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How to manage menisci lesions
 Is there a place for biological enhancement?





5th Advanced course on knee surgery February 2nd to 7th
 2014, Val d'Isère, France

Background

- The most common treatment for lesions of the avascular part of the meniscus is → arthroscopic partial **meniscectomy**
- Meniscectomy predisposes to **OA**

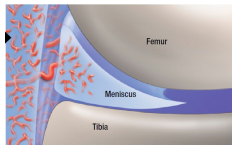
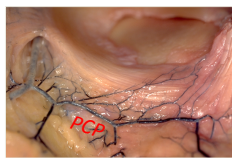
The future of the knee is inversely related to the amount of resected meniscal tissue

McDermott ID, Amis AA. The consequences of meniscectomy. J Bone Joint Surg Br. 2006
 Englund et al. The meniscus in knee osteoarthritis. Rheum Dis Clin North Am. 2009

Vascularity



- The meniscus is a relatively avascular structure
- The perimeniscal capillary plexus (PCP) surrounds the periphery of the meniscus providing blood mostly to the outer third of the meniscus

Arnoczky & Warren 1982

Healing Response

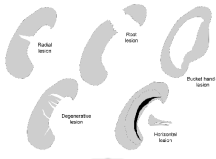
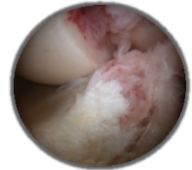
- Tear in the peripheral third
 - a fibrin clot forms (rich in inflammatory cells)
 - the PCP grows rapidly over the fibrin conduit and fibrous scar, while contributing undifferentiated mesenchymal cells
- Tears within the vascular peripheral zone are completely healed by a fibrovascular scar by 10 weeks



King D. The healing of semilunar cartilages. J Bone Joint Surg 1976

Meniscal Repair

- Meniscal healing principally depends on the vascular supply of the injured zone
- Repair should be considered depending on:
 - the type, size and location of the tear
 - how acute the tear is
 - activity level and age
 - knee stability
 - willingness to undergo postop rehab programs

Meniscal Repair Prognostic Factors

Location	Type of Tear	Chronicity	Size	Success %
	Longitudinal	Weeks	≤ 1cm	
	Radial	Months	1-2.5cm	
	Pedunculated	Years	2.5-4cm	
	Horizontal		> 4cm	
	Degenerative			

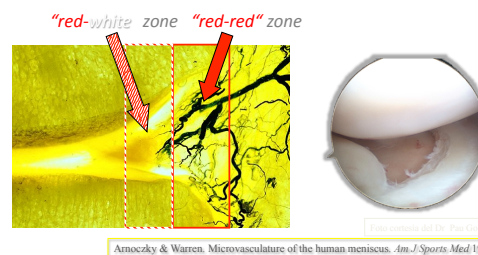
Meniscal Repair Results

- More successful for:
 - peripheral tears (rim width less than 3mm)
 - lateral versus medial meniscal tears
 - associated with ACL reconstruction
 - acute injuries (2 to 8 weeks)



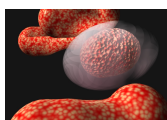
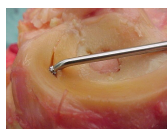
What about the avascular zone?

Meniscal repair require biological strategies for the stimulation of meniscal healing after repair



Biological Enhancement

- **Mechanical techniques**
 - rasping / abrasion
 - trephination
 - high frequency trephination
- **Biological techniques**
 - fibrin clot
 - PRP
 - stem cells



Rasping

Methods

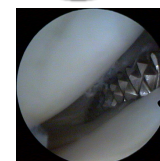
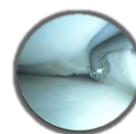
- Experimental work (rabbits)
- Abrasion vs non-abrasion
- Longitudinal tears (5mm) in white zone
- Sacrifice at different periods (max. 112 days)

Results

- Immunohistochemistry
 - significantly increased level of IL 1 α , TGF- β 1, PDGF and PCNA in the abrasion group

Conclusion

Key role of cytokines inducing vascularity to repair meniscal injuries



Ochi et al. Expression of Cytokines after Meniscal Rasping to Promote Meniscal Healing. *Arthroscopy* 2001

Trephination

Small incisions to produce vascular channels that redirect the blood flow from the vascular zone into the avascular one

