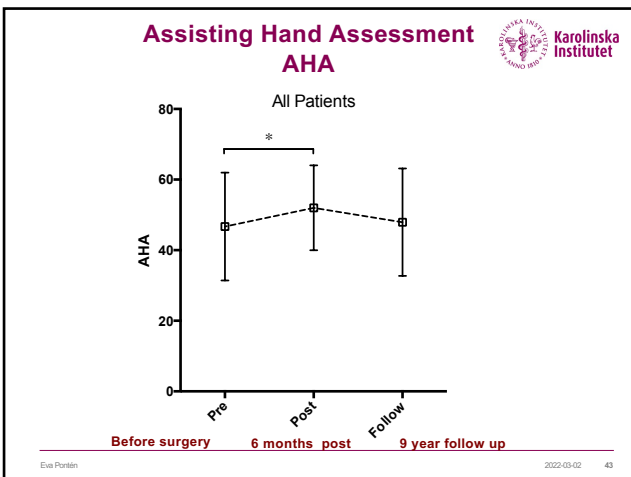
Methods

- Assisting Hand Assessment
- Range of Motion
- Appreciation of appearance

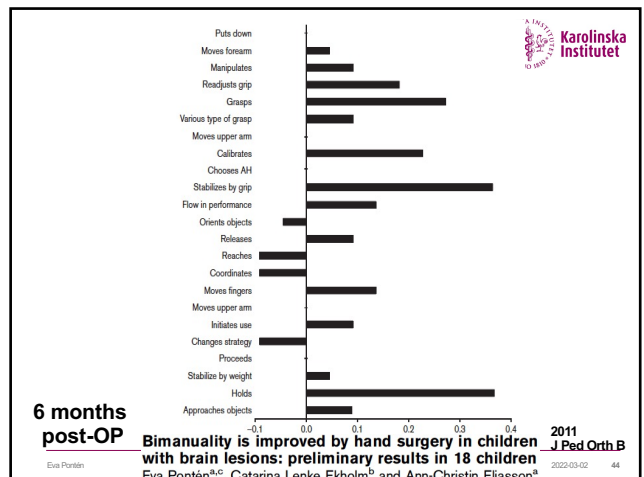
- Continuation of the paper:**
- Bimanuality is improved by hand surgery in children with brain lesions: preliminary results in 18 children**
 - Pontén E, Ekholm CL, Eliasson AC. *J Pediatr Orthop B*. 2011

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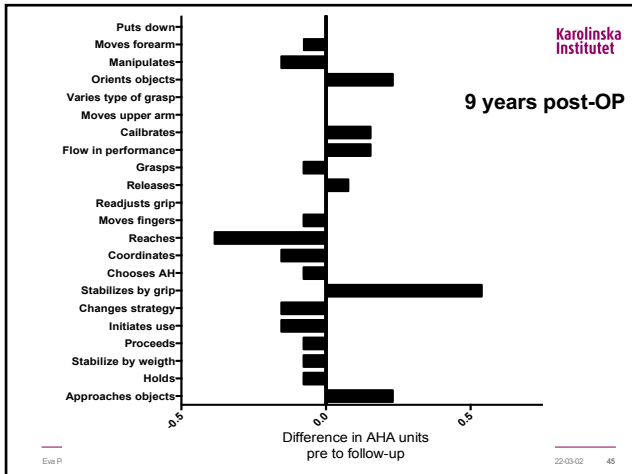
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Individualized assessments COPM and GAS identify areas of concern

- Canadian Occupational Performance Measure (**COPM**) (Law et al. 1990)
→ Performance, Ability and Satisfaction on a 0– 10 scale,
- Goal Attainment Scaling (**GAS**) (Kiresuk et al. 1994)
→ expected improvement is formulated = 0
→ -2 = less
→ +2 = more than expected
- The achievement of different personal goals can be compared between patients

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Setting Goals for the surgery Different for different MACS levels What is important for the child? Including appearance!

- CHEQ can be used for goal setting
- COPM
→ Canadian Occupational Performance Measure
- GAS
→ Goal Attainment Scaling

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Tendon lengthening:

Step cut lengthening = z-lengthening

- Facilitates usage of antagonists
- Shortens sarcomeres (to normal?)
- Diminishes stretch of muscle spindles
- Decreases spasticity (at least in the short term)
- Does not increase the range of motion, but puts the range of motion in a more functional position.

