

Imaging of Cartilage Repair

Carl S. Winalski, MD

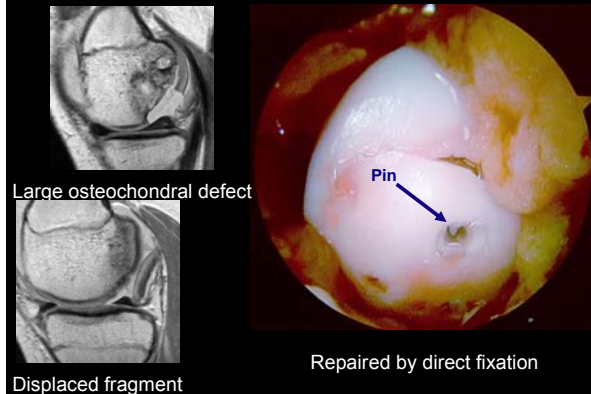
*Imaging Institute
Department of Biomedical Engineering
Cleveland Clinic*



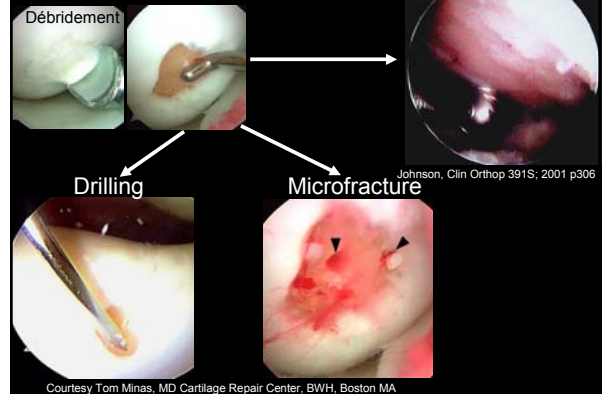
Cartilage Repair Options

- Direct repair
- Marrow stimulation
- Autologous transplantation
- Allogeneic transplantation
- Cell transplantation
- Acellular Scaffolds
- Combination techniques

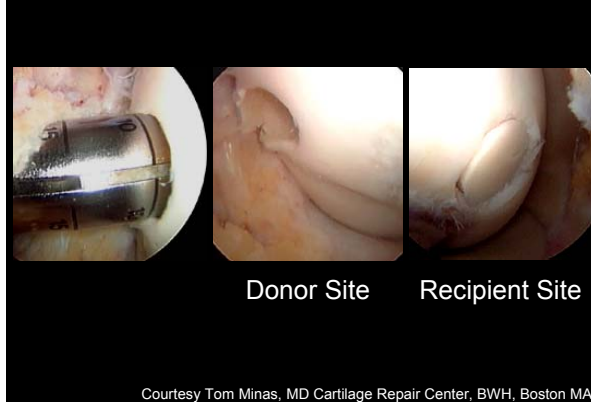
Direct Fixation of OCD



Marrow Stimulation

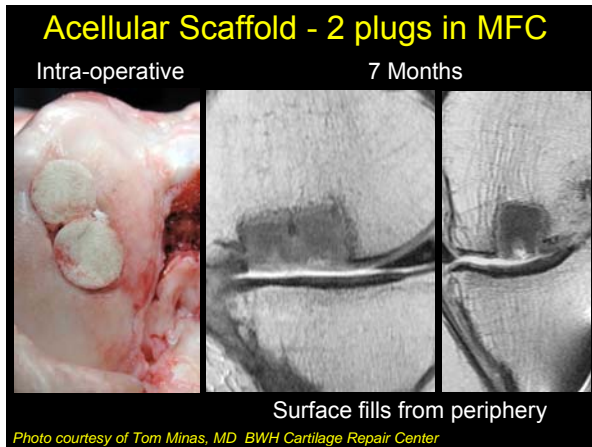
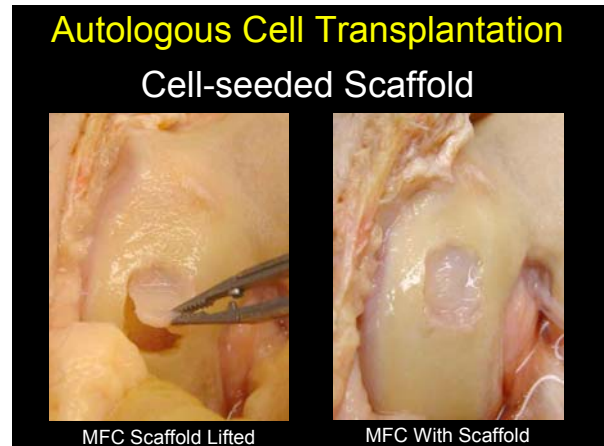
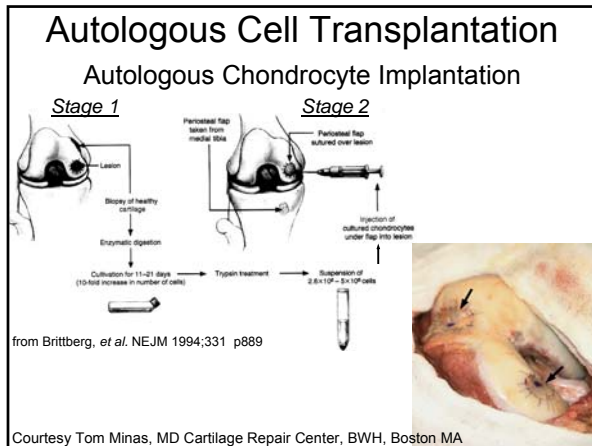