Methods

- longitudinal injuries in avascular area / goat model
- trephination and suture vs suture alone
- samples were studied at 3, 8, and 25 weeks

Results

- T+S \rightarrow 4/20 completely healed - 16/20 partly healed
- S \rightarrow 3/20 partly healed - the remainder showed no gross evidence of healing
- appears to promote healing of longitudinal injuries in the avascular area
- may break the collagen net



Zhang et al. Repairs by trephination and suturing of longitudinal injuries in the avascular area of the meniscus in goats. *Am J Sports Med* 1995

Fibrin Clot

Methods

- to evaluate mitogenic and chemotactic properties of a fibrin clot
- dog model
- a 2cm defect in the avascular area of MM

Results

- morphological healing of the experimental meniscal tears and absence of such a response in the control animals



Amoczy et al. Meniscal repair using an exogenous fibrin clot: an experimental study in dogs. *J Bone Joint Surg Am*. 1988

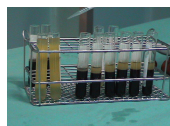
Platelet Rich Plasma

Methods

- circular meniscal punch defects in the avascular zone of rabbit menisci
- the defects were left empty or filled with hyaluronan-collagen composite matrices without cells loaded with PRP, autologous bone marrow, or autologous mesenchymal stem cells

Results

- Neither bone marrow or platelet-rich plasma loaded in matrices induced improvement in meniscal healing



Zellner et al. Role of mesenchymal stem cells in tissue engineering of meniscus. *J Biomed Mater Res A*. 2010

Growth Factors

Hypothesis

- some growth factors can increase proteoglycan synthesis

Methods

- animal samples
- TGF- β 1, PDGF & Bone Morphogenetic Protein-7

Results

- significant increase in cellularity in the deep and superficial aspects of the explants treated with PDGF-(AB) compared with those treated with basal medium alone



Selected growth factors might be useful in the maintenance and repair of menisci

Lietman et al. Effects of selected growth factors on porcine meniscus in chemically defined medium. *Orthopedics* 2003

Cell Therapy (Mesenchymal Stem Cells)

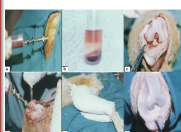
Methods

Autologous BMSCs from 8 adult dogs → injected into meniscal wounds
Clinical & immunomorphological evaluation of the healing process at 12 week

Results

Complete (5 vs 3), partial (1 vs 1) and no healing (1 vs 4) of the meniscal wounds in the injected* and non-injected menisci respectively

- *marked angiogenesis and chondrogenesis
- *prominent immune cell infiltrate
- *proliferation of the fibroblasts with deposition of collagen fibres

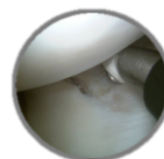


Autologous BMSCs can improve meniscal wound healing

Abdel-Hamid et al. Enhancement of the repair of meniscal wounds in the red-white zone (middle third) by the injection of bone marrow cells in canine animal model. *Int J Exp Pathol* 2005

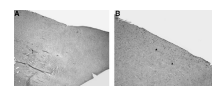
High Frequency Trephination

RF produce a line of necrosis of approximately 30 microns followed by a zone of hypercellularity (fibroblast proliferation at 2 weeks)



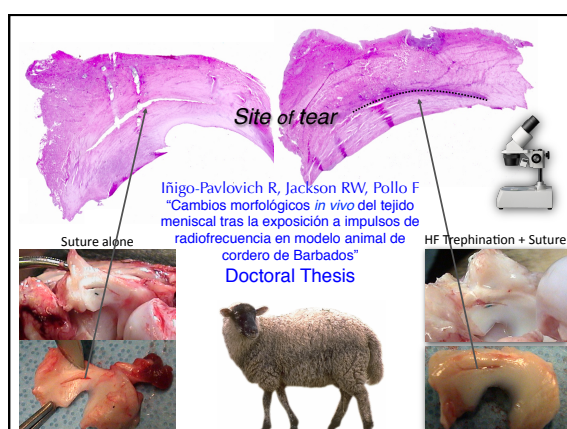
The acellular or necrotic area is completely repopulated at 12 weeks ("tide wave effect")

The meniscus may be repaired if parameniscal synovial tissue is stimulated using radiofrequency



Histologic Changes After Meniscal Repair Using Radiofrequency Energy in Rabbits

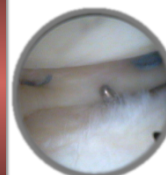
Korhonen Heikki, M.D., Heikki Heikki, M.D., Ph.D., Mikaela Kuita, M.D., Ph.D., Mikaela Kuita, M.D., Ph.D., Mikaela Kuita, M.D., Ph.D., Mikaela Kuita, M.D., Ph.D.