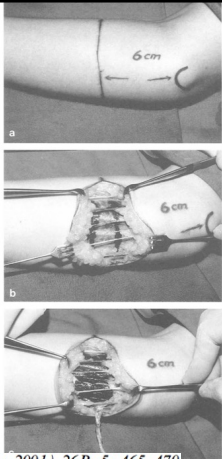
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Release of contracted aponeuroses

M. TONKIN and C. GSCHWIND
Journal of Hand Surgery (British Volume, 1992)

- All the septa of the flexor pronator mass are divided.
 - (Zancolli, 1979)
- Intramuscular release of FPL tendon



SURGERY FOR CEREBRAL PALSY
PART 3: CLASSIFICATION AND OPERATIVE PROCEDURES FOR THUMB DEFORMITY

M. A. TONKIN, N. C. HAIBICK, J. E. T. LEEKERLEY and G. COZZENS
From the Department of Hand Surgery and Peripheral Nerve Surgery, Royal North Shore Hospital, the University of Sydney and the Spinal Centre of New South Wales, Australia

Tonkin et al 2001

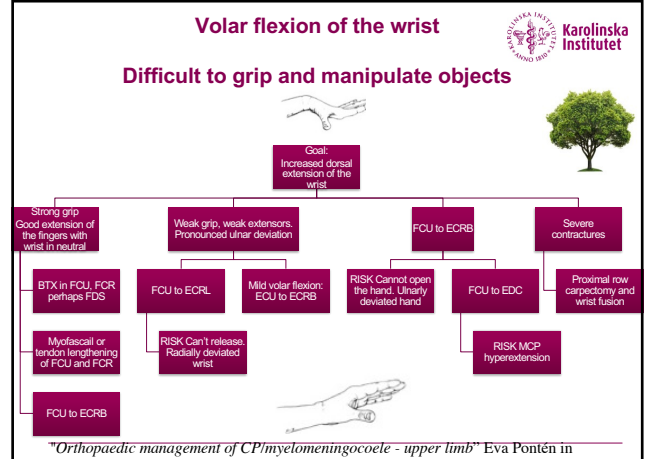
Journal of Hand Surgery (British and European Volume, 2001) 26B: 5: 465-470

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Volar flexion of the wrist

Difficult to grip and manipulate objects

Goal: Increased dorsal extension of the wrist



Strong grip: Good extension of the fingers with wrist in neutral

Weak grip, weak extensors: Pronounced Ulnar deviation

Severe contractures

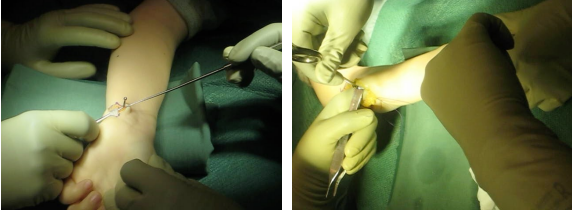
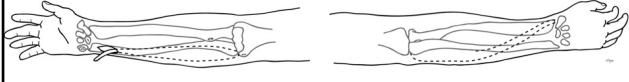
Options:

- BTX in FCU, FCR perhaps FDS
- FCU to ECRL
- Mild volar flexion: ECU to ECRB
- RISK Cannot open the hand. Ulnarly deviated hand
- FCU to EDC
- Proximal row carpectomy and wrist fusion
- Myofascial or tendon lengthening of FCU and FCR
- RISK Can't release. Radially deviated wrist
- RISK MCP hyperextension
- FCU to ECRB

"Orthopaedic management of CP/myelomeningocele - upper limb" Eva Pontén in "European Surgical Orthopaedics and Traumatology, the EFORT Textbook" 2014

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Taking the FCU for a tendon transfer

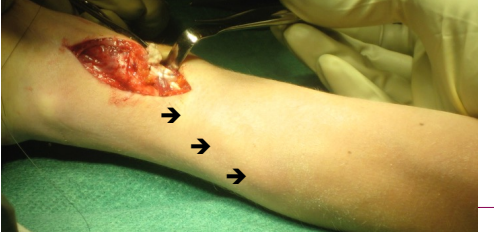
Eva Pontén 2008

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Volar wrist: FCU cut and pulled through to proximal wound



Dorsal wrist: FCU transferred over ulna and weaved into ECRB



At what tension?

