Orthopedische opvolging en behandeling van spina bifida patiënten ondersteund door ganganalyse

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Goal of the orthopaedic surgeon in the spina-team

- Maximize function
- Minimize disability and illness

By correcting or preventing deformities that otherwise would keep the patient from being as comfortable and mobile as possible

Goal of the orthopaedic surgeon in the spina-team

Challenging task

- Spina bifida = multisystem dysorder

  Coordinated approach from many health disciplines in order to maximize patient's potential

- Spina bifida = Complex congenital anomaly with dynamic and changing NM components
  - CNS anomalies + congenital pathologies of spine and lower extremities
  - Neurologic function can change over time, f.e. complicated hydrocephalus, scarring of spinal cord

Examination of the newborn/new patient with MMC

- Spina bifida (aperta) lesion
- Spinal column

  Scoliosis, Kyphosis
- Orthopaedic problems lower extremity: hip, knee, foot

- Neurological function:

  Try to identify the level of the paralysis for each extremity

  Scoring systems based on motor function, reflexes, bladder and bowel function

Define the level of the paralysis

- Neurosegmental function of the lower extremity,

  by root—by root assessment.

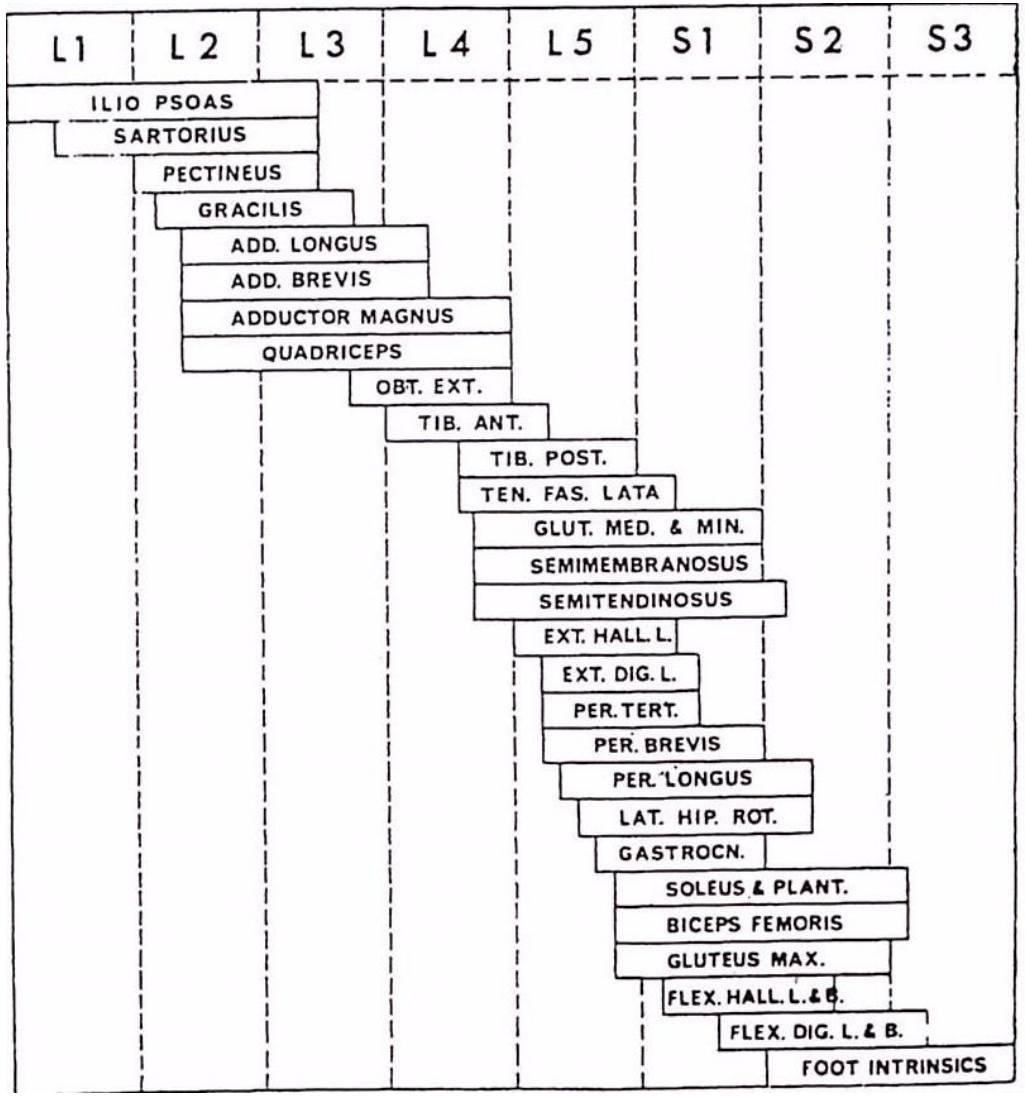
Sharrard (J Bone Joint Surg, **1964**)

Example: muscle function present if 3+ or better

L4: hipflexors, adductors, quadriceps, med. hamstrings, tib.ant., tib.post.

L5: + hipabductors

S1: + lat. hamstrings, gluteus max., triceps surae, long toe flexors



Define the level of the paralysis

- **Neurosegmental function of the lower extremity**, by root—by root assessment. Sharrard (J Bone Joint Surg **1964**)
  - To describe LE function
  - To make a prognosis for long-term ambulation and risk for secondary deformities during childhood

  - But:
    - difficult
    - change over time
    - asymmetric
    - may not correspond exactly to the neurosegmental scheme

Define the level of the paralysis

- Neurosegmental function of the lower extremity, by root—by root assessment. Sharrard (J Bone Joint Surg **1964**)
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- **Define sensory level**. Lindseth.
  - Muscles that communicate with the brain through sensory level are functional
  - Muscles that have no sensory input, become flaccid or spastic, functioning only by reflex

Define the level of the paralysis

- Flail legs — Lesion Th 12 or above
- Hip flexion — L1-L3 function
- Knee extension — L2-L4 function
- Plantar flexion — S1-S2 function

Assess spontaneous movements

Assess with periodic assessments (semi-annual or annual) that motor and sensory function remain stable and that mobility and bracing needs remain stable.

Prerequisites for walking

- Alignement of trunk and legs
  - Spine balanced over pelvis, such that center of gravity passes through joints
  - Absence of hip and knee contractures (or only mild)
  - Plantigrade, supple, braceable feet with center of gravity over them
- Range of motion
    - LS spine: shift of CoG from side to side
    - Hip: min 30° for forward progression
    - (Knee: flexion for clearance during swing)
- Control of hip, knee and ankle joints

  By muscle activity or by orthosis
- Power to provide forward motion

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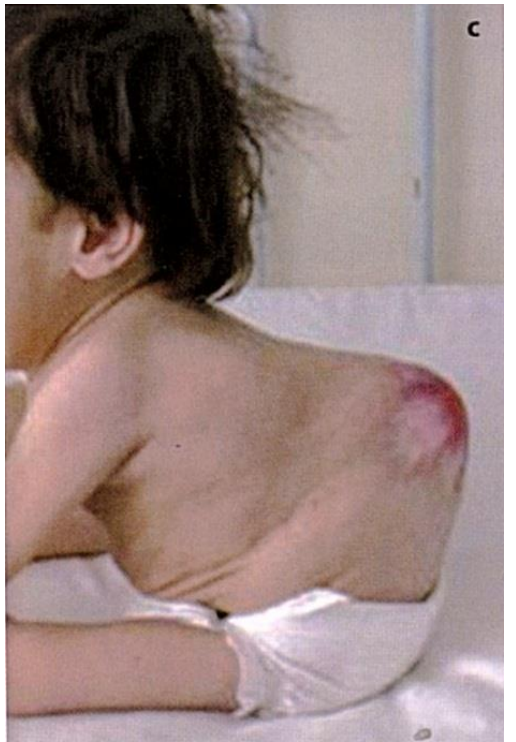