High Frequency Trephination

Methods

- Prospective study of meniscal repair
- Period → 3 years
- 34 men (72.7%) / 9 women (27.3%)
- Average age → 29.8 years
- Inclusion criterion:
 - total rupture of the meniscus >10 mm in length (range 10-45 mm) in either the red-white or white-white zone.
 - Fastfix® + HFT
- All tears considered chronic → 3 weeks to 2 years
- Average FU 2y



Monilau et al. Good Outcome after Meniscal Repair Frequency Using an All-Inside Suture System in Combination with High-Frequency Bioestimulation. *Orthopedics* 2010

High Frequency Trephination

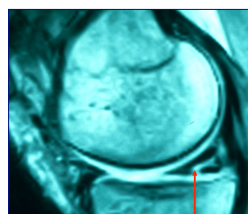
Results

- 41 / 43 evaluated
- IKDC → increased from 59 to **92** pop ($P < .009$)
- Lysholm → 60.9 preop to **91.9** pop ($P < .008$)
- No differences between isolated repairs (67.5%) and those combined with ACL (32.5%) ($P < .832$)
- xRay → no changes in Rosenberg view (Schuss)
- MRI → 100% site of tear visible
 - Partial healing / immature scar tissue

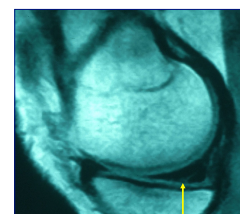


Monllau et al. Orthopedics. 2010

MRI - Results



preop



1 year postop

♦ 100% → meniscal site visible

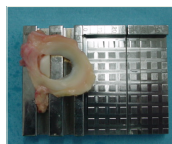
Results in AMTx

Methods

- 55 AMTx with/without bone blocks
- Stimulation with HF Trephination

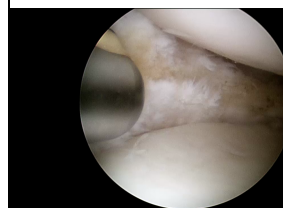
Results

- 53/55 primary healing
- Allograft failure rate 3.6%
- More variables

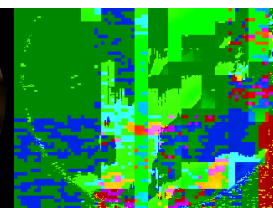


Abat et al. Prospective comparative study between two different fixation techniques in meniscal Abx. AJSM 2012

HFT in AMTx



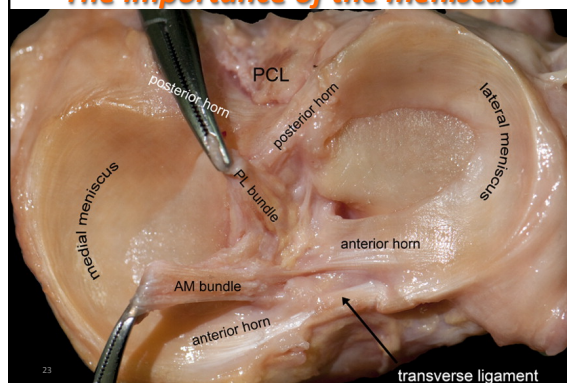
Index surgery



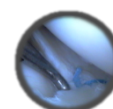
4 weeks Postop

Abat et al. Prospective comparative study between two different fixation techniques in meniscal Abx. AJSM 2012

The importance of the meniscus



Summary



The use of fibrin clot, and local delivery of growth factors are all potential biologic enhancements for the repair of meniscal tears in the avascular zone of the meniscus.

Cell-based therapy showed the possibility to improve healing in avascular areas. None of these cell therapies has entered clinical practice to date.

We still prefer **Mechanical Stimulation**, particularly High-Frequency Trephination due to the easy access, low cost and reproducible results.

14/02/14