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Tendon transfers could become over-tight or over-loose over time

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Nann Ebermann 2022-03-02 53

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MACS IV-V with severe flexion deformity. Proximal row carpectomy combined with wrist fusion

- Shortening of the bone
 - Less muscle shortening
 - Combine with
 - Aponeurotic release
 - Intramuscular tendon release
 - Serial casting

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Eva Pontén 2010

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Supination deficit: Difficulty to see what is in the hand, Difficult to carry a tray, catch a ball

Goal: Increased supination

FCU to ECRB
If also volar flexion of the wrist

- Weak supination and weak grip
 - Release or lengthening of the PT
- Strong supination Dynamic contracture
 - BTX in PT and/or PQ
 - RISK!! BTX diffusion to FDP/FDS => weakened grip
- Strong supination Static contracture
 - PT release
- No voluntary supination Static contracture
 - PT release
 - PT re-routing
 - PQ lengthening, interosseus membrane release
 - RISK!!! Supinated position of the hand!!!

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"Orthopaedic management of CP/myelomeningocele - upper limb" Eva Pontén in "European Surgical Orthopaedics and Traumatology, the EFORT Textbook" 2014

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PRONATOR TERES

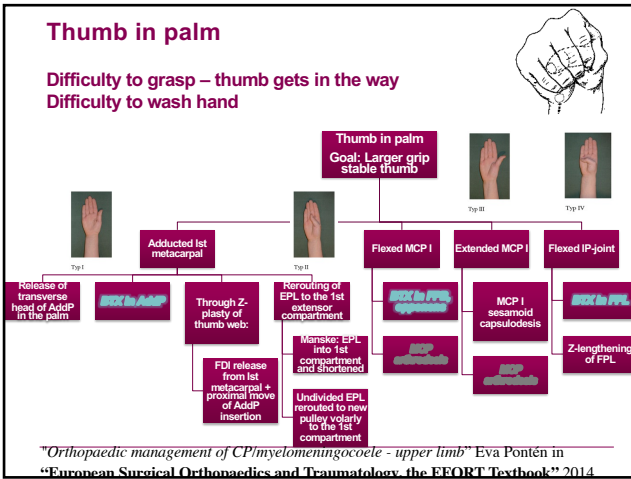
- Veeger, Kreulen, Smeulders 2004, Kreulen, Smeulders 2004, Strecker, Emanuel 1988, Gschwind, Tonkin 1992
 - Release
 - Lengthening
 - Nylander et al 1999
 - Rerouting
 - Drill-hole and sutures
 - Suture anchor (Mitec)
 - Z-lengthening, rerouting of tendon slip and suture.
 - Gschwind and Tonkin -92
- Risk: fixed supinated position of the arm

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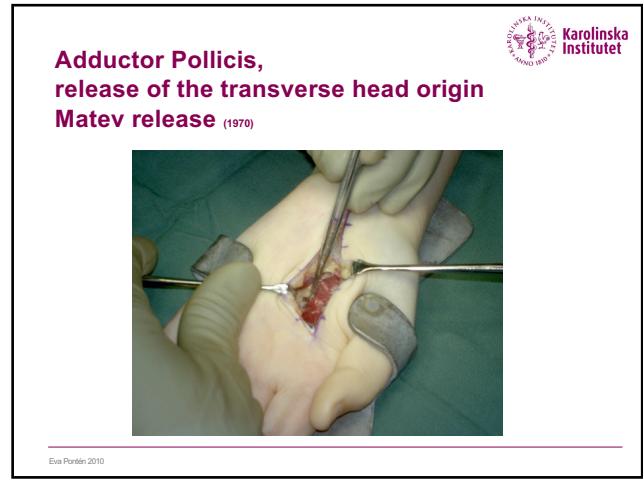
Eva Pontén 2010

