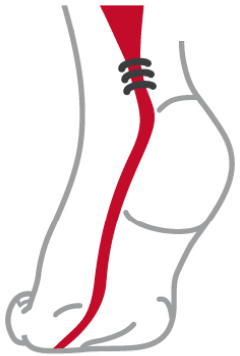
Functional Hallux Limitus



LES AMIS DU FHL

FLEXOR HALLUCIS LONGUS

Jacques Vallotton MD, FMH

Medicol-Hirslanden

Clinique Bois-Cerf

Lausanne-Suisse

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"Columbus Egg" of Orthopedics

Functional Hallux Limitus (FHL) is a loss of MTP joint extension during terminal stance when the weight-bearing foot is in maximal dorsi-flexion and it constitutes a sagittal plain blockade.

Substantial evidence highlight the tenodesis effect of the **Flexor hallucis longus(Fhl)** tendon during his passage in the retrotalar pulley as one of several origins of functional hallux limitus.



Monument to the discovery of America by Columbus in the shape of an egg in Sant Antoni de Portmany, Ibiza, Spain

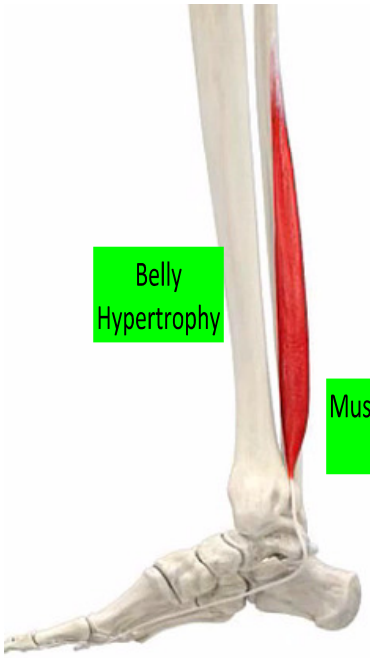
Topographic anatomy

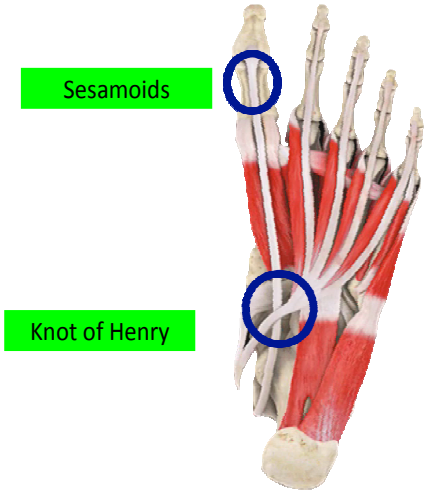


Origin
Inferior 2/3 of posterior fibular surface

Course
Superior → Inferior
Lateral → Medial
Posterior → Anterior

Conflict areas





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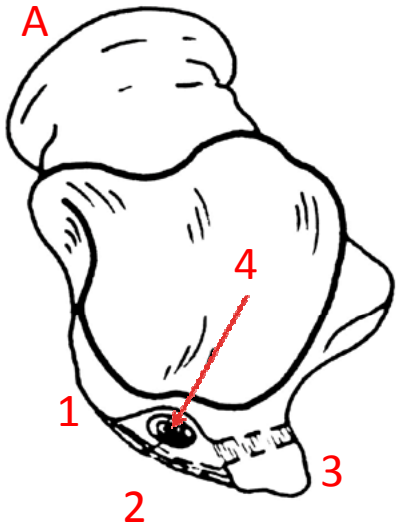
During the evolution

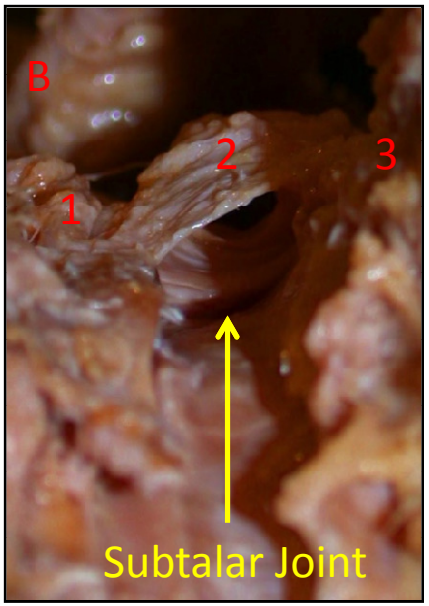
- ✓ The hallux and its flexor hallucis longus tendon have evolved from a prehensile function to a propulsive one.
- ✓ The muscle became more powerful
- ✓ Talus has been anteriorised
- ✓ The ankle plantarflexion decreased and the dorsiflexion increased.