Autologous Osteochondral Transplantation



Osteochondral Allograft

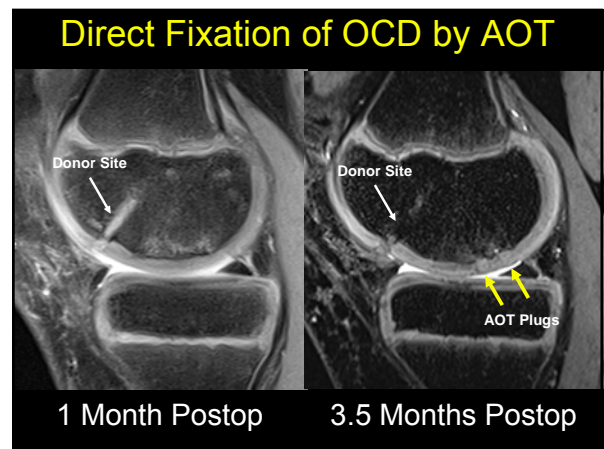
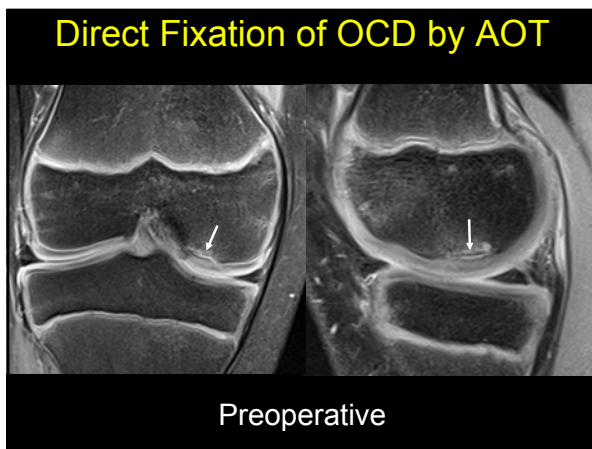




Direct Fixation of OCD by AOT

- Osteochondral lesion fixed in place by osteochondral plugs
- No cartilage defects from pins or screws
- No screw removal needed

Courtesy Anthony Miniaci, MD
Cleveland Clinic Sports Health Center



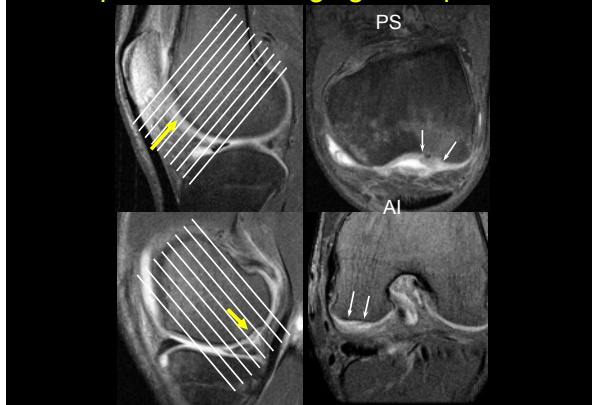
Cartilage Repair: Treatment Choice Decision

- Lesion size and depth
 $<4\text{cm}^2$: marrow stimulation, AOT
 $2\text{cm}^2 - 12\text{cm}^2$: ACI, Allograft
- Only symptomatic lesions treated
- Patient activity level
- Patient expectations

Postoperative Assessment

- Defect fill
 - volume & thickness
 - surface contour
- Integration of repair tissue
 - repair-bone interfaces
 - repair-native cartilage
- Subchondral bone response
 - "edema-like" marrow signal
 - cyst formation
- Non-repair site complications
 - adhesions
 - new defects

