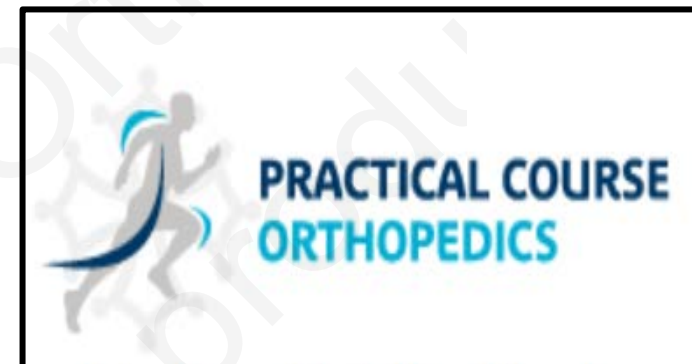


Brain and ACL Surgery



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Lyon, France



Disclosures

- Editorial Board OJSM
- Research support Ramsay & Arthrex
- Educational Consultant Arthrex
- Royalties Arthrex
- Stock Options AREAS



CAMIK Project - PhD

Cerebral Activity Changes in AMI following Knee Injury: A functional brain MRI Study Pr CAVAINAC



https://www.youtube.com/watch?v=1yE0wu_H-xM

Université Fédérale
Toulouse Midi-Pyrénées

THÈSE
En vue de l'obtention du

DOCTORAT DE L'UNIVERSITÉ DE TOULOUSE
Université Toulouse 3 Paul Sabatier (UT3 Paul Sabatier)

Présentée et Soutenue par :
Bertrand SONNERY-COTTET
Le 8 Décembre 2022

Titre :
Mise au point sur l'Inhibition Motrice d'origine Centrale dans les suites d'une entorse du Genou

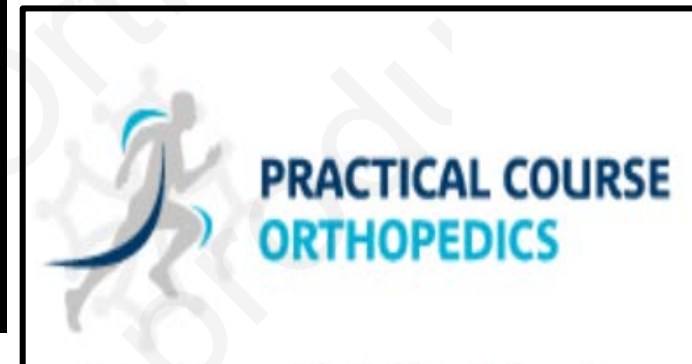
Centrally Derived Muscle Dysfunction following Knee Injury :
A Comprehensive Overview of Arthrogenic Muscle Inhibition

Cerebral Activity changes in Arthrogenic Muscle Inhibition following ACL Rupture :
A functional brain MRI Study

Ecole Doctorale et discipline ou spécialité :
Unité de Recherche
Laboratoire AMIS
ED 858 : Anthropobiologie

Directeur de Thèse :
Pr Etienne CAVAINAC

Jury :
Pr BOISGARD Stéphane, Professeur des universités - Praticien Hospitalier, Clermont-Ferrand
Pr THOREUX Patricia, Professeur des universités - Praticien Hospitalier, Paris
Pr BAUER Thomas, Professeur des universités - Praticien Hospitalier, Paris
Pr CLAVERT Philippe, Professeur des universités - Praticien Hospitalier, Strasbourg
Pr TROJANI Christophe, Chirurgien Orthopédiste, Nice



Future of Sport Medicine ?



Daily Practice

- **After injury**
- **After Surgery**



Definition

- Functional neuroplasticity in the brain after ACL injury is predominantly in the sensory and the motor areas of the cortex

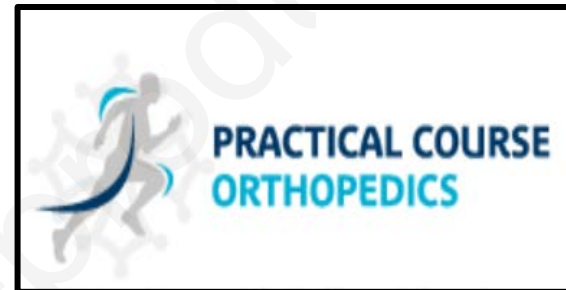
Anterior cruciate ligament deficiency causes brain plasticity: a functional MRI study

E. Kapreli, S. Athanopoulos, J. Gliatis et al. *AJSM*, 2009.

- Arthrogenic muscle inhibition (AMI) is a process in which neural inhibition following knee injury or surgery, results in quadriceps activation failure and knee extension deficit.

Functional Brain Plasticity Associated with ACL Injury: A Scoping Review of Current Evidence

Neto T, et al. *Neural Plast* 2019



Definition

- Sequelae of AMI include gait abnormality, chronic quadriceps atrophy and weakness, poor function, dynamic instability, joint contracture, arthrofibrosis, cyclops syndrome, persistent knee pain, proprioceptive deficits, impaired motor coordination, altered movement patterns and early osteoarthritis.
- Low effectiveness of previously described interventions