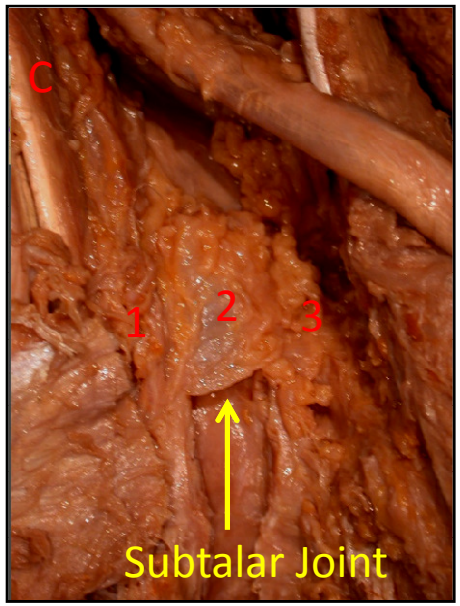


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Critical Situation
The retrotalar tunnel







Talus axial view

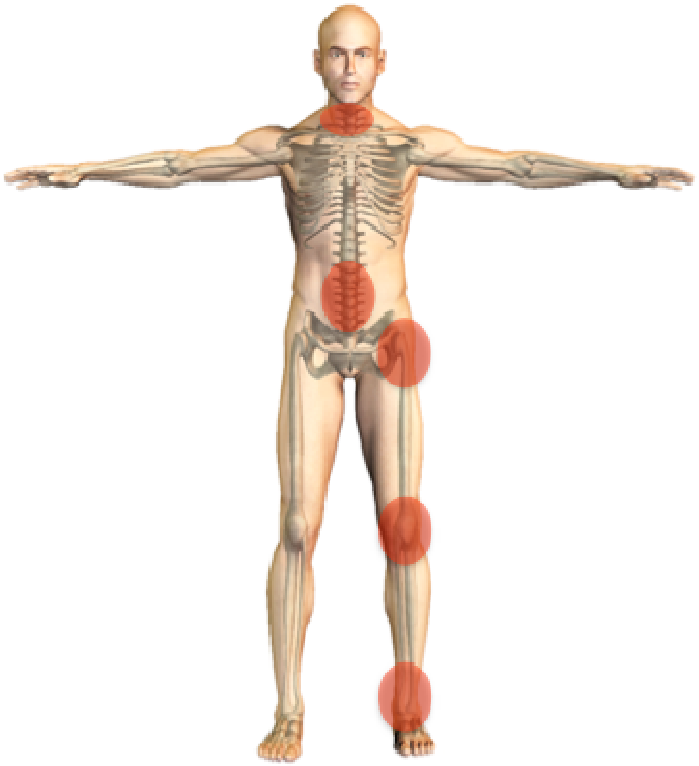
1.Postero-medial talar process
2. Retrotalar pulley
3. Postero-lateral talar process
4. Fhl tendon

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Flexor Hallucis Longus

This tenodesis effect

- Derails the normal gait pattern
- Desynchronizes the normal passage from pronation to supination and vice versa



This functional derangement acts like a cascade

- Modifies body balance
- Disrupts joint mechanics from toe to head

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Normal gait : synchronism in rotation

Stance phase:

The lower limb is globally oriented in internal rotation (femoral and tibial internal rotation and foot pronation)

Push off phase:

Transition to supination and external rotation

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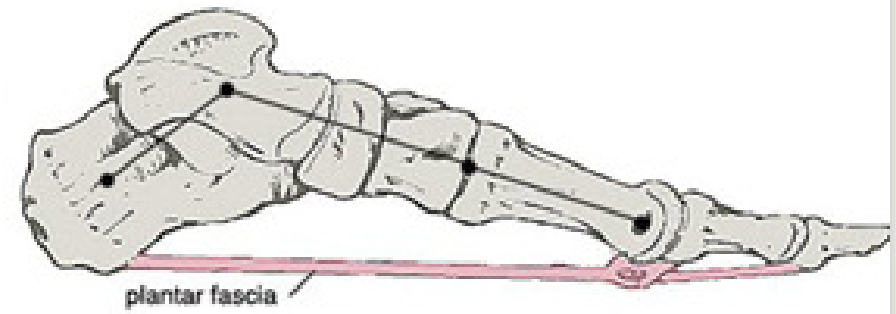
Autosupport mechanisms

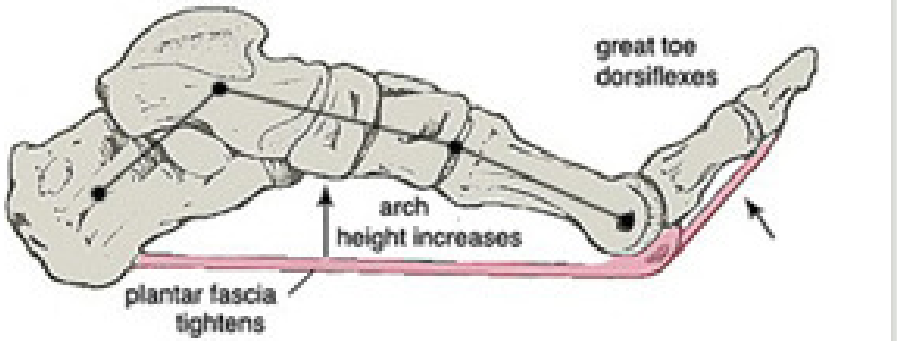
- Hicks Windlass (1954)
- Bosjen- Moller Calcanocuboidal Joint stability (1979)
- Locked wedge effect i.e. compressive loading of osseous structures.

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1st MTP Joint
ROM and Self Stabilization

- In 1954 in the Journal of Anatomy, JH Hicks published a series of papers collectively called the Mechanics of the Foot, I-IV
- Within these, the Windlass Concept was introduced
- Hallux dorsiflexion causes an unstoppable arch raising with simultaneous lower leg external rotation

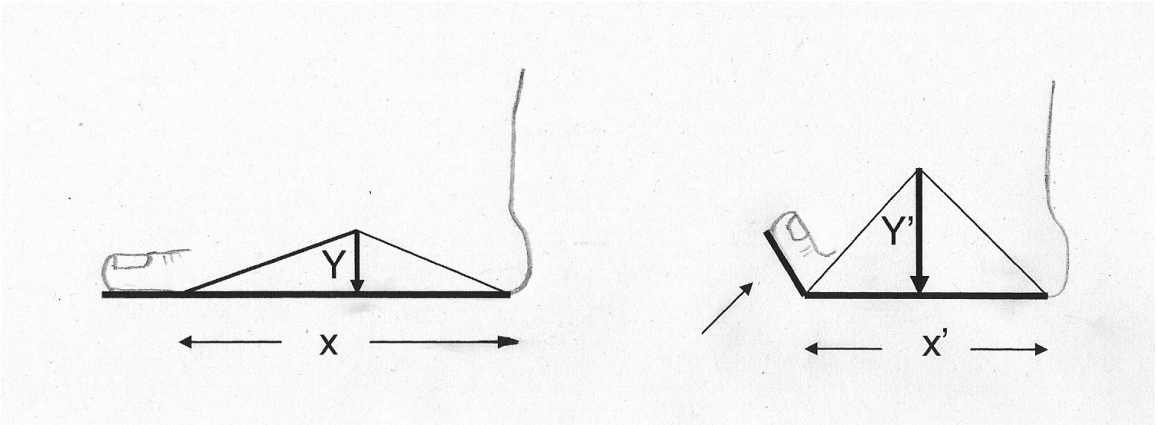




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Normal hallux dorsiflexion: key for the Windlass mechanism to work

Windlass mechanism (Hicks 1954): Toe acts as a winch pulling Fascia Plantaris and Flexor Hallucis Longus



- Shortens distance between 1st MTT and calcaneus
- Foot supination
- External rotation of lower extremity on the subtalar joint.