Oblique Coronal Imaging of Repair Sites

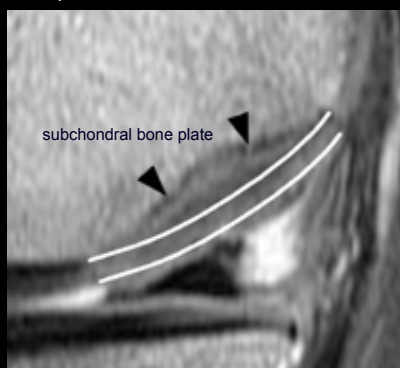


Defect Fill

- Complete fill expected early
 - Autologous osteochondral transfer (OATS, mosaicplasty, etc.)
 - Osteochondral allograft
 - Most "classic" ACI & CACI (collagen-assisted ACI)
 - Direct osteochondral repair
- Initial underfilling expected
 - Microfracture
 - Cell-seeded scaffold ACI (MACI, Hyalograft-C, etc.)

Complete Fill Restores Articular Surface

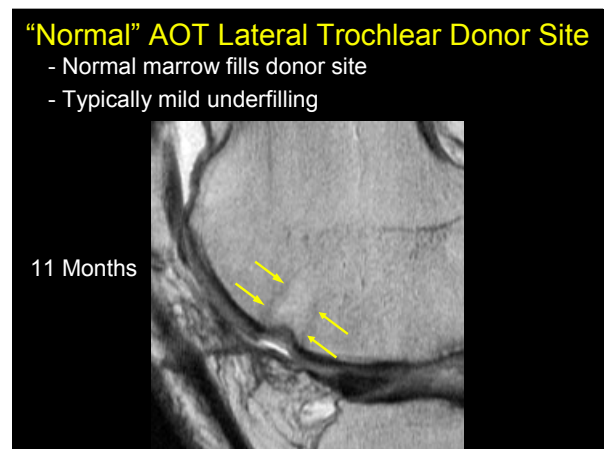
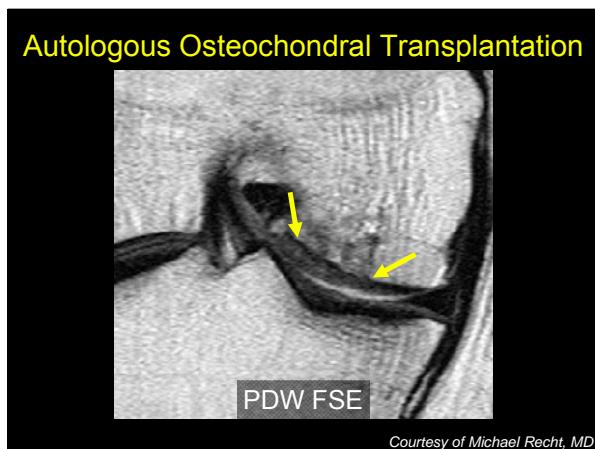
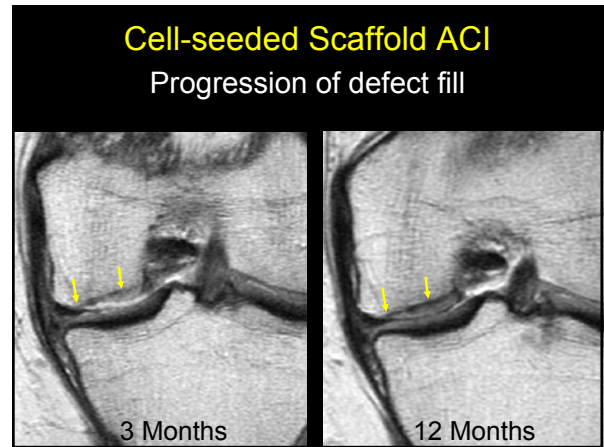
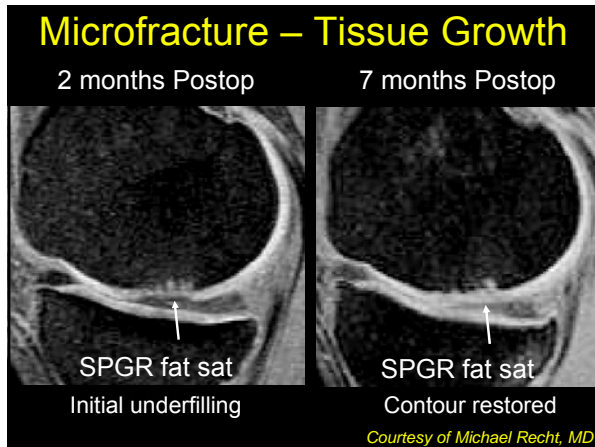
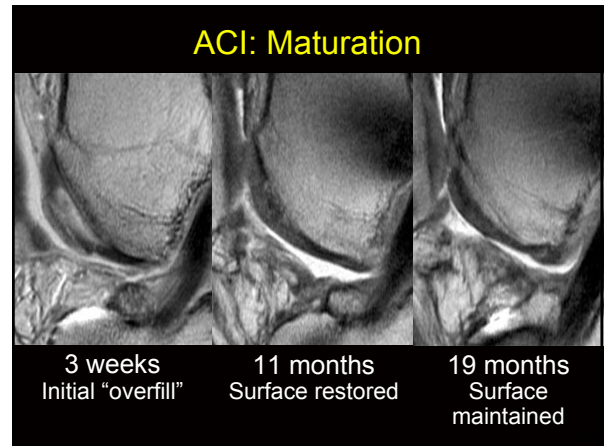
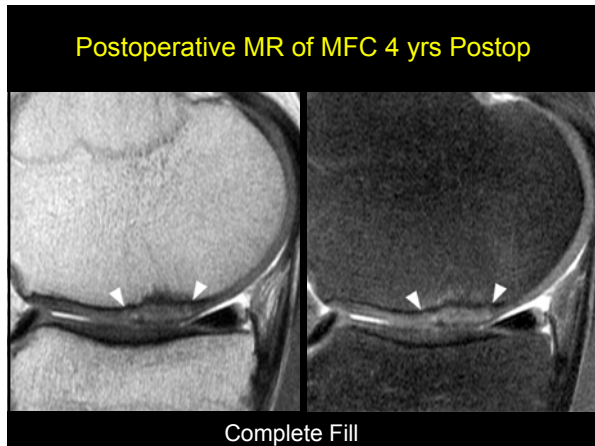
Repair of Osteochondral Defect with ACI