Physiopathology

Arthrogenic Muscle Inhibition

Local factors

Spinal Reflex Pathways

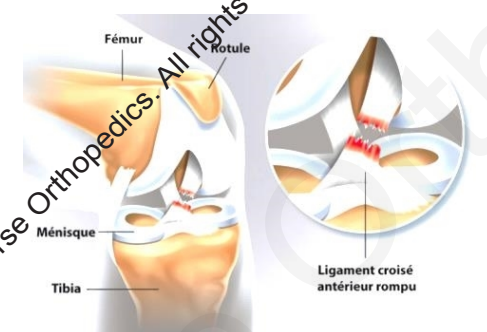
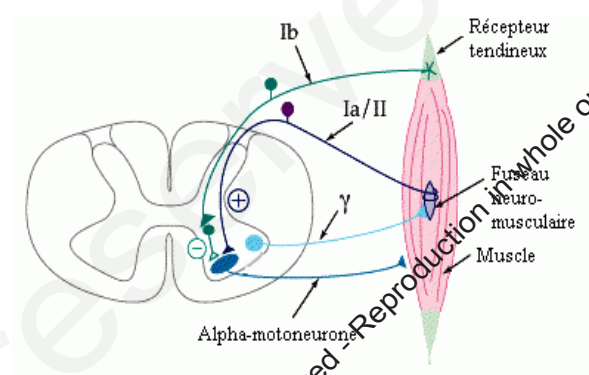
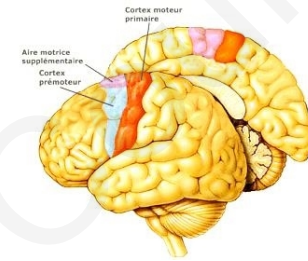
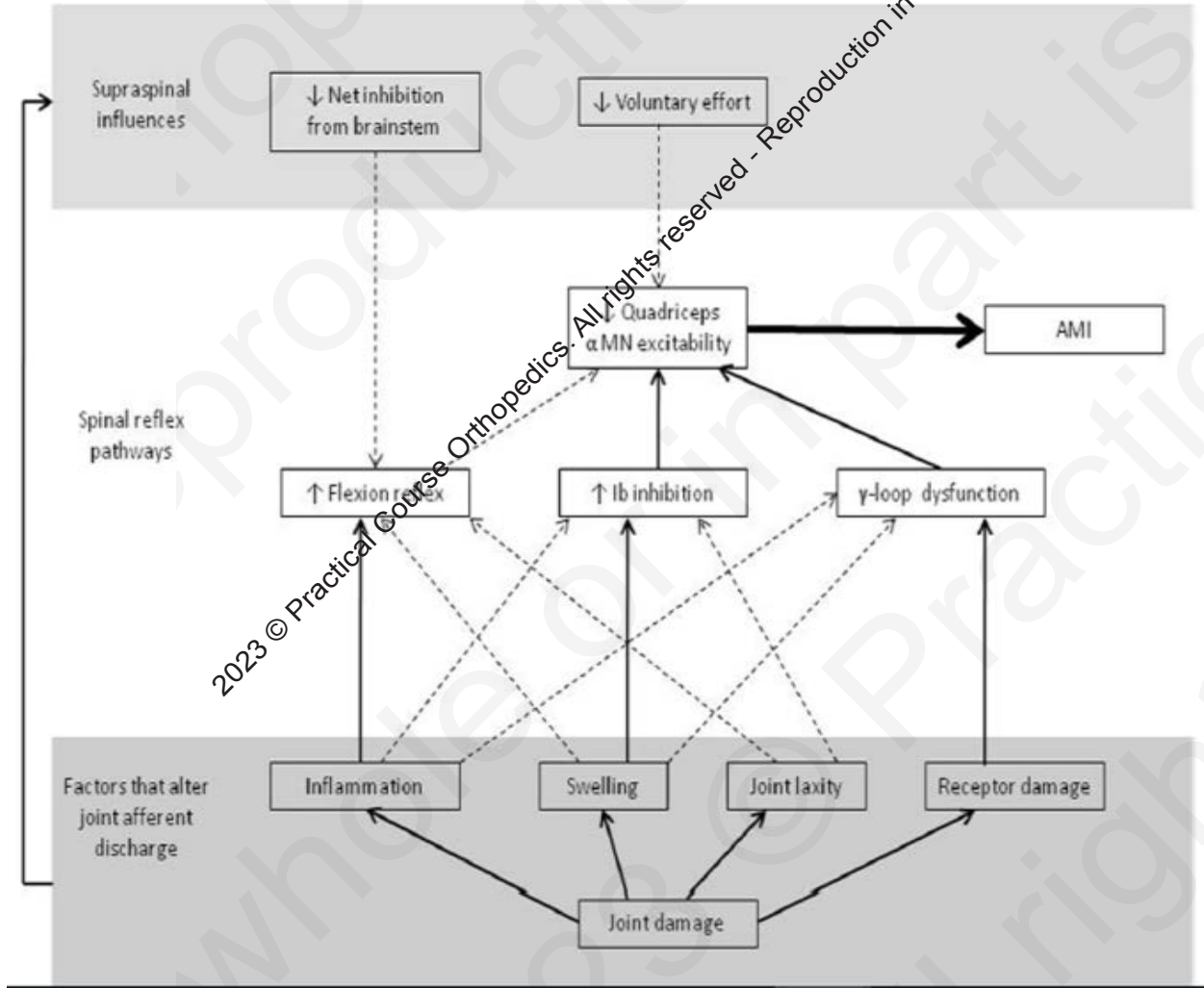
Supraspinal Influences

Quadriceps arthrogenic muscle inhibition: neural mechanism and treatment perspective