From C. GSCHWIND and M. TONKIN Surgery for Cerebral Palsy Part 1, Journal of Hand Surgery (British Volume, 1992) 17B: 391-395

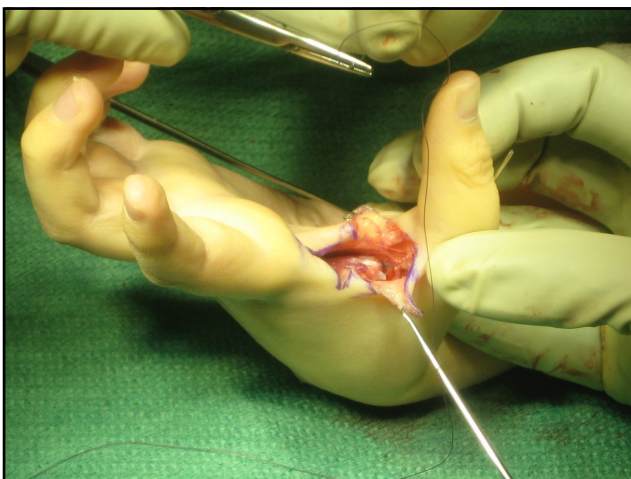
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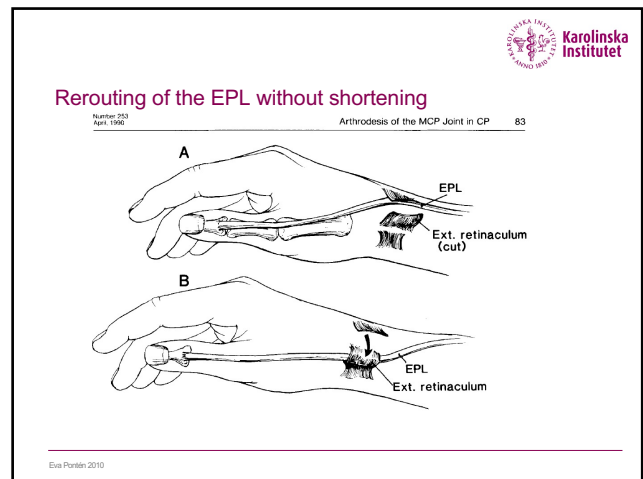
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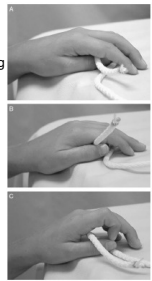
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SHUEE thumb,
 Shriners Hospital Upper Extremity Evaluation
 Surgical Management of Thumb Deformity in Children With Hemiplegic-type Cerebral Palsy
 n=33
 Jon Davids et al, J Pediatr Orthop 2009

- For the thumb:
 - Web space release
 - EPL rerouting from 3rd to 1st extensor compartment + tensioning
 - MCP joint stabilization
- Thumb dynamic positional analysis (DPA)
 - Thumb alignment when
 - taking money from wallet
 - folding paper,
 - tearing paper
 - string beads



THUMB DYNAMIC POSITIONAL ANALYSIS

Position	Pre-Op	Post-Op
OPEN	8	20
CLOSED	14	9
IN PALM	11	4

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Sesamoid bone arthrodesis for MCP I hyperextension. Tonkin et al 1995