33 y.o. male ACI's of MFC, Trochlea, & Patella



Photos courtesy of Tom Minas, MD BWH Cartilage Repair Center



Abnormal Defect Fill

Drilling: Failure of Tissue Growth

- No defect fill
- Continued symptoms 6 months following drilling
- Cysts formed along drill tracks

Pre-operative: Lesions LFC, LTP

Failed Microfracture

Poor fill, cyst formation

Failed Microfracture

Poor fill, cyst formation

Scope courtesy Tom Minas, MD Cartilage Repair Center, BWH, Boston MA

ACI: Failure of Tissue Growth

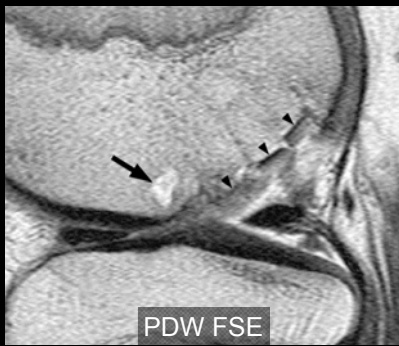
44 y.o. woman with catching symptoms 3 months after 25 x 16mm ACI to MFC for an osteochondral defect

3 mos. postop

PDW FS

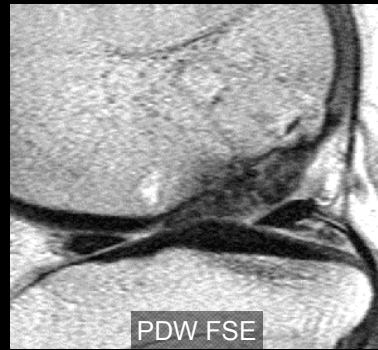
Scope courtesy of Tom Minas, MD BWH Cartilage Repair Center