Rice D, Mcnair JP. Muscle 2010



Physiopathology

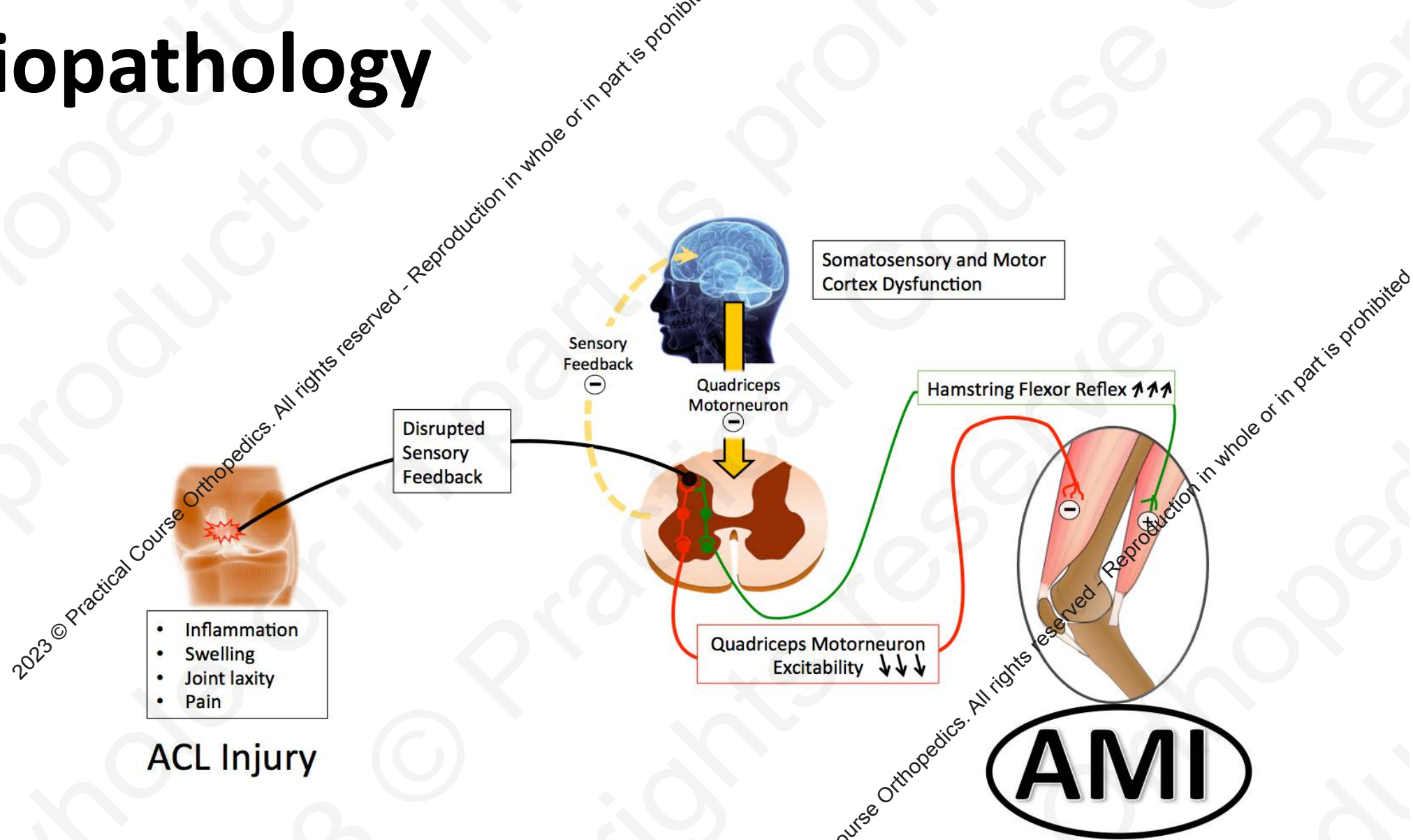


Quadriceps arthrogenic muscle inhibition: neural mechanism and treatment perspective

Rice D, Mcnair JP. Muscle 2010



Physiopathology






Knee Extension Deficit in the Early Postoperative Period Predispose to Cyclops Syndrome After ACL R:
A Risk Factor Analysis in 3633 Patients From the SANTI Study Group Database.

Delaloye JR et al. Am J Sports Med. 2020



The AMI Classification

Arthrogenic Muscle Inhibition Following Knee Injury or Surgery: Pathophysiology, Classification, and Treatment

Bertrand Sonnery-Cottet,^{*†} MD, Graeme P. Hopper,^{*†} MD, FRCS (Tr & Orth) 
Lampros Goussopoulos,^{*†} MD, Thais Dutra Vieira,^{*†‡} MD , Mathieu Thauinat,^{*†} MD,
Jean-Marie Foyard,^{*†} MD, Benjamin Freychet,^{*†} MD , Hervé Ouanezar,[§] MD,
Etienne Caylaignac,^{||} MD, and Adnan Saithna,[¶] MD

Investigation performed at Centre Orthopédique Santy, FIFA Medical Centre of Excellence, Groupe Ramsay-Générale de Santé, Hopital Privé Jean Mermoz, Lyon, France



VJSM
Blockbuster
Award



The AMI Classification



- **Grade 0:** Normal VMO contraction
- **Grade 1a:** VMO contraction is inhibited but activation failure is reversible with simple exercises
- **Grade 1b:** as 1a but requires longer and specific rehabilitation programs
- **Grade 2a:** VMO contraction is inhibited with an associated extension deficit due to hamstring contracture but activation failure and loss of range of motion is reversible with simple exercises
- **Grade 2b:** as 2a but refractory to simple exercises and longer and specific rehabilitation programs are required
- **Grade 3:** Chronic extension deficit that is irreducible without extensive posterior arthrolysis