Functional Hallux limitus = Windlass BLOCKED

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Functional hallux rigidus

- Induces a time-lag with a prolonged pronation at the push-off phase when the knee is extending as the limb approaches push off, the knee is unable to acquire tibial external rotation



- Medial collapse of the knee in stance

Dannanberg HJ, 1993

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Pathologies related to Fhl

- *Hallux valgus et rigidus*
- *Tendinopathies (peroneals, TFL, …)*
- *Periostitis and stress fractures*
- *Ankle and knee(ACL) injuries*
- *Anterior knee pain syndrome (AKPS)*
- *Sacro iliac and lumbar dysfunction*
- *Piriformis syndrome*
- *etc …*

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“Hallux Valgus and the First Metatarsal Arch Segment: A Theoretical Biomechanical Perspective”

- 1st MT rotates around axis that is almost in horizontal plane
- 2 sesamoid bones are located in intrinsic muscles underneath MT head
- Hallux carries 40% of body weight at end of stance phase



Ward M. et al Physical Therapy Journal, 2010

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Associated Findings

- Pronated foot
- Decreased ankle dorsiflexion
- Hallux limitus or rigidus

Most common risk factor is **overpronation** which causes the 1st ray to be unstable and therefore hypermobile during gait

Patients often walk with the **feet laterally rotated and overpronated** to compensate for lack of dorsiflexion and/or great toe extension during gait

Collapse of medial longitudinal arch shifts the joint axis of the 1st MT from horizontal to vertical

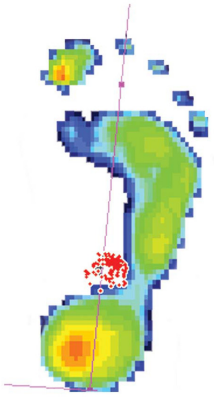
What is the predisposing factor for all these findings???

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Sagittal plane blockade and FHL
Effects on balance and gait

Negative effect on balance

- Reduced mobility of subtalar joint
- Centre of average instantaneous pressures abnormally displaced towards the rear of the foot



Cascade of compensatory mechanisms during gait required to overcome sagittal plane blockade:

- Increased dorsal flexion of ankle, flexion of knee, hip, lumbar spine, cervical spine

The sagittal plane blockade **increases the foot pronation** in late stance

- Medial collapse of foot, knee, hip

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How The Pathology Progresses To Deformity

- FHL progresses to either hallux rigidus or hallux valgus

- Common characteristic

decreased ability to dorsiflex the big toe joint when the heel comes off the ground in gait, forcing the joint to move when there is limited motion

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Why some people have HV and others HR?

large range of motion of the first ray
+highly tilted big toe joint axis
+ subluxation

→ HV deformity

smaller range of motion of the first ray
+ slight tilt of joint axis

→ HR deformity

Kelso SF, et al. Direction and range of motion of the first ray.

J Am Pod Med Assoc 72:600-605, 1982

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Clinical Examination

High degree of suspicion

Clinical Diagnosis

- Typical callus formation
- De-charging head of the 1st metatarsal
- IP Hyperextension (occasionally)





A new clinical test

Specialized three phase test allows to differentiate the existence of Hallux Rigidus from the eg the pseudo tenodesis effect of the Fhl tendon at the posterior aspect of the subtalar joint.

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Clinical Examination
FHL Stretch Test



1.Ankle in plantar flexion. Verify full ROM of the 1st MP joint.