Subsidence of Plugs – 3 months Post-op



Courtesy of Michael Recht, MD

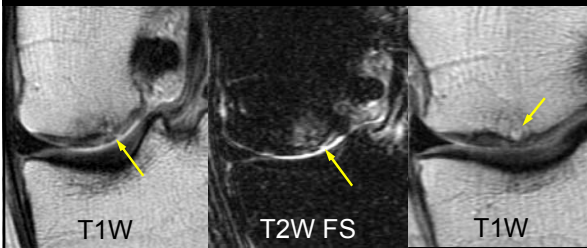
Restored Contour - 35 months Post-op



Courtesy of Michael Recht, MD

Degeneration of Repair Tissue

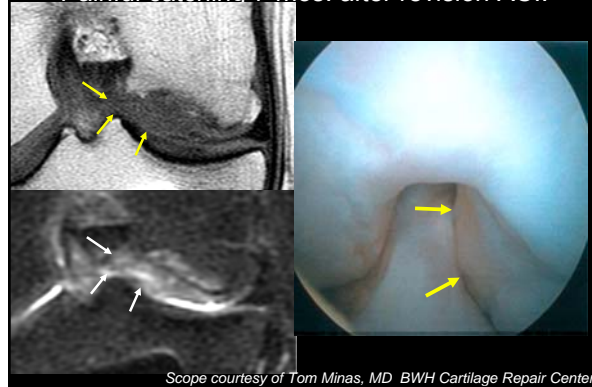
3 yrs. After Abrasion



Irregular contour, advancement of subchondral bone plate at base of lesion

ACI: Periosteal Hypertrophy

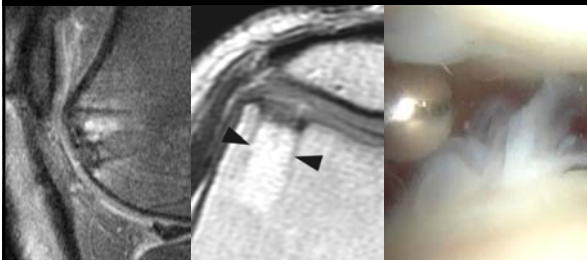
Painful catching 7 mos. after revision ACI:



Scope courtesy of Tom Minas, MD BWH Cartilage Repair Center

Referred for Painful Knee Donor Site

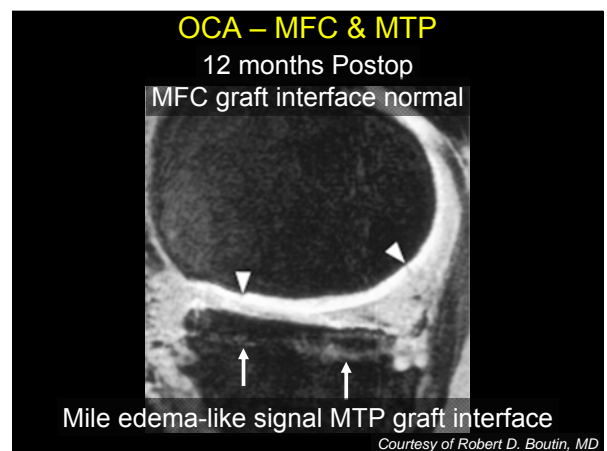
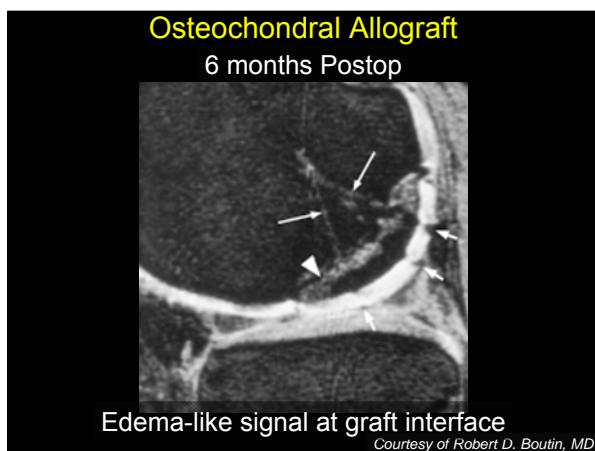
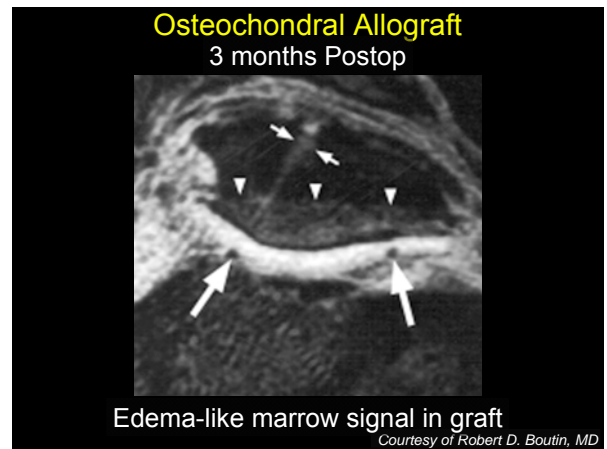
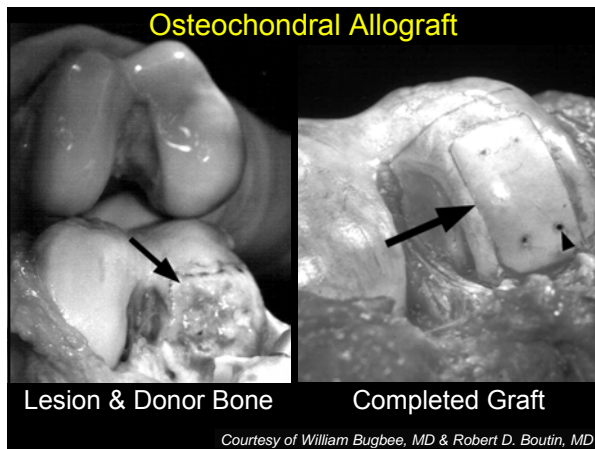
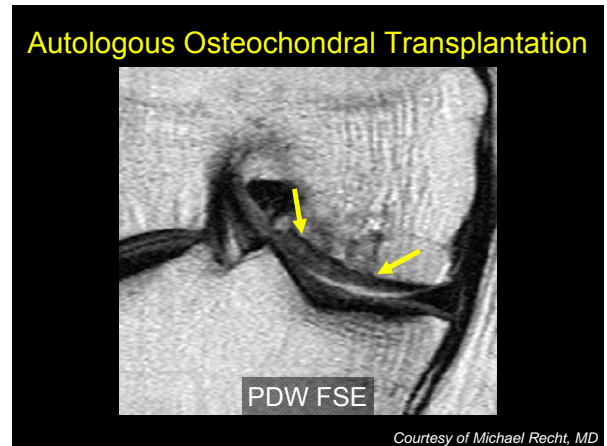
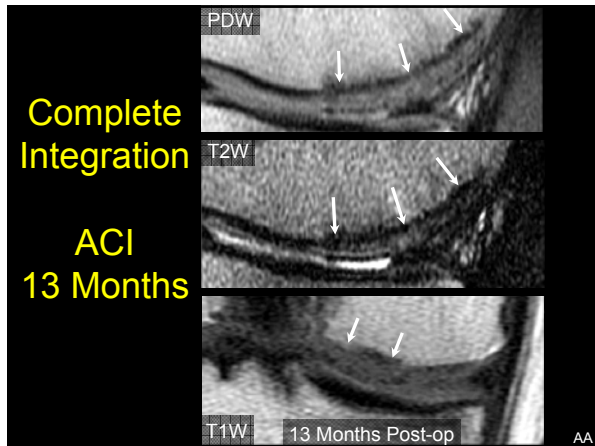
AOT – Knee to Talus