Definition



Grade 1 = VMO Inhibition

Definition



Grade 2 = VMO inhibition + Hamstring Contracture

Definition



Grade 2 = VMO inhibition + Hamstring Contracture

Definition



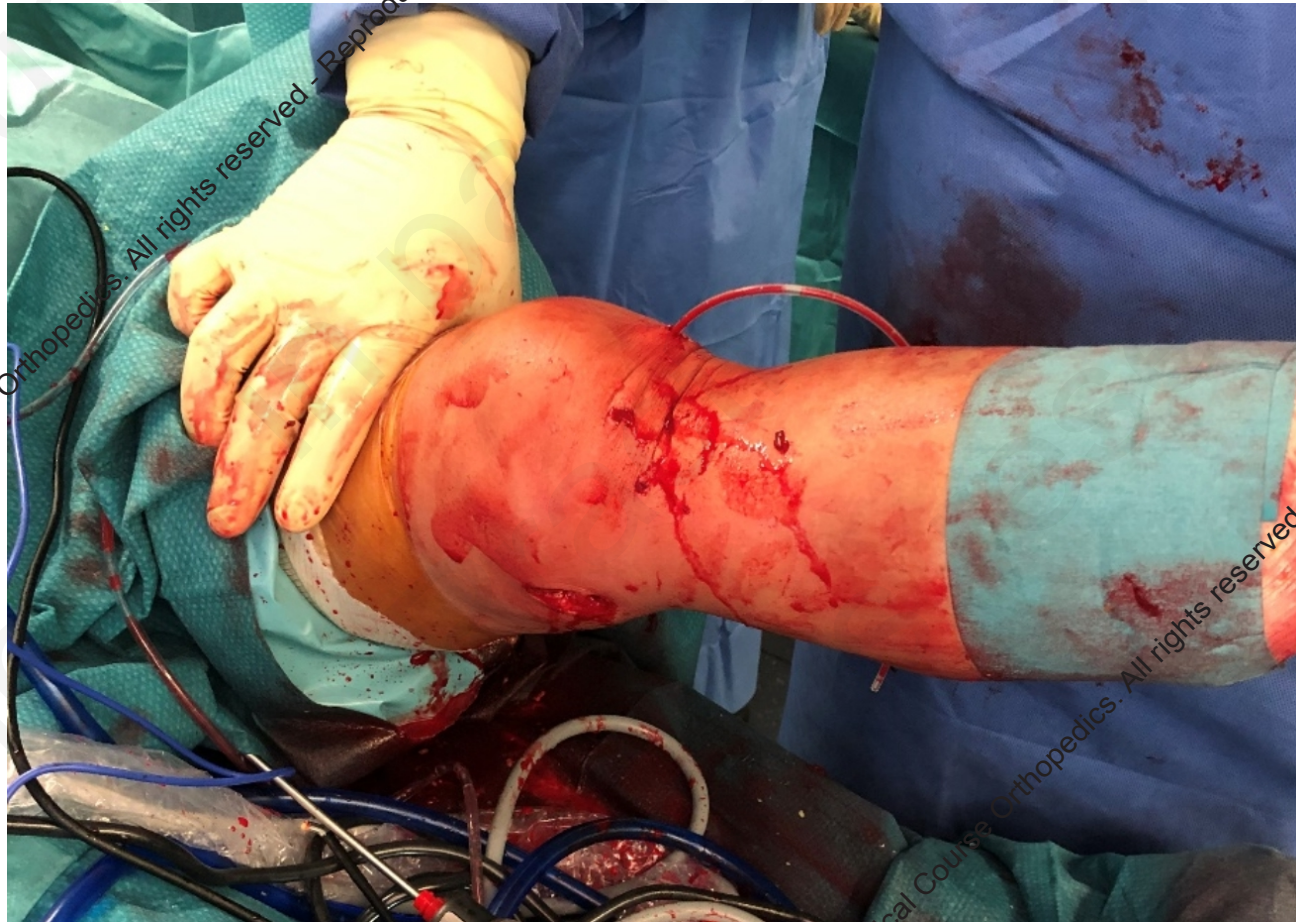
Grade 2 = VMO inhibition + Hamstring Contracture

Definition



Grade 3 = Chronic Extension Loss

Definition



Grade 3 = Chronic Extension Loss

Easy Reduction of AMI 2a



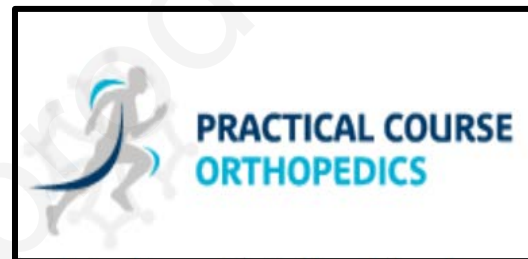
ACL rupture

+

**Bucket Handle of
Medial Meniscus**

How to Rapidly Abolish Knee Extension Deficit After Injury or Surgery

Delaloye JR et al. *Arthroscopy Techniques* 2018



Easy Reduction of AMI 2a



How to Rapidly Abolish Knee Extension Deficit After Injury or Surgery

Delaloye JR et al. [Arthroscopy Techniques](#) 2018



PRACTICAL COURSE
ORTHOPEDICS

Incidence of AMI in Acute ACL injuries



Incidence of AMI in Acute ACL injuries

- 300 consecutive patients with acute ACL ruptures (>6weeks) were prospectively enrolled in the study.
- Patients with AMI showed inferior Lysholm, IKDC, SKV and KOOS scores than patients without AMI ($P < 0.0001$).

Incidence of Arthrogenic Muscle Inhibition Following Acute ACL Injuries:
A Cross Sectional Study and Analysis of Associated Factors From the SANTI Study Group.

Sonnery-Cottet et al. *AJSM* Submitted



Incidence of AMI after ACL Rupture

AMI	N (%)	95% CI
0	130 (43.3)	[37.7;48.9]
1A	73 (24.3)	[35.5;50.4]
1B	13 (4.3)	[3.7;11.6]
2A	62 (20.8)	[29.2;43.7]
2B	22 (7.3)	[7.9;18.0]

60%

Incidence of Arthrogenic Muscle Inhibition Following Acute ACL Injuries:
A Cross Sectional Study and Analysis of Associated Factors From the SANTI Study Group.