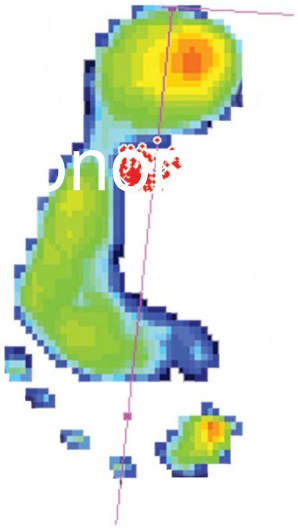
2. Ankle in dorsiflexion by pressure applied at the metatarsal heads



3.Forced passive dorsiflexion of the MP1 joint.
Inability to dorsiflex
= Positive test

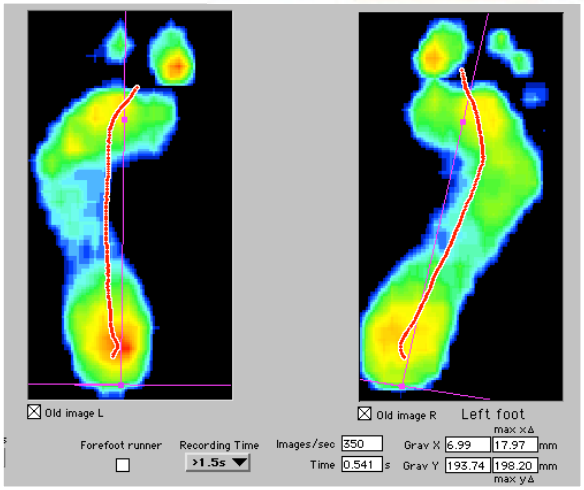
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Gait analysis