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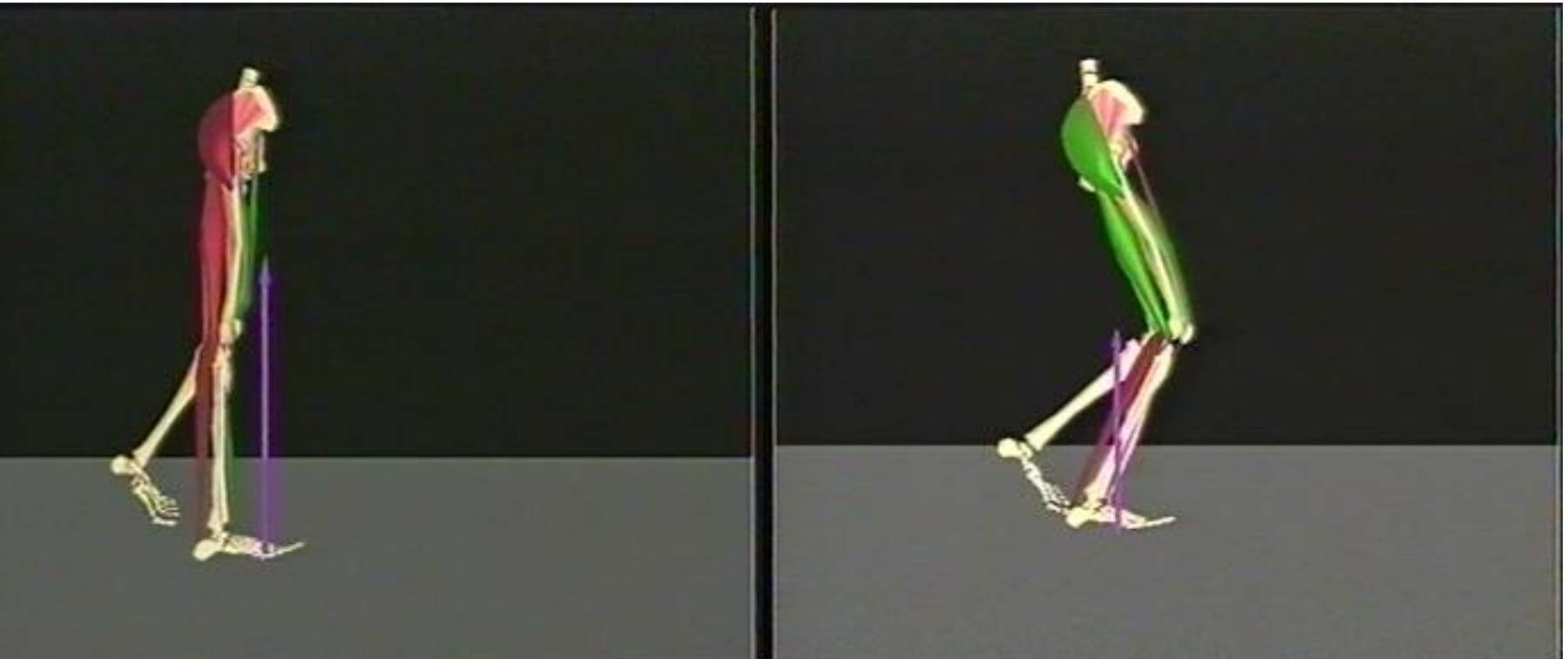

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Plantar flexors and hip extensors

! Sacral level innervation

Define the level of the paralysis to make a prognosis on functional capacity

- Flail legs — Lesion Th 12 or >
- Hip flexion — L1-L3 function
- Knee extension — L2-L4 function
- Plantar flexion — S1-S2 function

- **Lesion above L2: wheelchair**
- **L3: wheelchair or (a lot of) braces**
- **L2L4: ambulatory with braces**
- **Lesions below S1: walk without aids**

Single most important prognostic factor for maintaining ambulation in adulthood: strength of the quadriceps muscle

Barden, 1975

Define the level of the paralysis to make a prognosis on functional capacity

- Most **children** can be enabled to **walk** at young age “with a combination of deformity correction, bracing and instruction”
  - Even children with high-level lesions benifit from walking during the first 10 years of live: they tend to be more mobile, have fewer fractures and skin pressure sores. *(Mazur et al)*
  - Most children achiev their maximal level of ambulation around the age of 9 years
  - Walking is unlikely, if not standing independently by the age of 6 years.

- Many **adults** are not able to continue walking; the extent of bracing and energy consumption are to great.

Neurologic lesion at *thoracic level*

- Flail lower extremities
  - Typically frog leg deformity

  (hip flexion, abduction and external rotation contractures; sometimes with knee flexion and ankle equinus contractures);

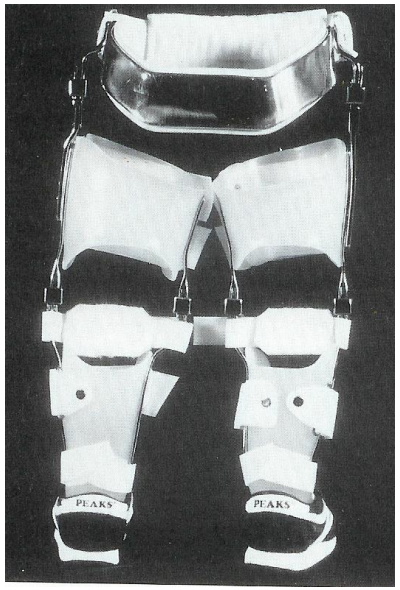
  also a lot of associated orthopaedic defects at birth (clubfeet, kyphosis, …)
  - ! Hip flexion contracture difficult/impossible to correct

- Exercise or household ambulation as children

  With extensive above hip bracing and walker or crutches

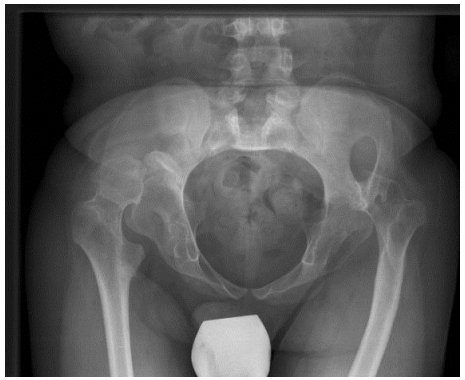
  using swing through gait using UE and abdominal muscles

Reciprocating **G**ait **O**rthosis



Neurologic lesion at *upper lumbar level*

- Hip flexor and some adductor power, no motor control over knees and feet
  - More paralytic hip dysplasia, because of imbalance at the hip
  - No quadriceps function



- Theoretically more efficiant walkers, f.e. with RGO, but usually not enough to keep ambulating as adult.

  Community ambulation only when trunk balance is excellent and UE functions are nearly normal

Neurologic lesion at *lower lumbal level*

- Greater hip adductor strength and quadriceps power

  Hip strength is usually adequate to allow these patients to walk with hips unbraced; knee ankle foot orthosis KAFO.

  L5 functioning: tibialis anterior and medial hamstrings

  Why not only AFO?
  - Strength around knee is not completely normal.
  - Weakness of foot and hipabductors and extensors leads to lurching gait, which imposes a lot of stress on the knee

  Also high risk for progressive hipsubluxation/dysplasia

Neurologic lesion at *sacral level*

- Normal knee function and more stable hip, foot and ankle function

- Foot problems: cavovarus, clawtoes, neurogenic ulcers
- Knee problems because of torsional or angular stress when ambulating

- AFO's: weak gastrocnemius and foot intrinsics result in abnormal foot and ankle function
- Use of crutches: weakness foot and ankle; stresses at the knee

Age 7y

Age 11y

- Children with L3 or L4 lesion have the most gain from orthopaedic treatment of musculoskeletal deformities

- Role of documenting gait by 3D gait analysis
    - Kinematics
    - Kinetics
    - Dynamic EMG

    - Detailed analysis of locomotion
    - Evaluating treatment:
        - Orthoses, walking aids
        - Physiotherapy
        - Surgery
    - Follow-up (comparison)

Gait analysis in spina bifida patients

- **Three-dimensional gait analysis in spina bifida**. Duffy CM, Hill AE, Cosgrove AP, Corry IS, Mollan RA, Graham HK; **1996**, JPO

  28 children; L5, L4 or S1 level lesions

  - **Increased pelvic rotation**
  - **Increased pelvic obliquity** necessitate a degree of hypermobility of lumbar spine
    leading to progressive degenerative changes
    spinal fusion (for scoliosis) may stop walking
  - **Failure of plantar flexion-knee extension couple** need for orthoses

  - **Coronal plane kinematics of hip and knee** need for walking aids (cruches)

- **Gait analysis in myelomeningocele: possibilities and applications**. Fabry G, Molenaers G, Desloovere K, Eyssen M; **2000**, JPO