Sonnerly-Cottet et al. *AJSM* Submitted

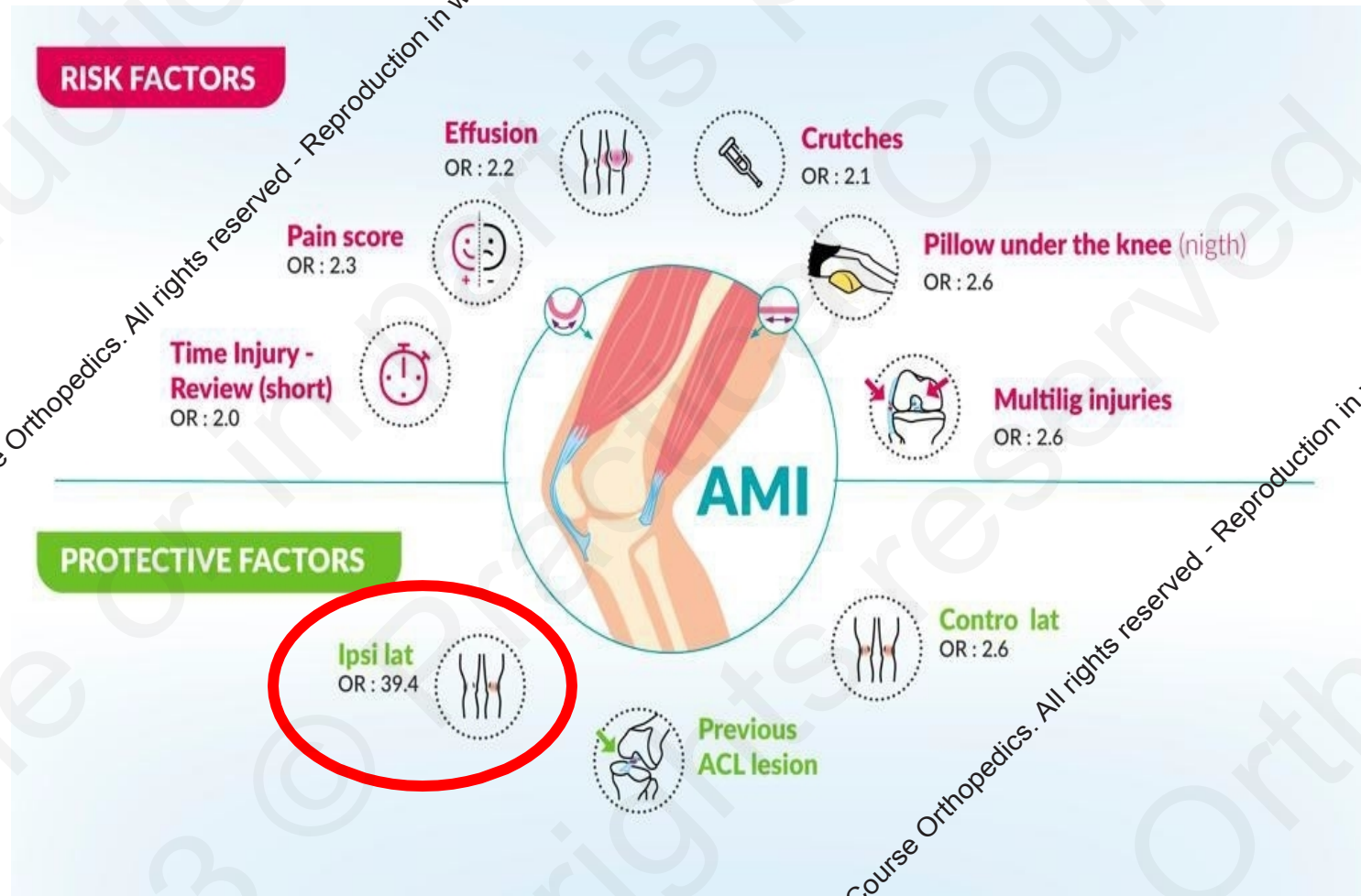
Incidence of AMI after ACL Rupture



Incidence of Arthrogenic Muscle Inhibition Following Acute ACL Injuries:
A Cross Sectional Study and Analysis of Associated Factors From the SANTY Study Group.

Sonnerly-Cottet et al. *AJSM* Submitted

Incidence of AMI after ACL Rupture



Incidence of Arthroгенic Muscle Inhibition Following Acute ACL Injuries:
A Cross Sectional Study and Analysis of Associated Factors From the SANTY Study Group.