The Journal of Hand Surgery / Vol. 20A No. 2 March 1995 335

Namni Ellermann 2022-03-02 63

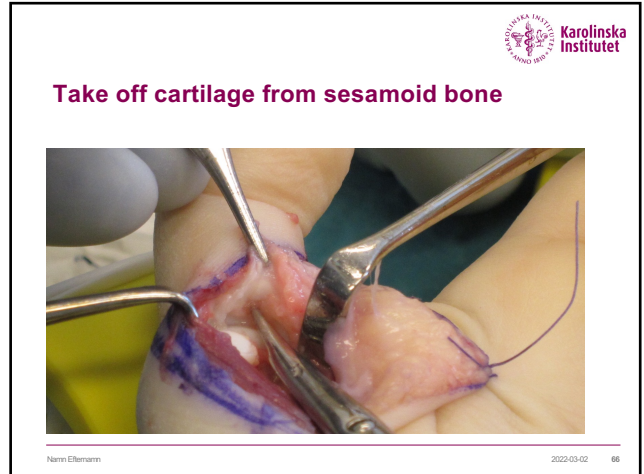
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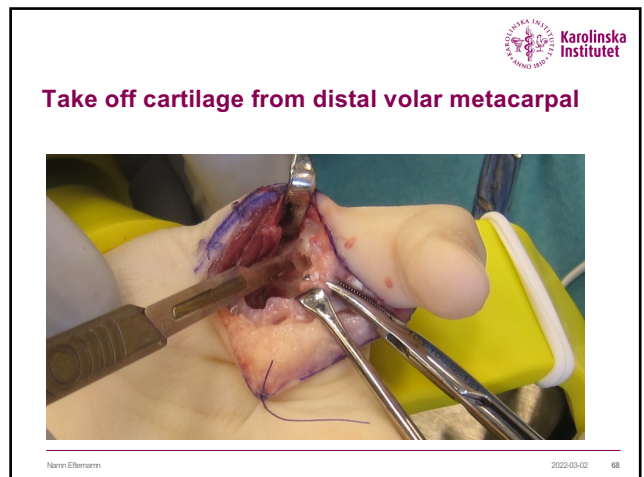
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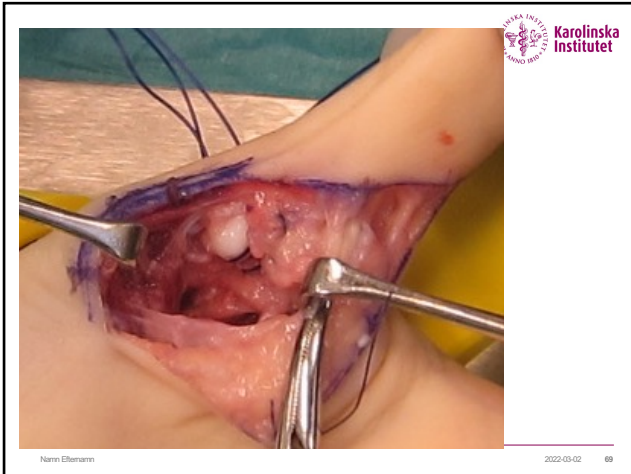
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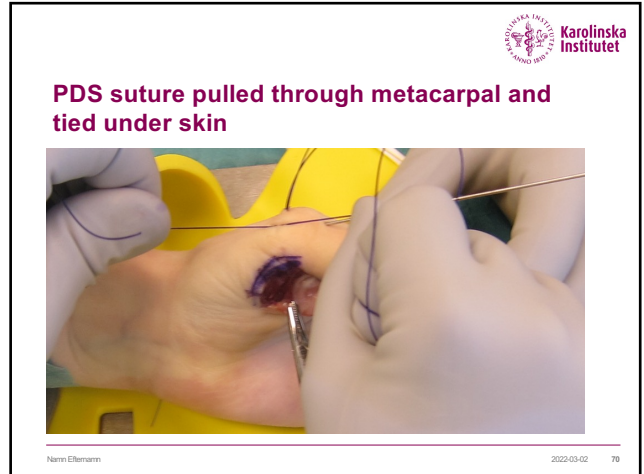
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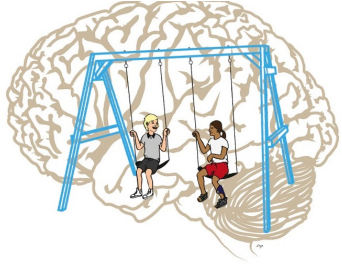
Tendon transfer surgery in CP involves complicated decision making!

- Goals
 - Different for different MACS and GMFCS categories
- Age concerns
 - Spasticity peaks at 4
 - Growth spurts are unpredictable
 - BEWARE OF EARLY
 - tendon transfers
 - fusions
 - Contracture formation is ongoing and unpredictable
- Severity concerns – type of CP
 - Dystonic
 - Beware! Movement patterns change with age!
 - Weakness
 - Relative overactivity
 - Stiffness/shortening, pathology of muscle

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Thank You!



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