Effect of ankle foot ortheses

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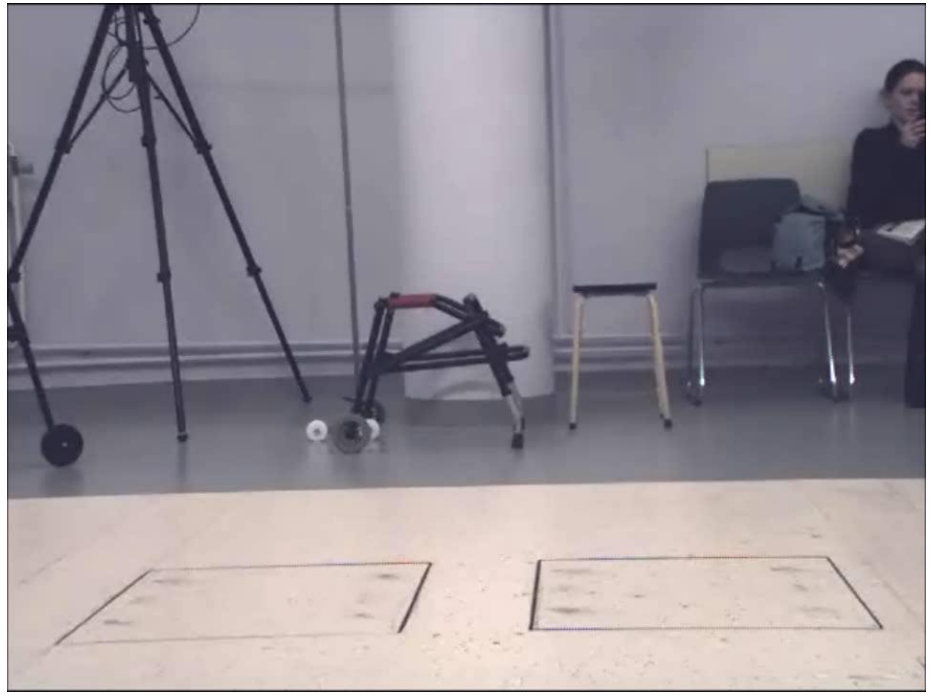
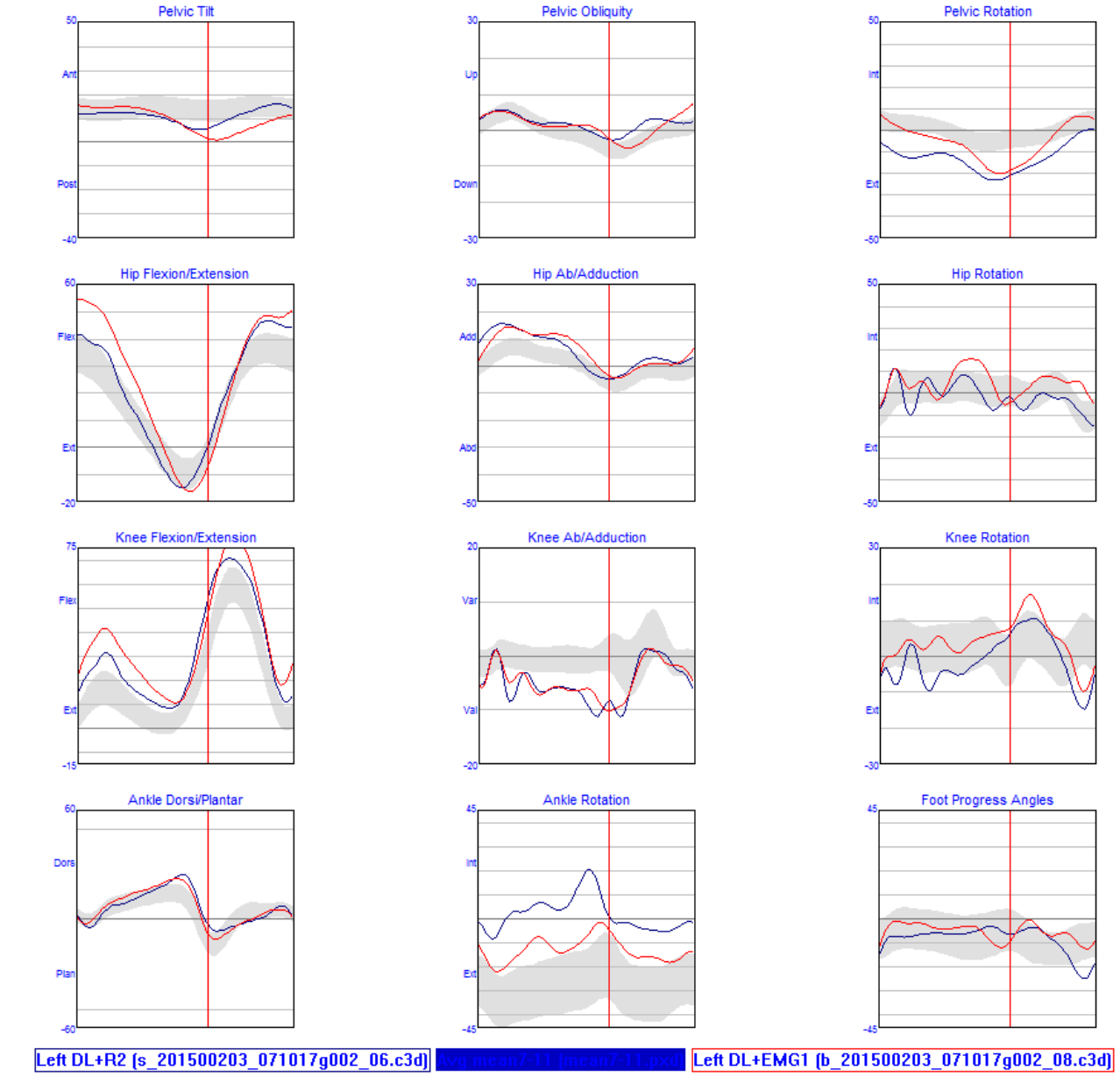


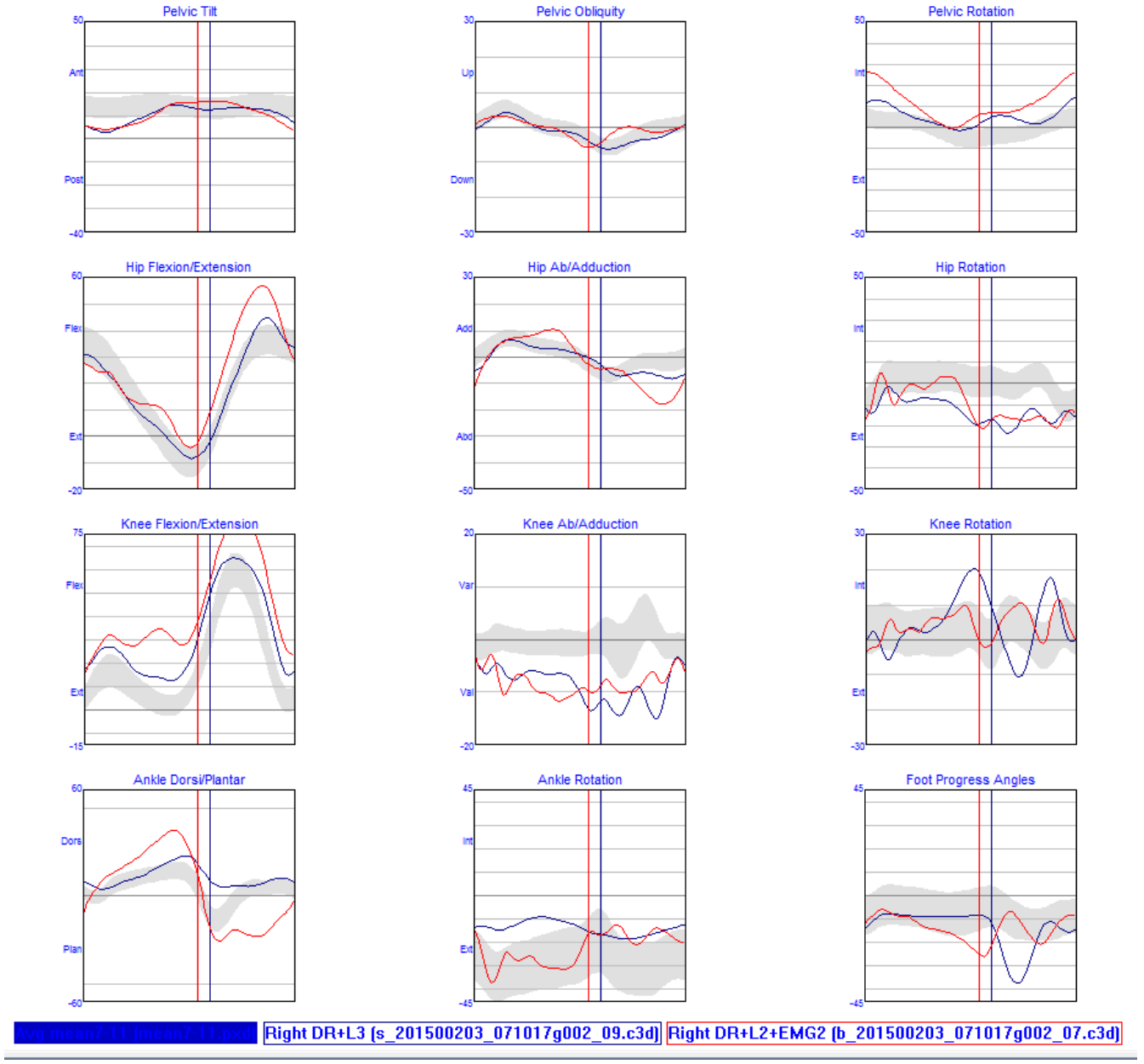
Left kinematics



Red = barefoot

Blue = shoes

Right kinematics



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Effect of ankle foot ortheses