Sonnery-Cottet et al. *AJSM* Submitted

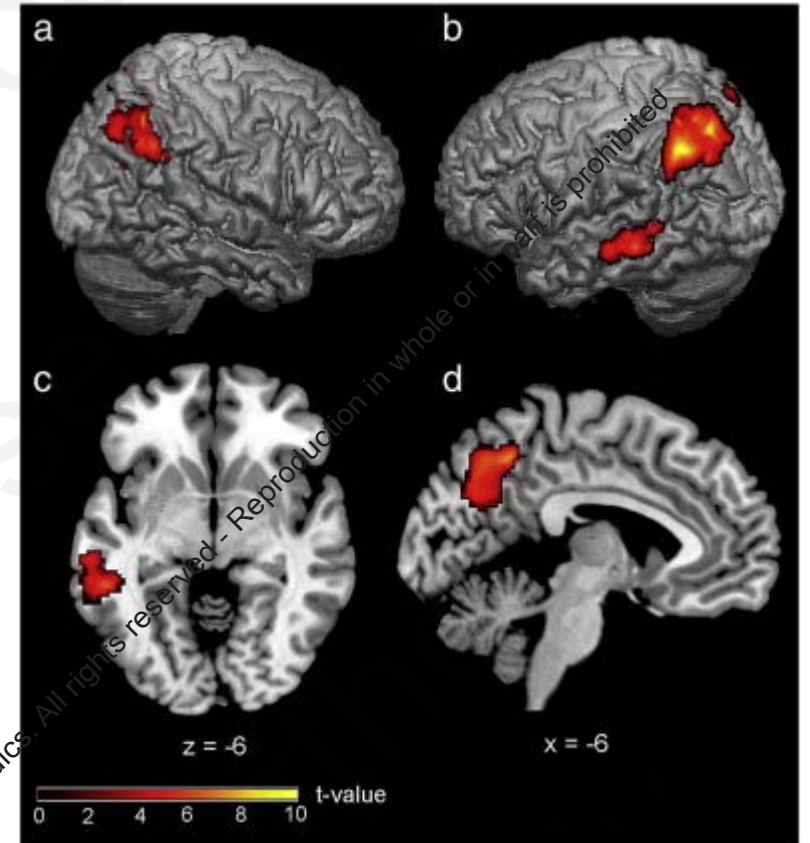
CAMIK Project

PhD

Acute ACL Rupture

- AMI vs no AMI

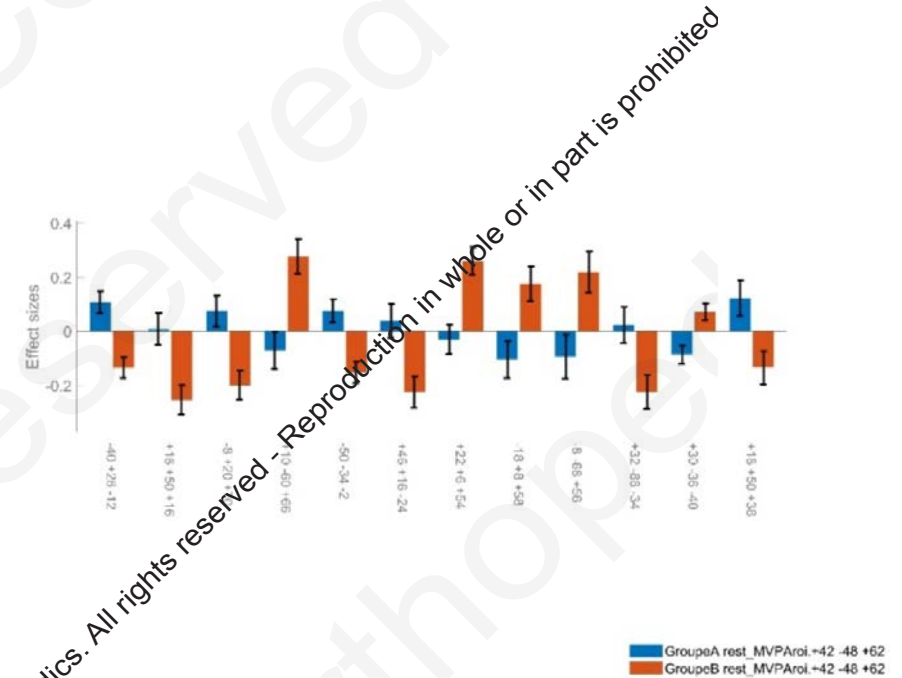
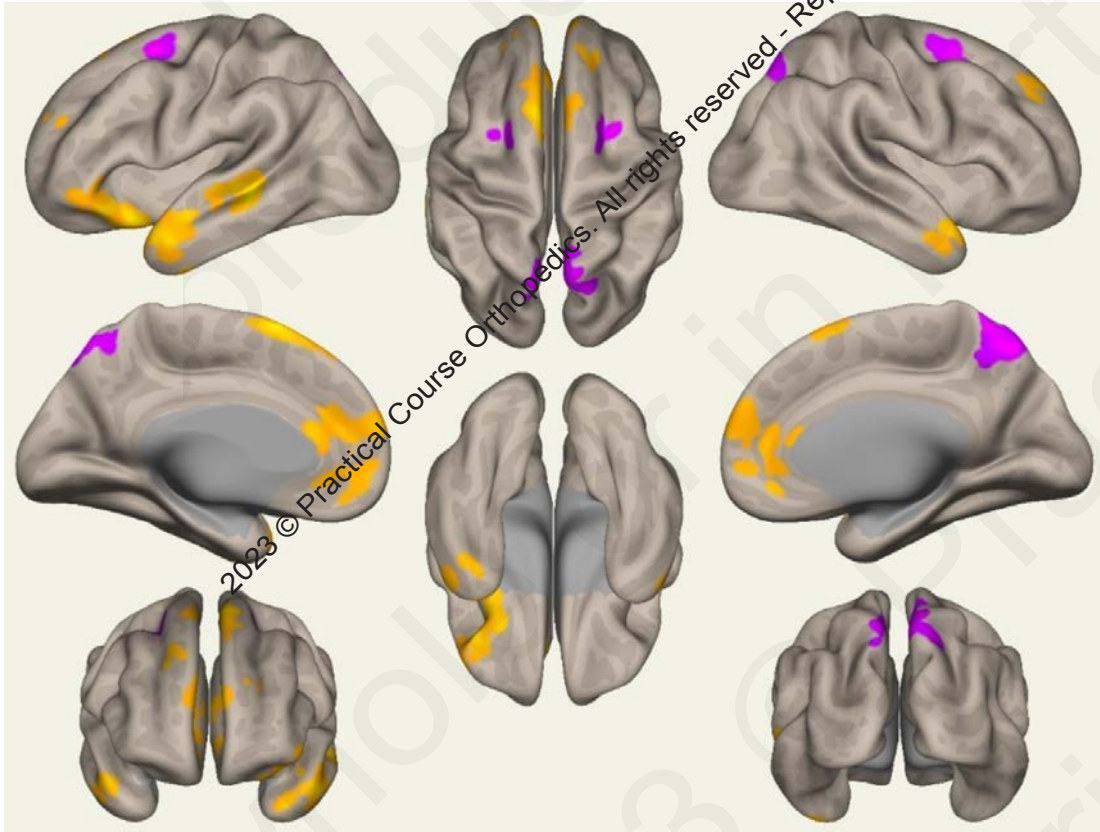
→ Brain Functional MRI



Cerebral Activity Changes in AMI following Knee Injury:

A functional brain MRI Study - Pr CAVAIGNAC

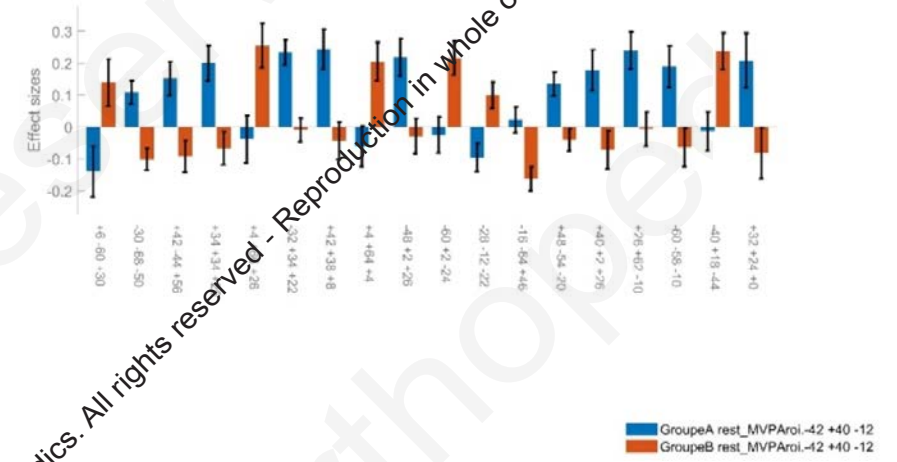
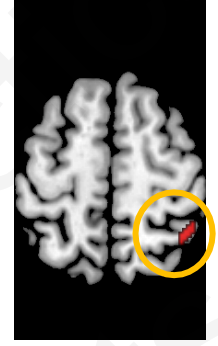
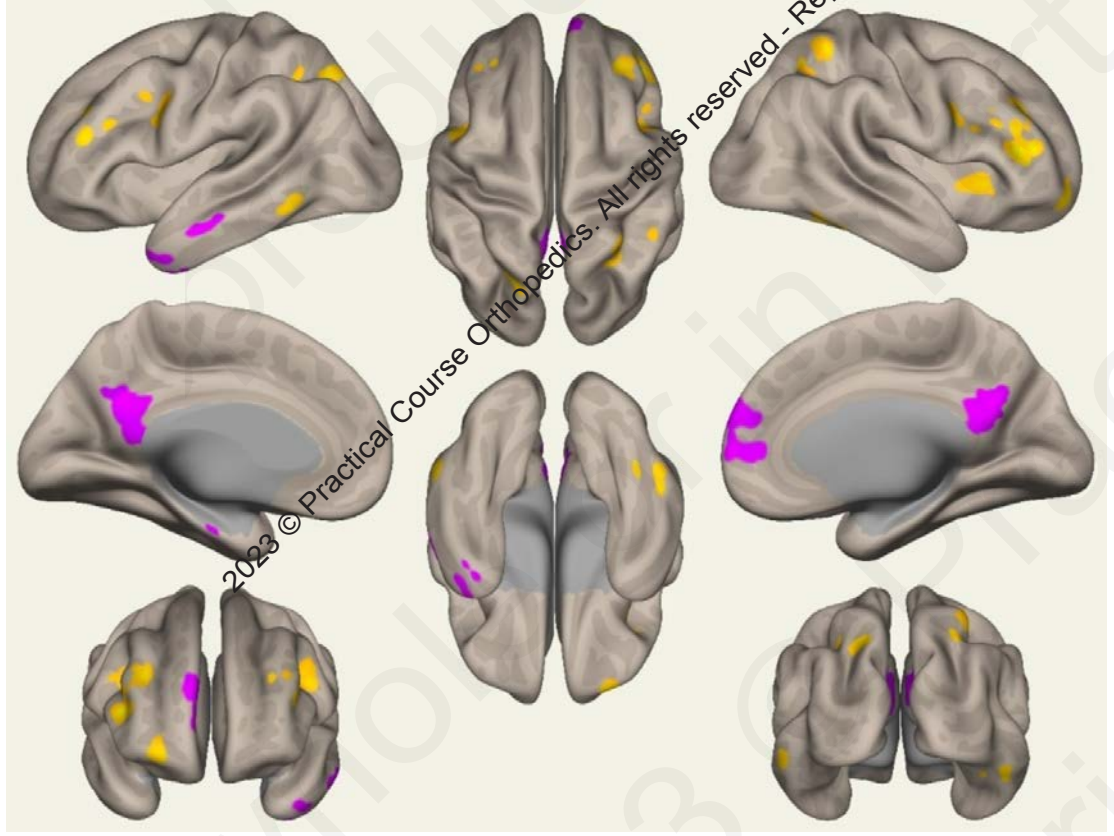
AMI > without AMI (yellow)
without AMI > AMI (purple)



Seed to voxels analysis

The presence of AMI modules the functional connectivity of Frontal Cluster

AMI > without AMI (yellow)
without AMI > AMI (purple)



The presence of AMI modules the functional connectivity of Parietal Cluster

Acute Surgery = High risk of Stifness +++

Thaunat M, Barbosa NC, Gardon R, Tuteja S, Chatellard R, Fayard JM, Sonnery-Cottet B. Prevalence of knee stiffness after arthroscopic bone suture fixation of tibial spine avulsion fractures in adults. Orthop Traumatol Surg Res. 2016

→ **15%**

Meister M, Koch J, Amsler F, Arnold MP, Hirschmann MT. ACL suturing using dynamic intraligamentary stabilisation showing good clinical outcome but a high reoperation rate: a retrospective independent study. Knee Surg Sports Traumatol Arthrosc. 2018

→ **25%**

Deroche E, Batailler C, Swan J, Lustig S, Servien E. Significant risk of arthrolysis after simultaneous anterior cruciate ligament reconstruction and treatment of dislocated bucket-handle meniscal tear. Orthop Traumatol Surg Res. 2022