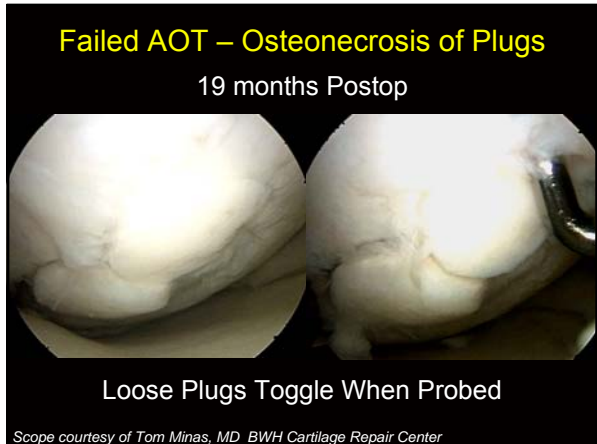
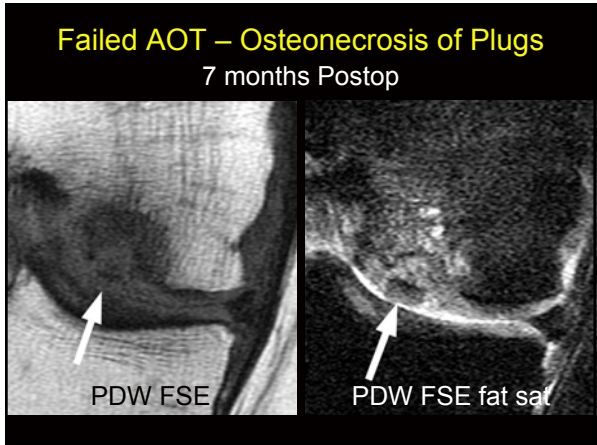
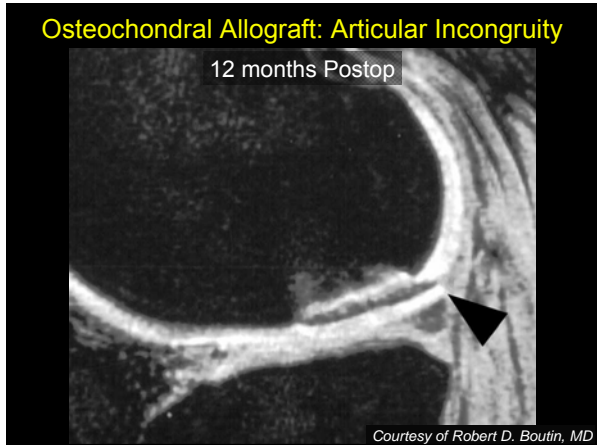
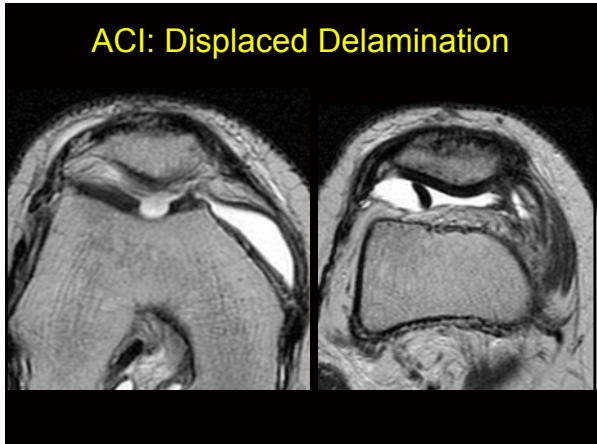
9 months Post-op: hypertrophic tissue
Not seen by MR, but marrow edema present