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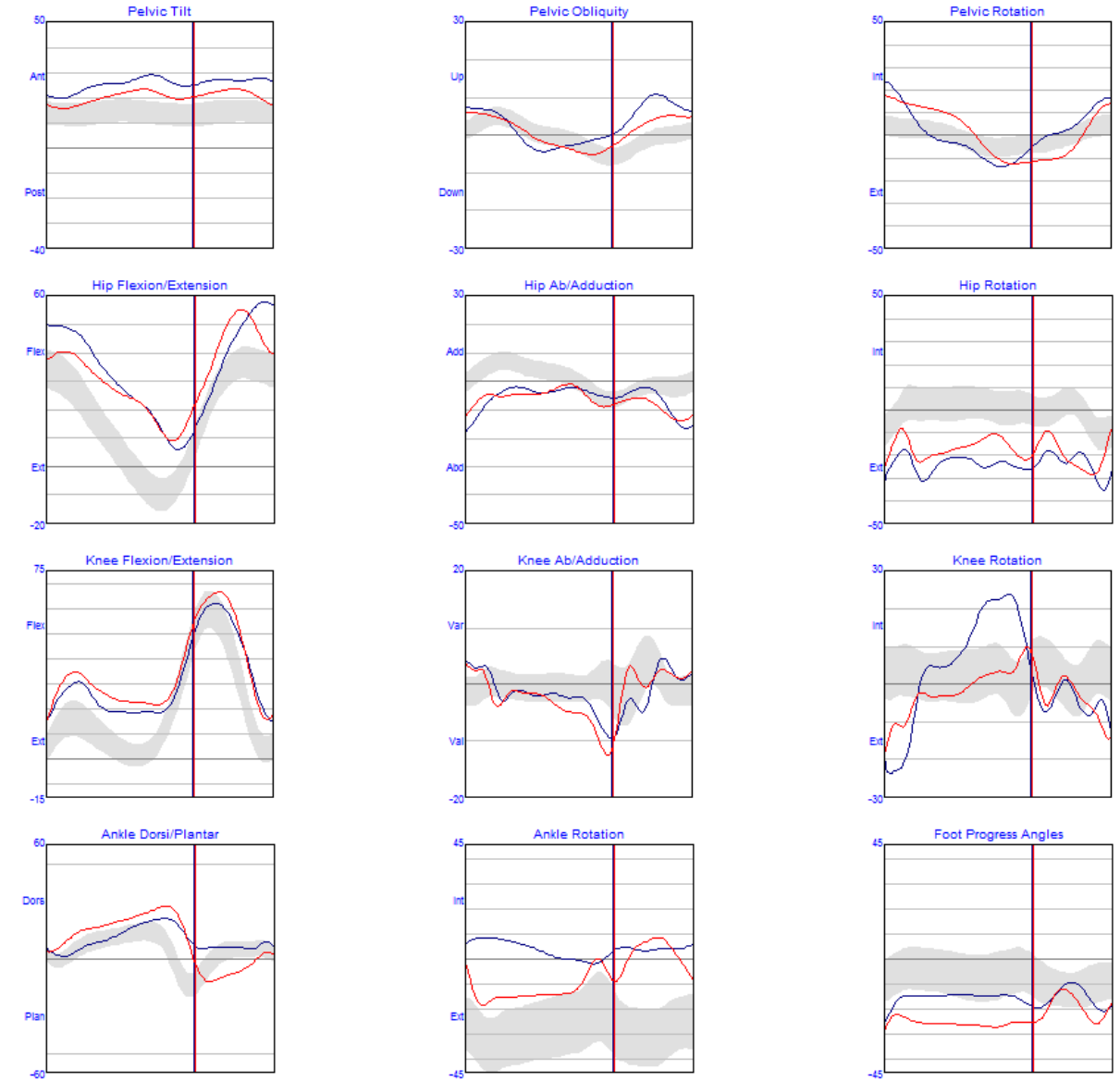

Red = barefoot

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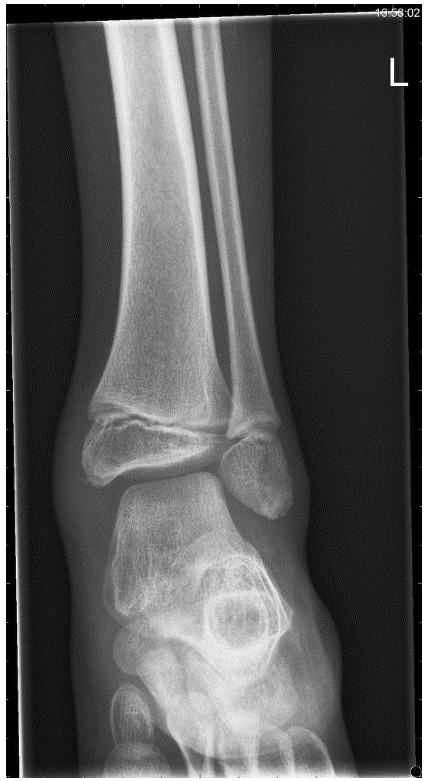
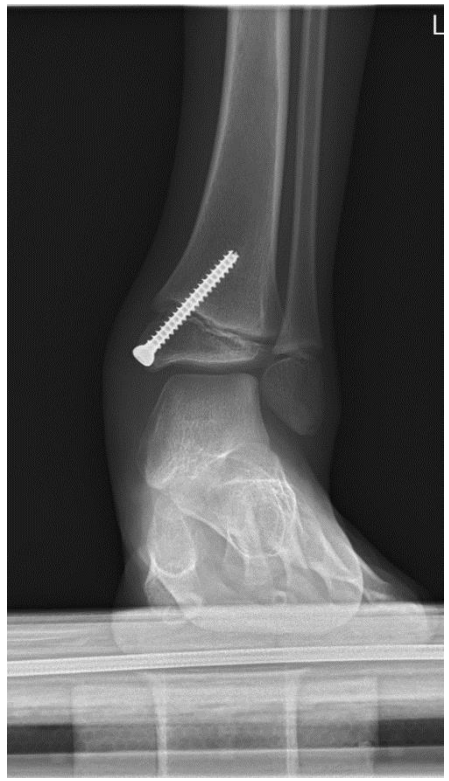
Effect of ankle foot ortheses

Age 4,5y

Treatment of valgus ankle





Age 8y

Treatment of ankle and foot abnormalities

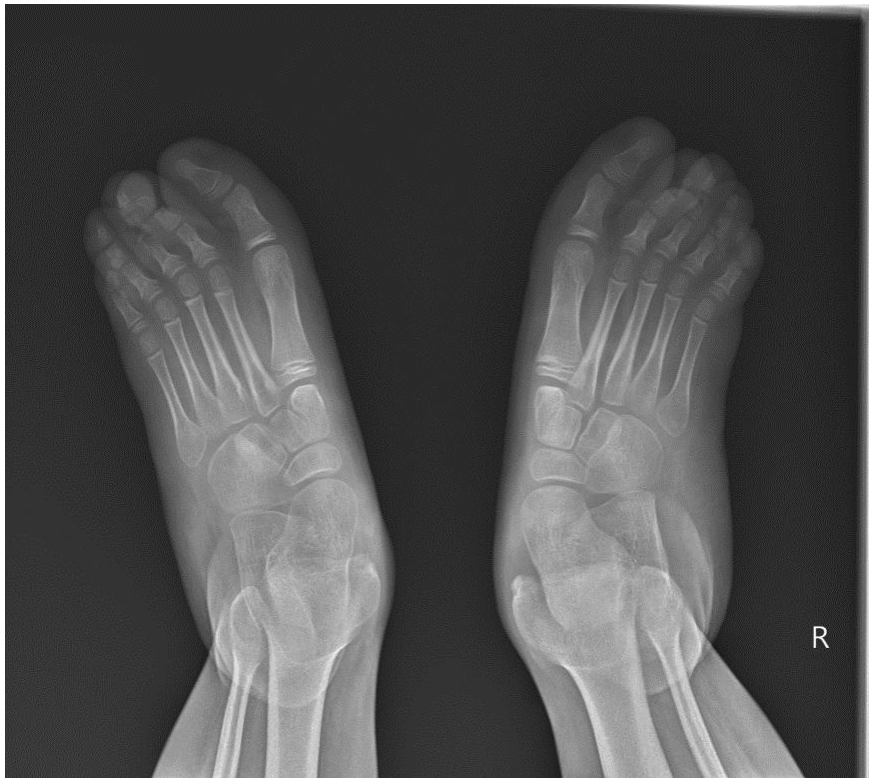
- Valgus ankle
- Pes planovalgus
- Tibia malrotation
- Talipes calcaneus