→ **10%**

AMI Clinical Practice

- Physiotherapists
- Sports doctors
- Surgeons



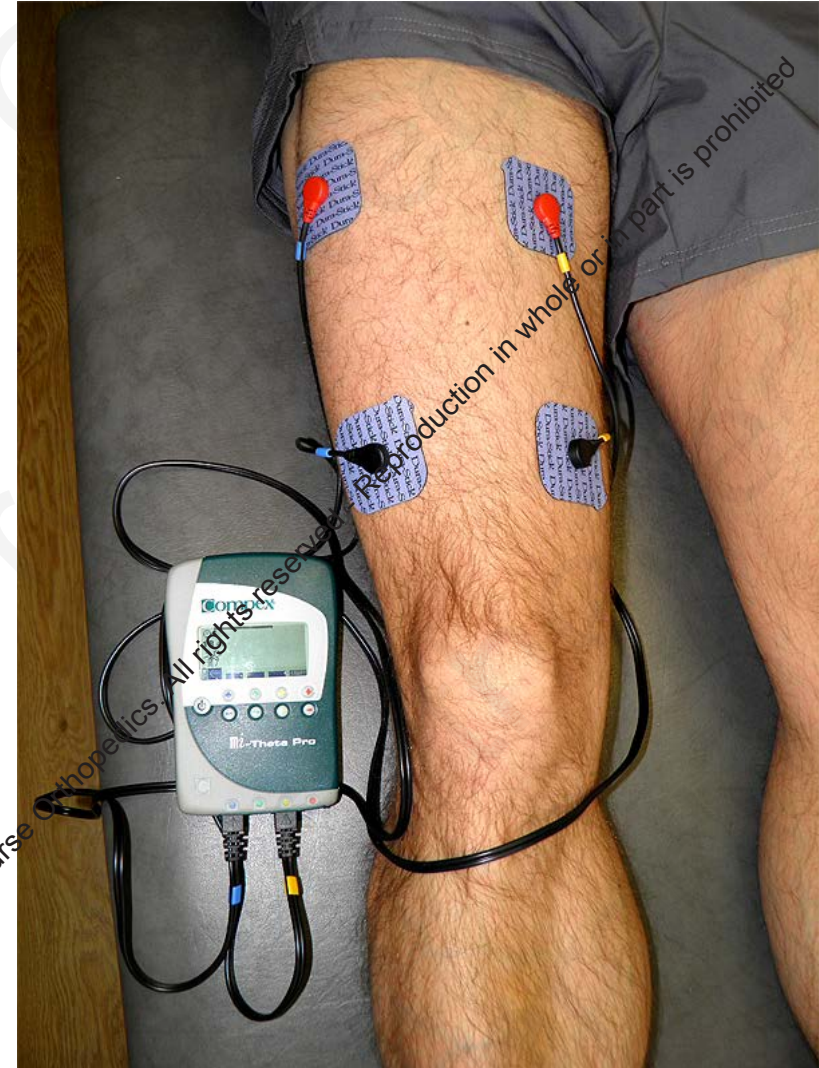
AMI Clinical Practice



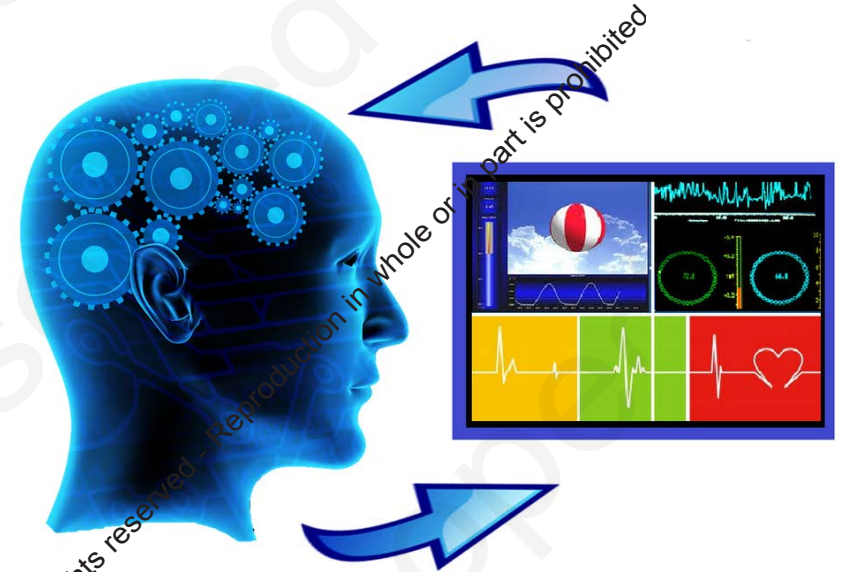
Extension Deficit



AMI Clinical Practice

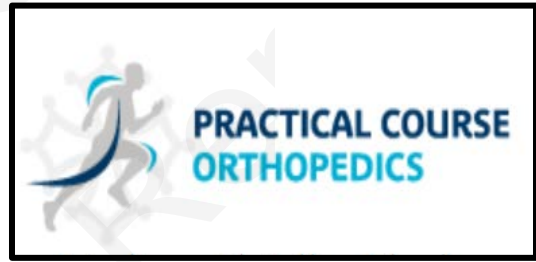


AMI Clinical Practice

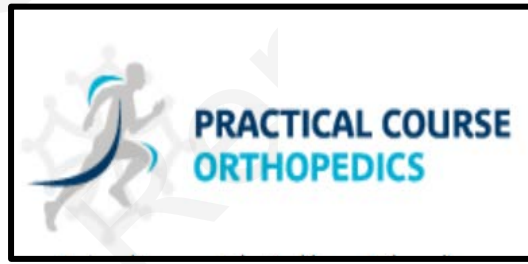


BIOFEEDBACK

AMI Clinical Practice



AMI Clinical Practice



Conclusions

- AMI is a central neural inhibition following knee injury, or surgery, results in quadriceps activation failure and knee extension deficit
- Extension Deficit = Arthrofibrosis, Cyclops, Anterior Knee Pain
- A Classification has been published and will allow to talk about the same subject
- Incidence is almost 60% in acute ACL injuries



Conclusions

- Simple exercises can reduce this process before it becomes chronic and irreducible
- Understanding *AMI* and *cortical influence* will guide therapeutic strategies for both treatment and prevention
- All patients need full extension and a good VMO contraction before Knee Surgery



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Merci !

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