Scope courtesy of Tom Minas, MD BWH Cartilage Repair Center

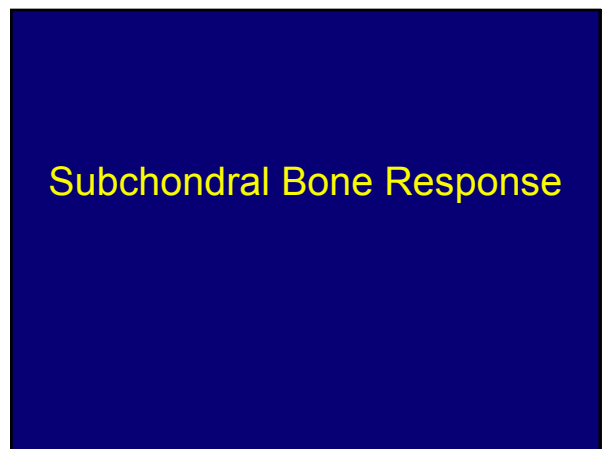
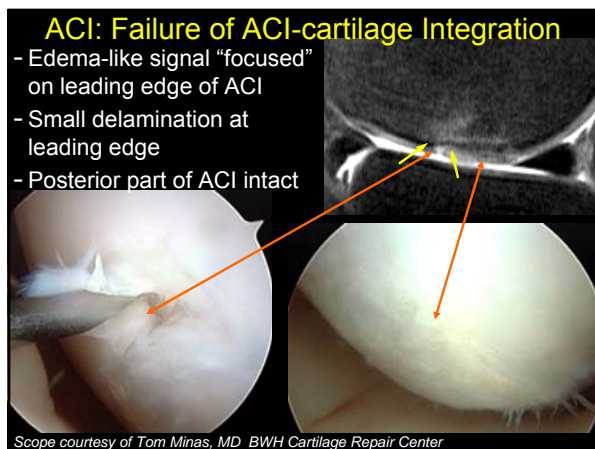
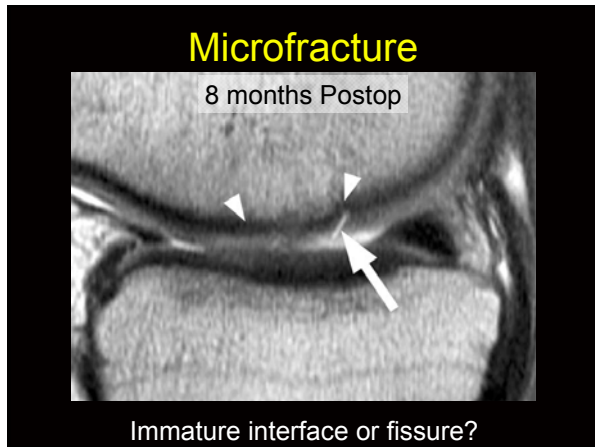
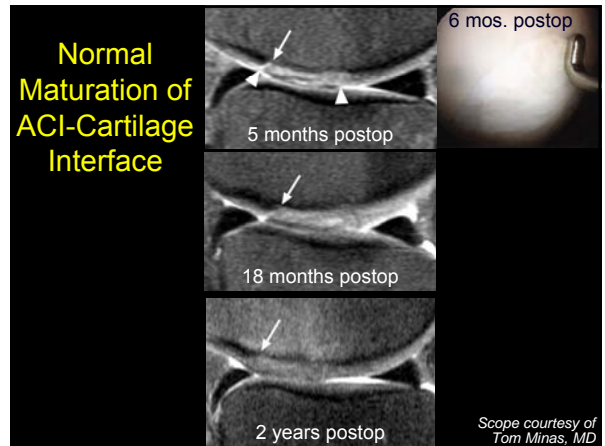
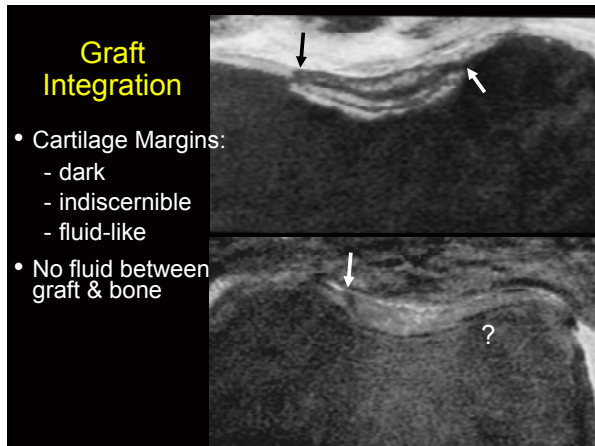
Repair-Bone Integration