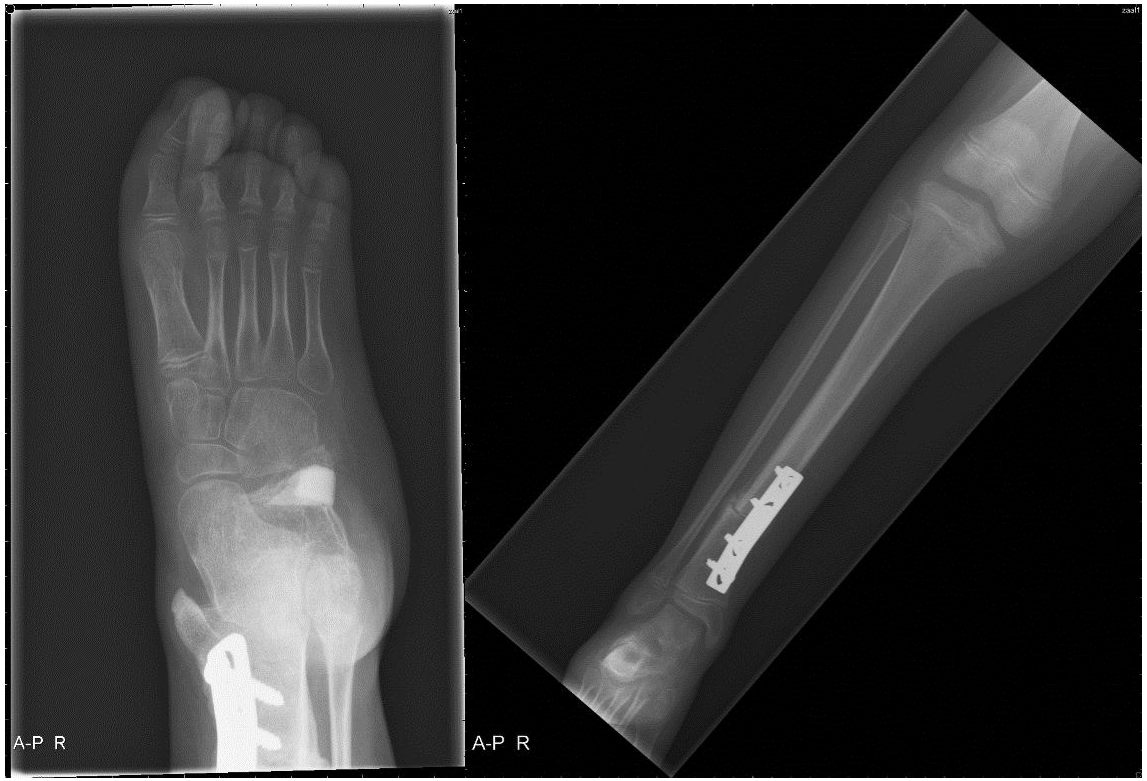
With its repercusions on gait

Treatment of pes planovalgus and tibia malrotation

Age 9y

Treatment of pes planovalgus and tibia malrotation

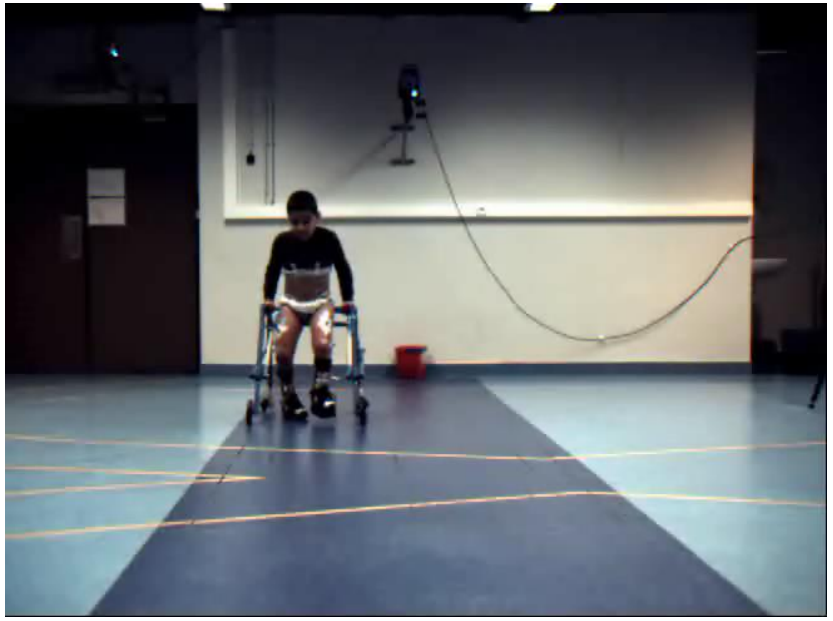




Treatment of pes planovalgus and tibia malrotation

Age 13y

Tibia malrotation



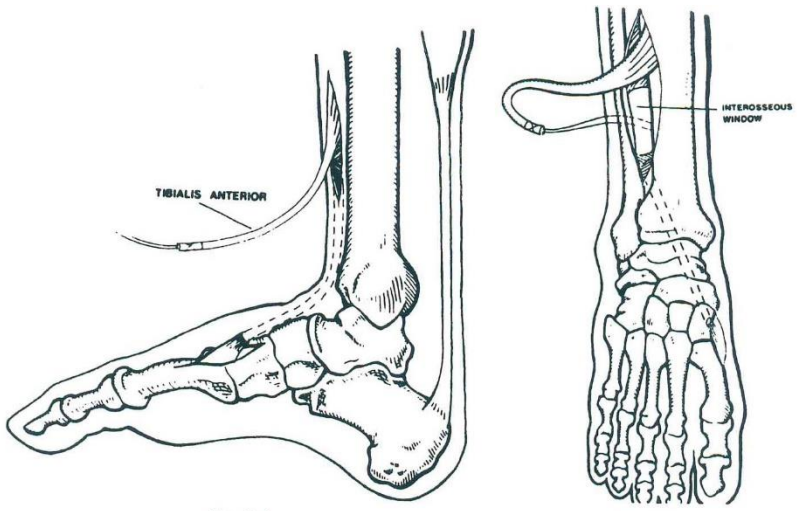
Treatment-prevention of talipes calcaneus

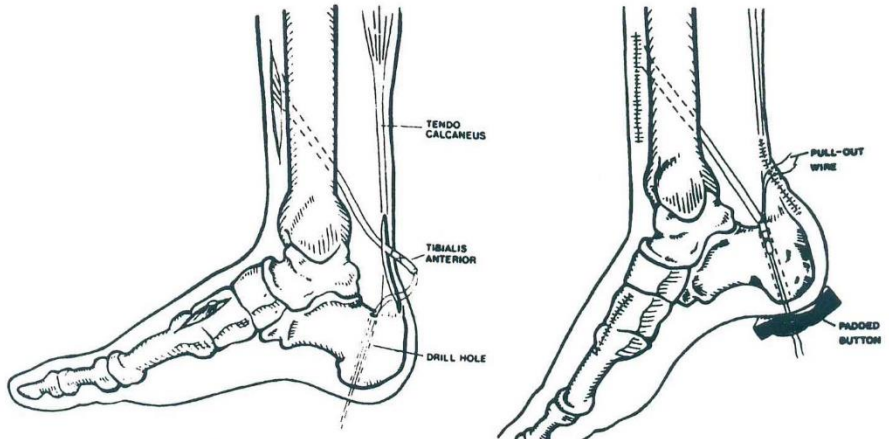
- Weak plantar flexors – active dorsiflexors: ankle in dorsiflexion

  Leads to: gait problems, difficulty in shoe wear, pressure ulceration of heel

- R/ Physiotherapy & Orthosis

  Surgery: transfer of dorsiflexor (tibialis anterior) to plantar flexors (Achillestendon)





Treatment-prevention of talipes calcaneus

- Transposition of tibialis anterior in the treatment of paralytic talipes calcaneus. Herndon CH, Strong JM, Heyman CH. J Bone Joint Surg, **1956**
  in poliomyelitis
- Posterior transfer of the anterior tibial tendon in children who have myelomeningocoele. Georgiadis GM, Aronson DD. J Bone Joint Surg, **1990**
  - 39 feet, 20 pts; retrospective study
  - Average age 4,6 y (2,2-17y), follow up 6 y (4,5-24y)
  - Best: after the age of 4 y; L5 or S1 motor level

  - Indication: calcaneus deformity of foot, with active function of ant tibial muscle (grade 4) and absent or weak plantar flexors of foot and ankle.
  - Results: no calcaneus deformity; functioning tib ant in 2/3 (esp. when surgery after 4 y)