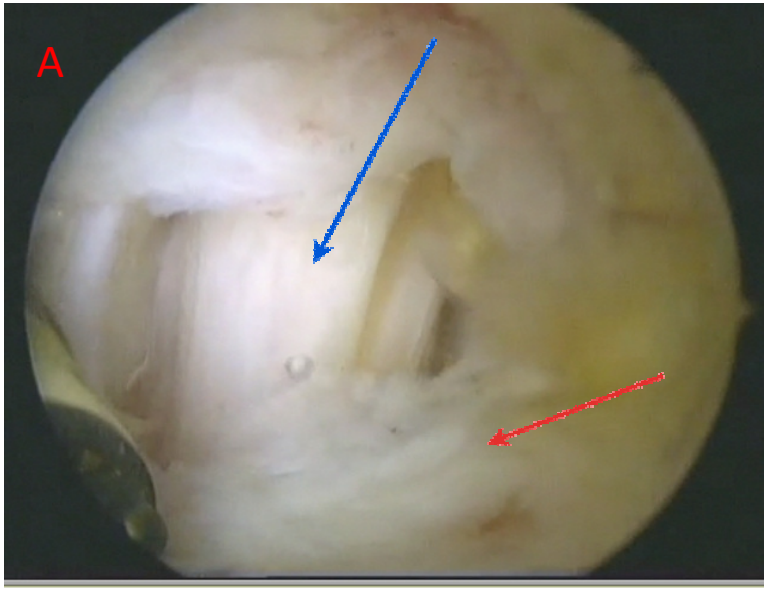


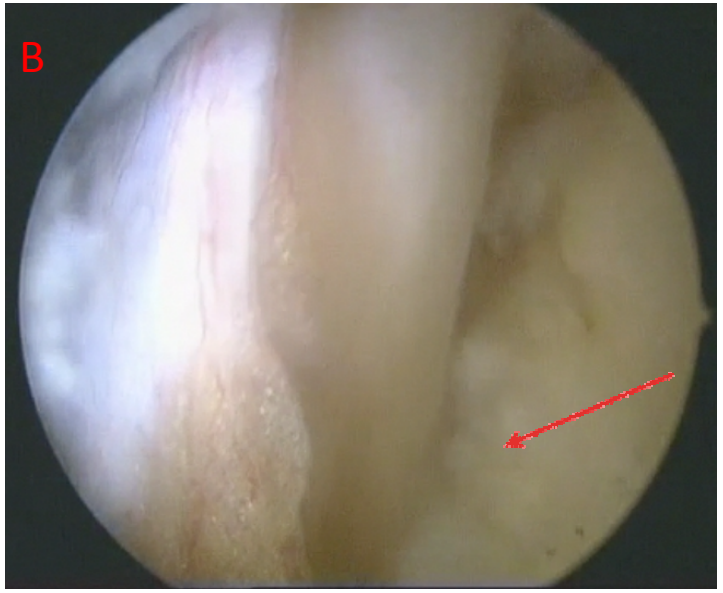




Our experience

More than 500 arthroscopic Fhl tendon tenolysis



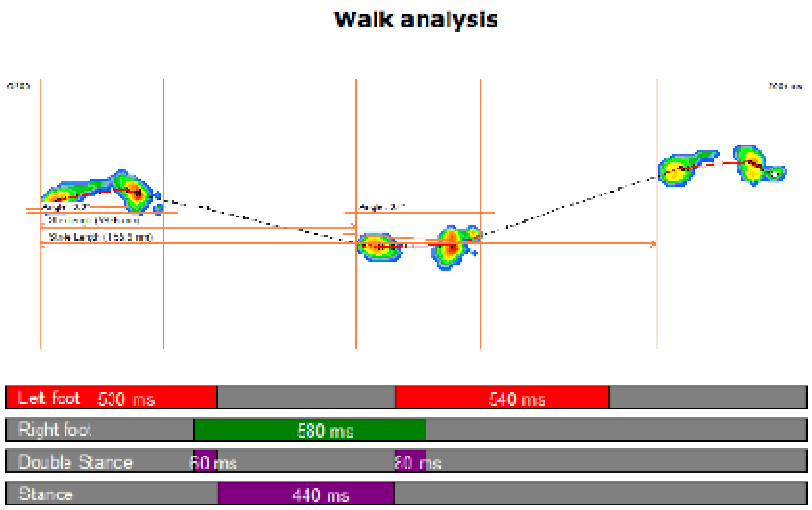


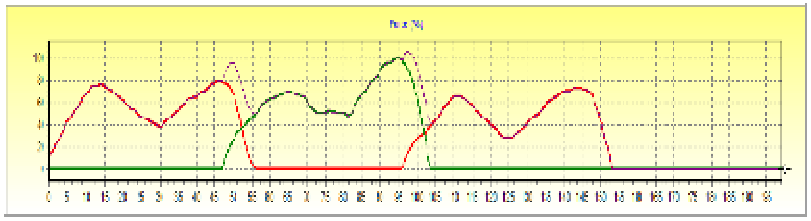
Blue arrow: Fhl tendon. Red arrow: Retrotallar pulley.
A: before resection. B: after resection

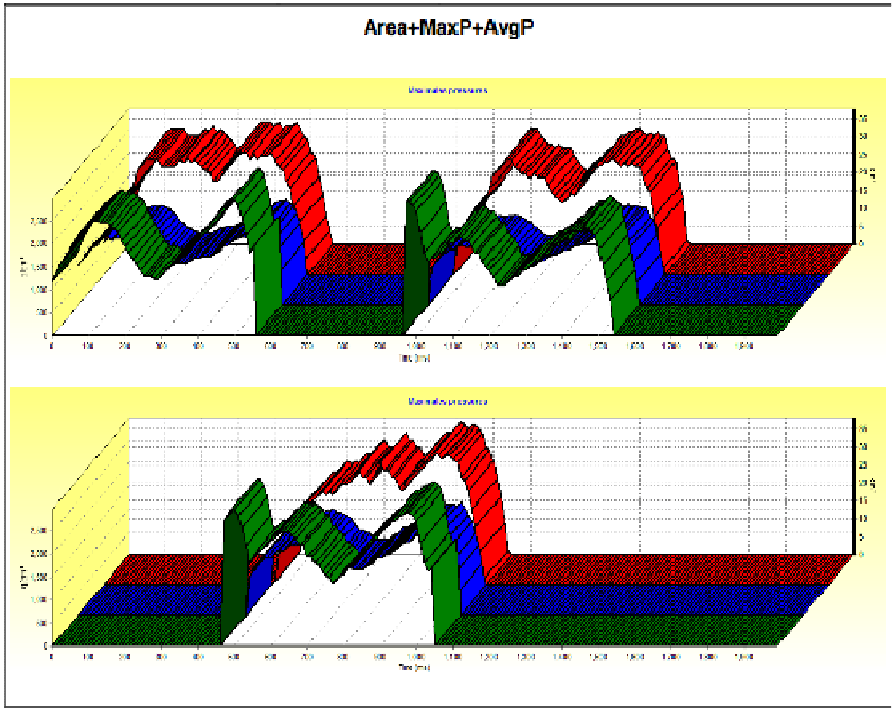
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2D Gait analysis
Study Population