Treatment-prevention of talipes calcaneus

Preop age 3y

Treatment-prevention of talipes calcaneus

Postop age 4y

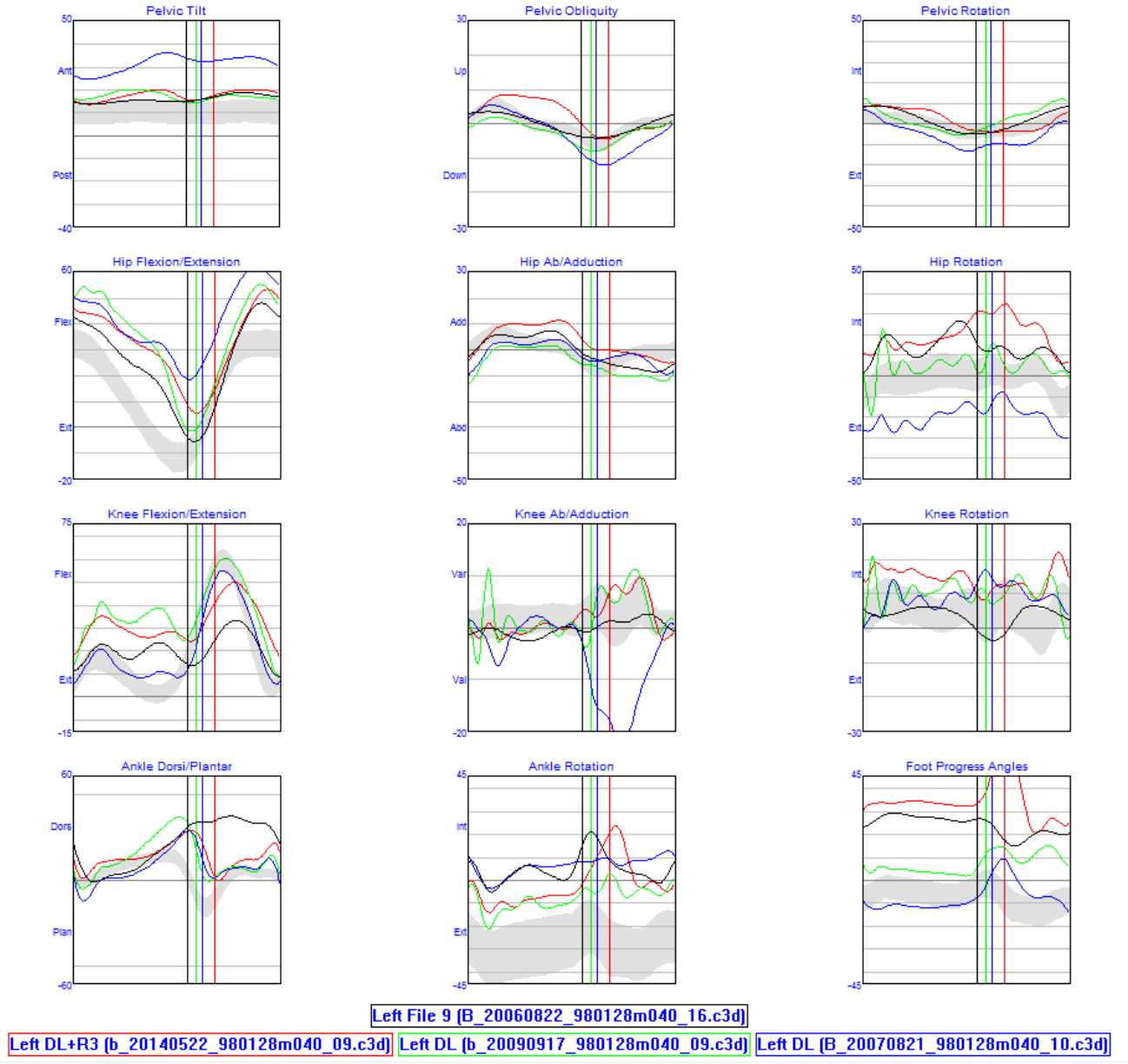
Treatment-prevention of talipes calcaneus

Preop age 6,5 y

Treatment-prevention of talipes calcaneus

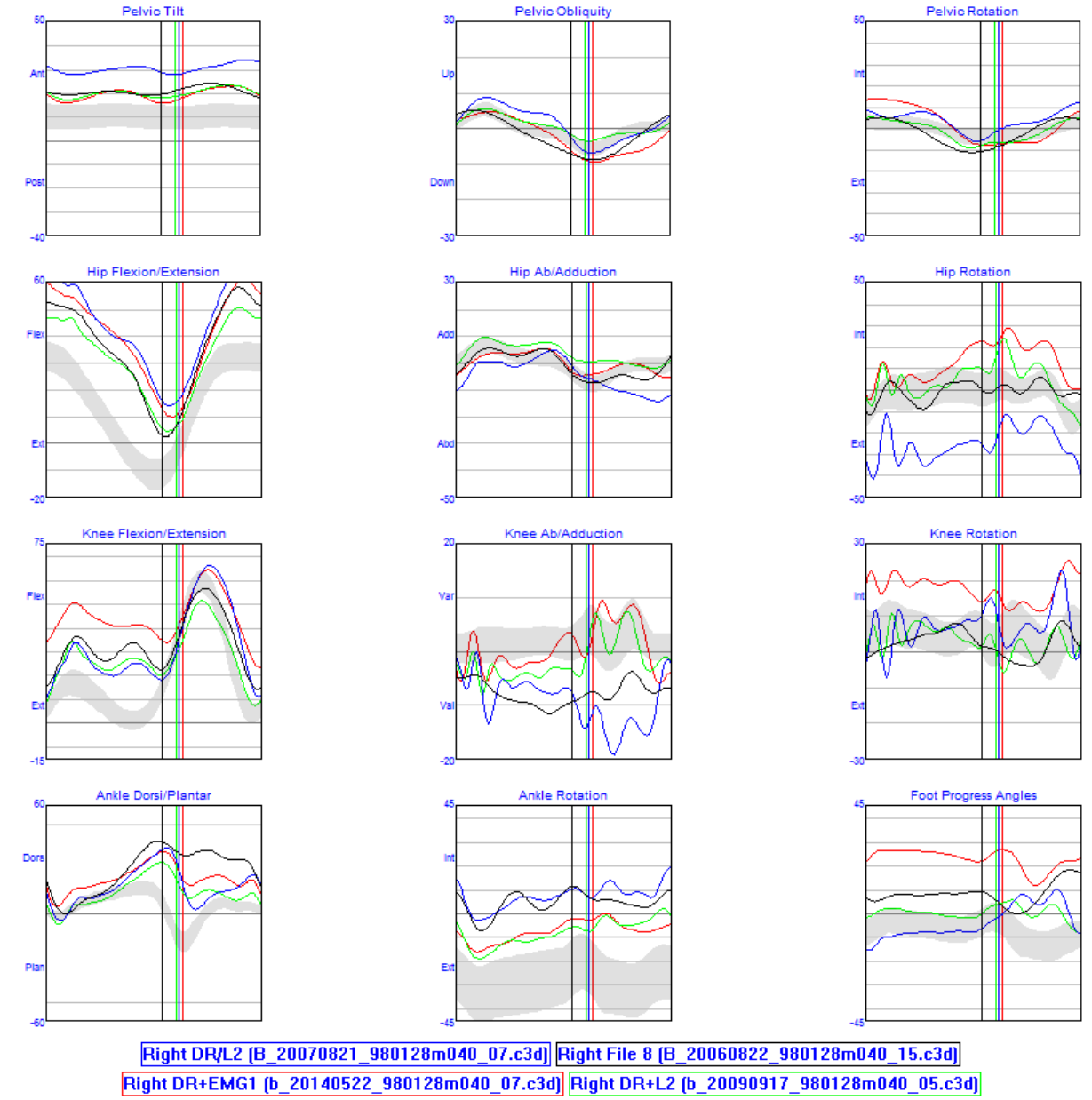
Postop age 8y

Comparison left kinematics



Black = 22/08/2006 surgery
Blue = 21/08/2007
Green = 17/09/2009
Red = 22/05/2014: age 15y

Comparison right kinematics



Black = 22/08/2006 surgery
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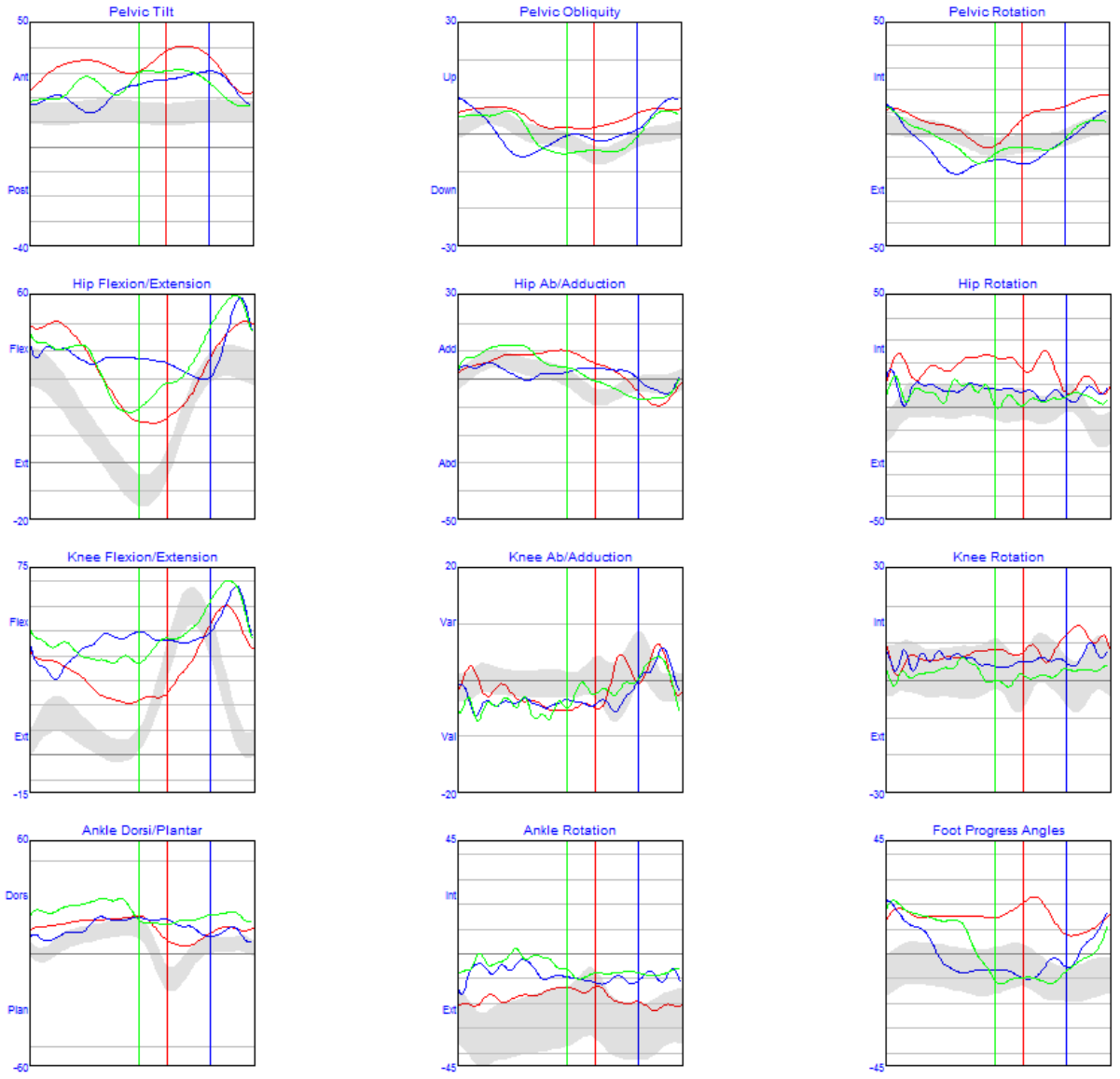
pre

Knee flexion contracture BTX-A treatment

post

Left kinematics

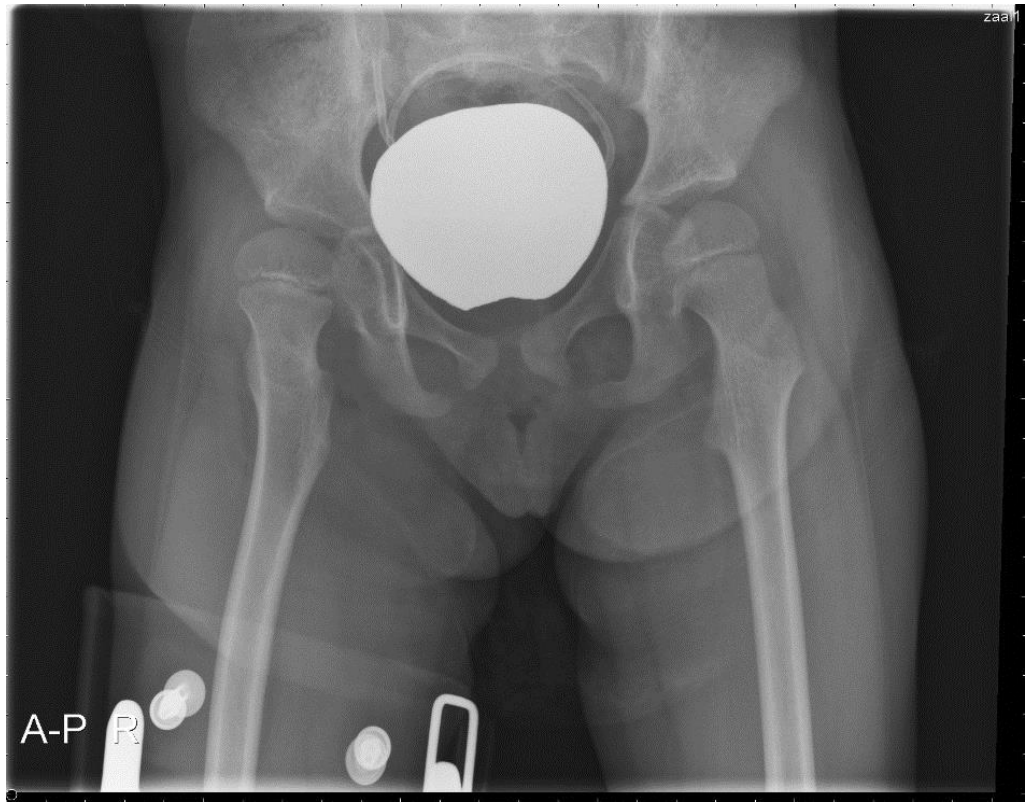


Left DV-KW (b_20121203_060505g036_12.c3d)

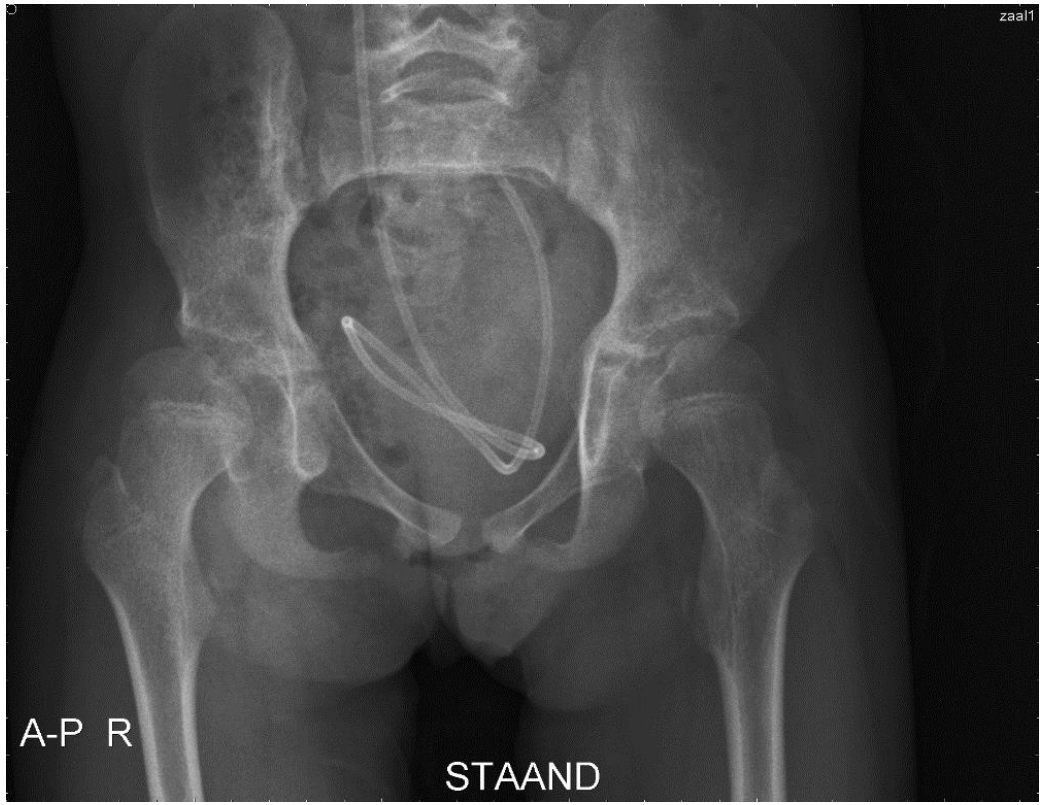
Left DD+EMG1 (b_20140512_060505g036_06.c3d) Left EMG2 + DD (b_20101116_060505g036_09.c3d)