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Résultats Podométriques

	1	2	3
Area	78.0	70.0	74.0
Average P.	1177.0	1700.5	1404.4
Maximal P.	2969.2	2969.2	2969.2

GaitLine MaxLine

Résultats Spatio-Temporels

Step Duration (ms)	470	500
Gait Cycle Duration (ms)	970	
Single Stance Duration (ms)		
Double Stance Duration (ms)	140	
Swing Duration (ms)	1050	1040
Stride Duration (ms)	1510	
Step length (mm)	594	562
Gait Cycle Length (mm)	1156	1148
Angle (°)	3.30	3.37

Area Average P Maximal P

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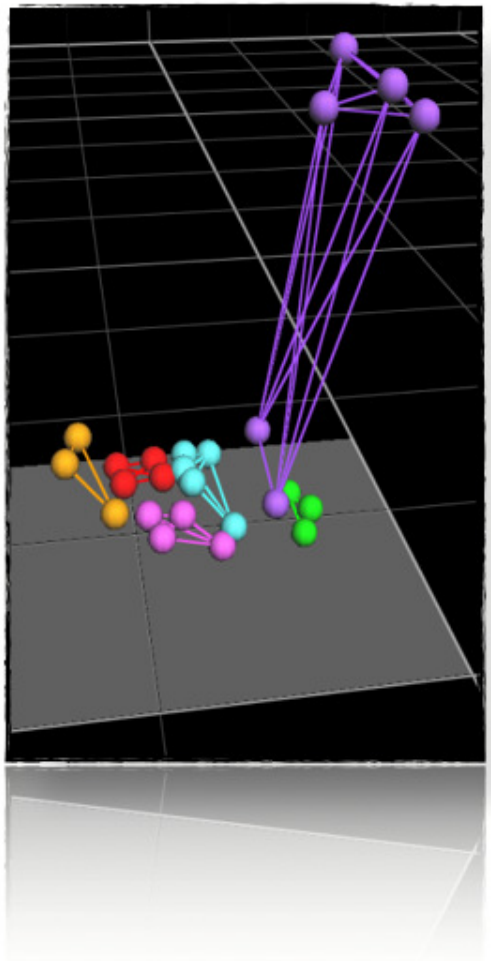
3D Gait analysis

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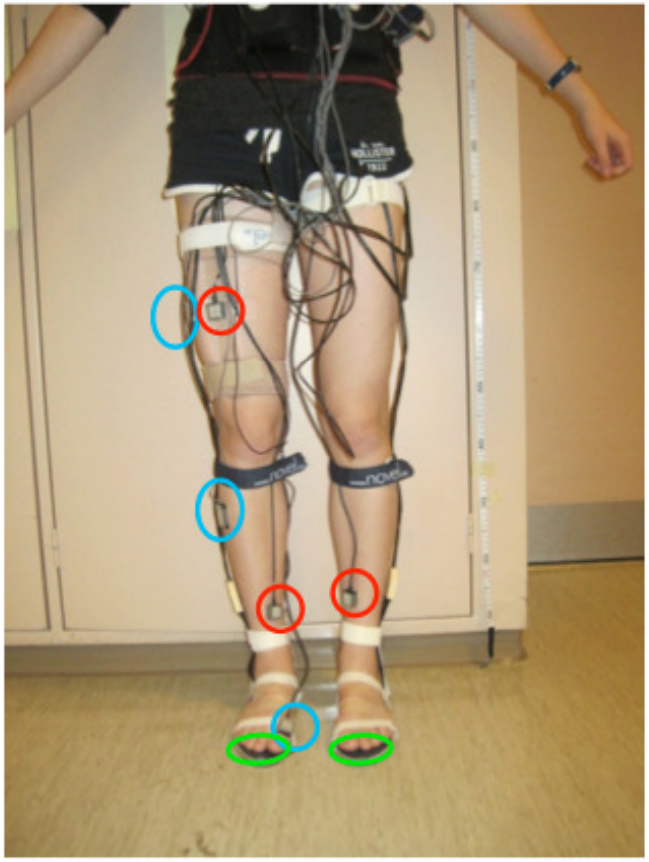
- Collaboration with EPFL
- 3D movement analysis