Blue = 16/11/2010
Green = 03/12/2012
BTX-A injection
Red = 12/05/2014

Treatment of hipdysplasia/subluxation



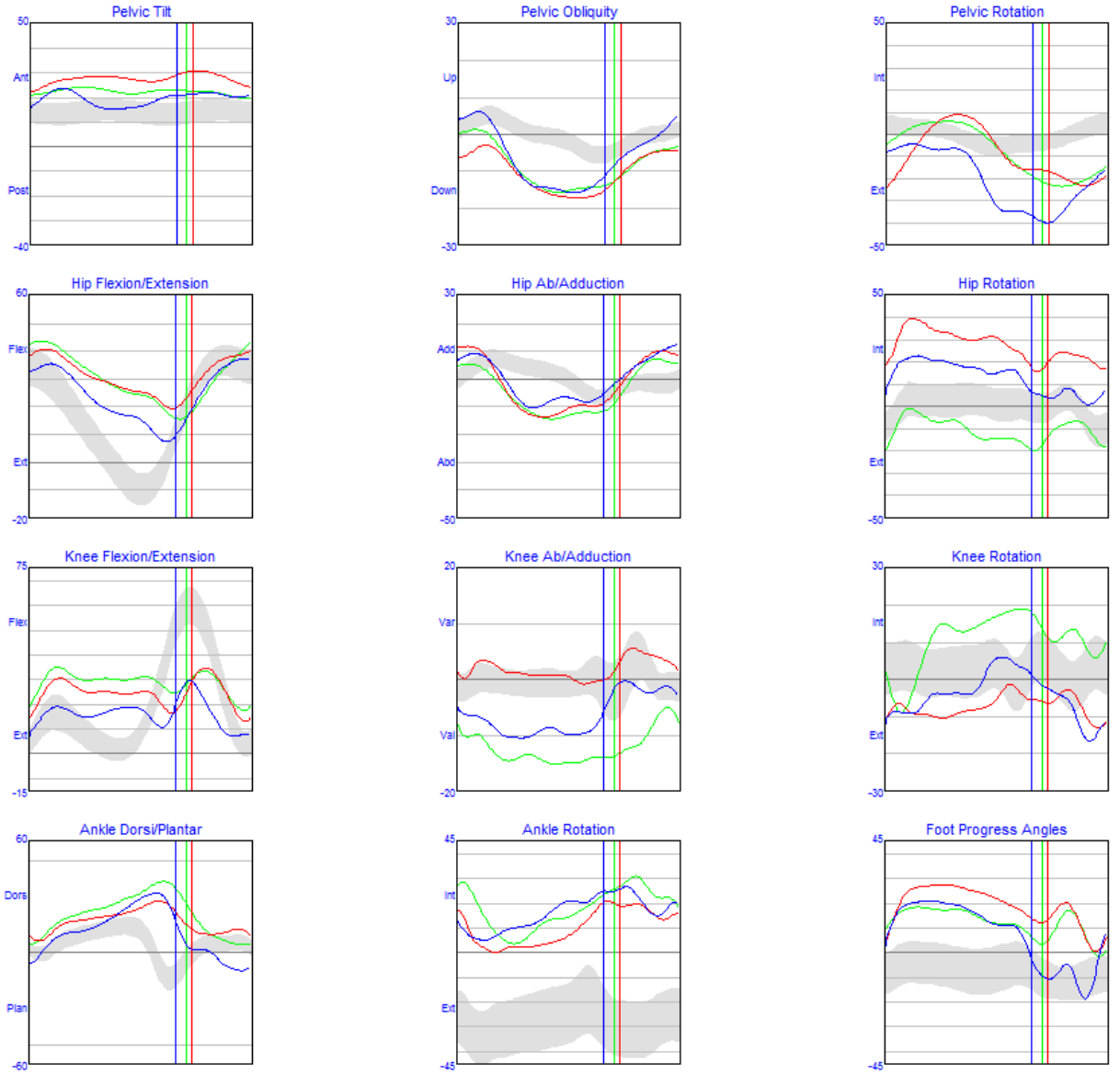
Age 5y



Age 10y

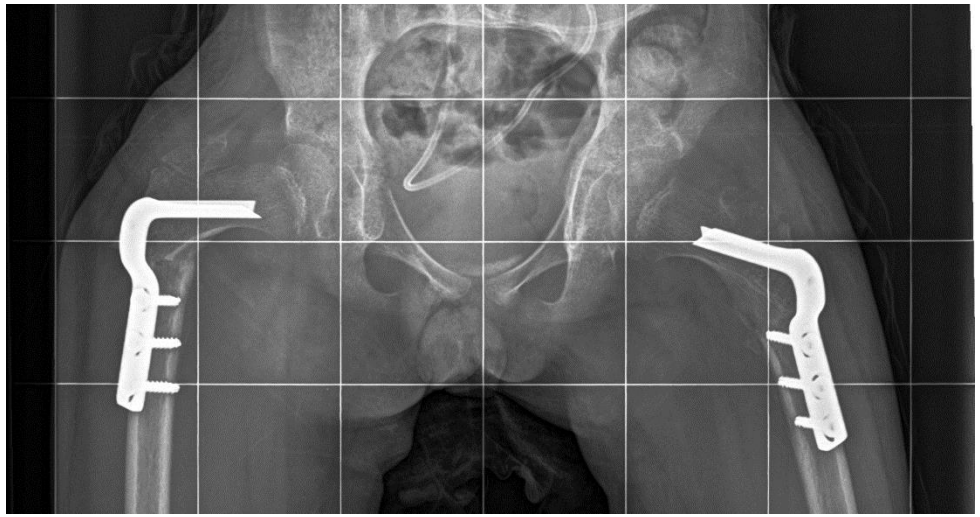
Treatment of hipdysplasia/subluxation

Comparison left kinematics

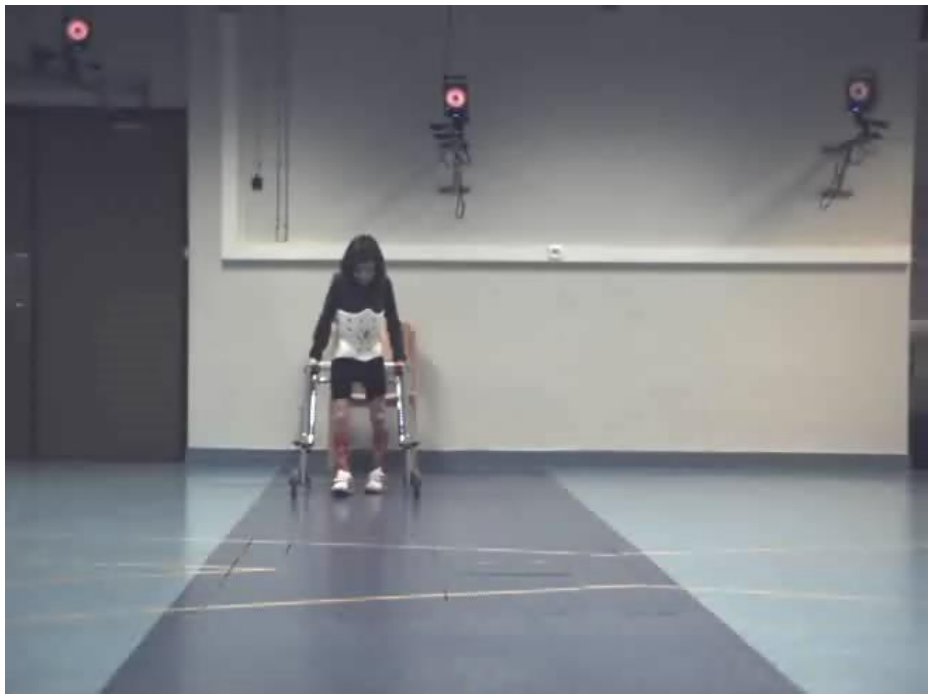


Blue = 28/09/2010
Green = 05/06/2012
Red = 19/08/2014

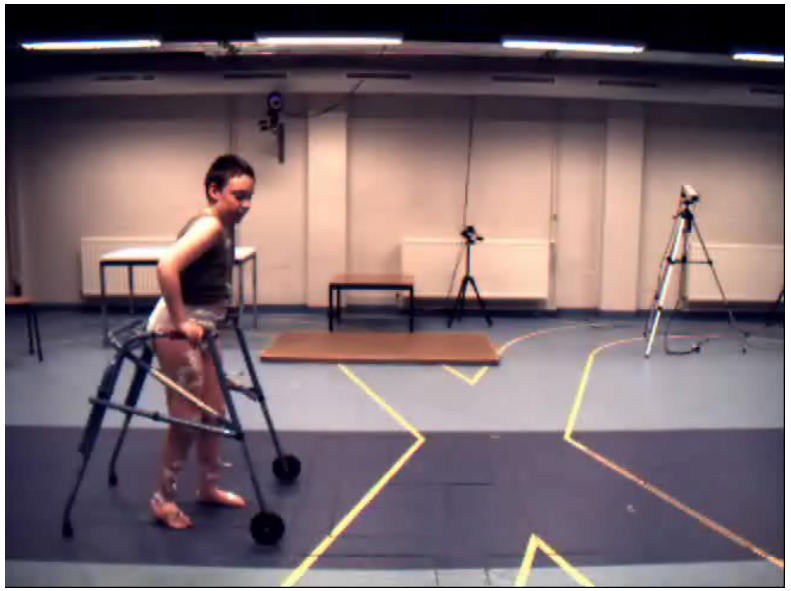
Treatment of hipdysplasia/subluxation



3 m after surgery



Age 12y

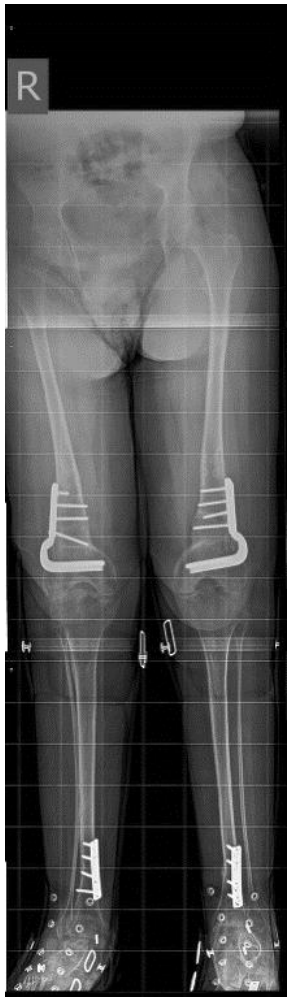


Age 14y

Fixed knee flexion contracture ‘crough gait’

Age 16 y

SEMLS Single Event Multilevel Surgery



- Distal femur osteotomy
  - extension
  - derotation
- Patellar tendon advancement
- Rectus femoris transfer
- Tibia derotation

1y postop SEMLS

Role of gaitanalysis in patients with MMC

- Dynamic evaluation of level of neurologic lesion
  - Baseline
  - Follow-up/comparison
- Evaluation of treatment
  - Fine-tuning orthosis, need for walking aids (crutches)
  - Effect of PT
  - Effect of spasticity treatment
  - Effect of surgery

  - On individual basis; patient evaluation
  - On groups of patients: need for prospective trials (RCT)…