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Laboratory of Movement Analysis and Measurement LMAM



Measurement system

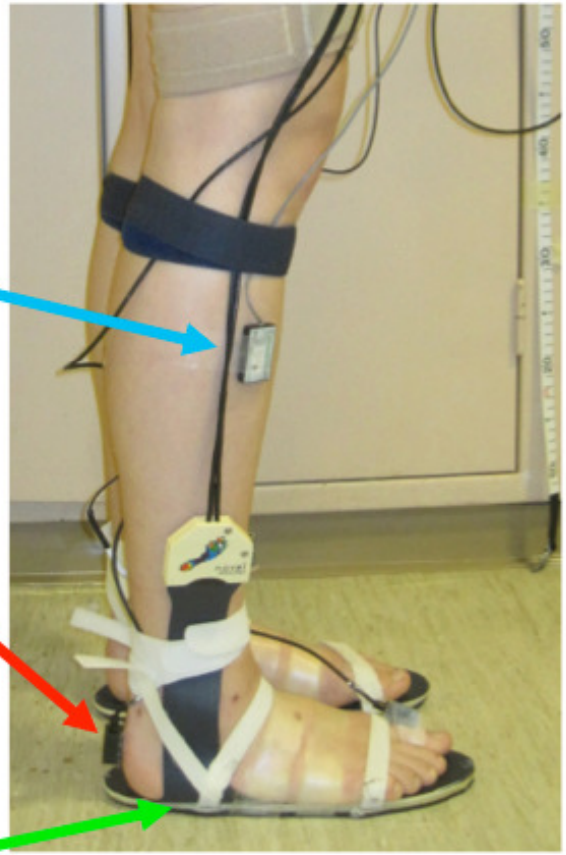


Electromyography:
4 electrodes on
* Quadriceps,
* Hamstring,
* Gastrocnemius
* Tibialis anterior

Inertial sensors:
3D gyroscope +
3D accelerometer

on Hallux, Calcaneus, Tibia, Thigh

Pressure insole:
99 sensors per insole



A multi-segment model study to evaluate the sagittal plane blockade in patients with Functional Hallux Limitus (FHL); Results after endoscopic tenolysis of the Flexor Hallucis Longus at the retrotallar pulley

14th EFORT Congress 2013
Istanbul | 5-8 June 2013

C.C. Tzioupis[1], S. Diehl[1], K. Boulos[1], K. Aminian[1,2], H. Rouhani[1,2], J. Vallotton[1,2]
[1]Medicol, Centre Orthopédique Lausanne, Switzerland
[2]LMAM-EPFL, Lausanne, Switzerland

The average pressure under the Hallux is statistically significantly lowered, postoperatively reflecting the repartition of the pressure between the Hallux and the augmented area under the first metatarsal head.

The time of support in dynamic conditions under the head of the first metatarsal head did significantly change after surgery, which means that the foot becomes a more stable structure for balance and gait.

1st International Congress

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CERTIFICAT
DE PARTICIPATION

a participé au

HALLUX LIMITUS FONCTIONNEL

Concepts et perspectives

Congrès destiné aux médecins,
physiothérapeutes et ostéopathes
le vendredi 29 novembre 2013 de 8h à 18h à
l'hôtel Beau-Rivage Palace,
à Lausanne.



FHL
STUDY
GROUP



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Conclusions

- Based on our patient cohorts, FHL can be considered as a factor implicated in the pathogenesis of various lower limb pathologies
- Careful examination is mandatory in order to reveal the pathognomonic symptoms usually masked especially in young adults.
- Postural analysis has shown a remarkable postoperative restoration of the functional anatomy of the forefoot.
- Postoperative clinical improvement, patient satisfaction and return to previous activities was good and excellent in more than 90%

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Future steps

- Define a clear gait pattern pathognomonic of FHL pathology.
- Imaging modalities to further investigate the anatomical structure of pulley
- Illustrate the correlation of FHL with other pathologies by use of larger populations
- Implement 3D gait analysis technology to further delineate the implications of FHL in the context of functional anatomy and unity of form and movement

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Thank you

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