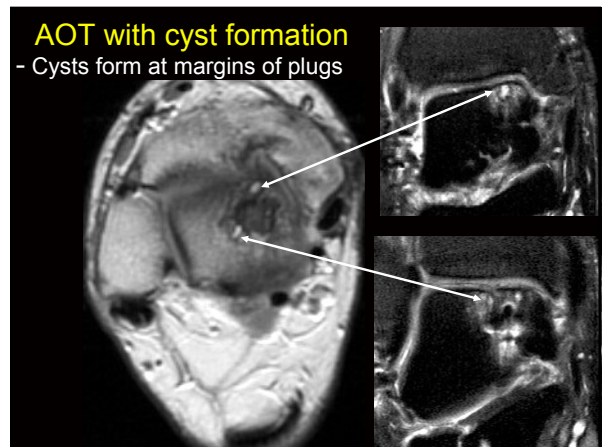
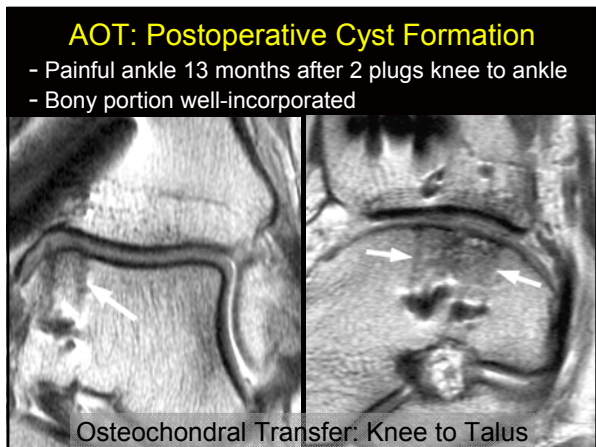
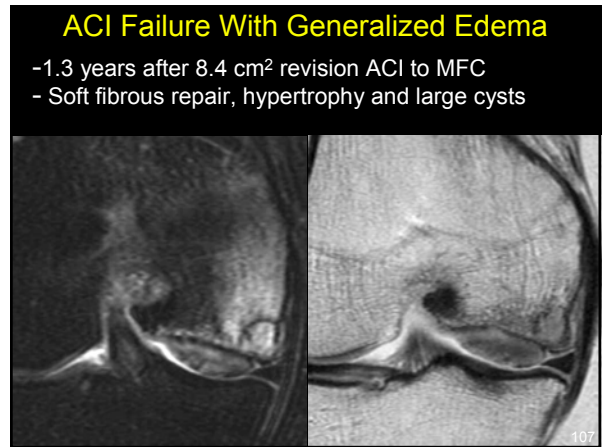
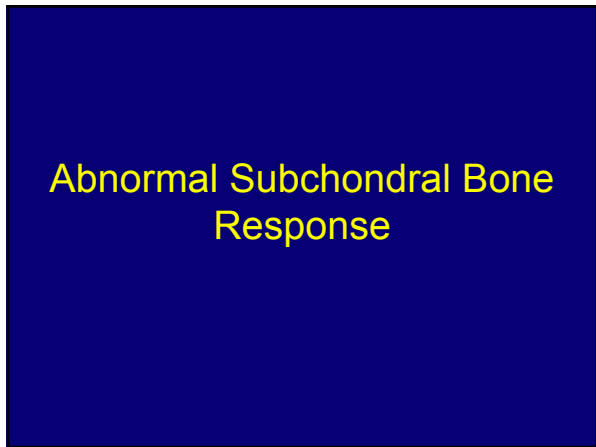
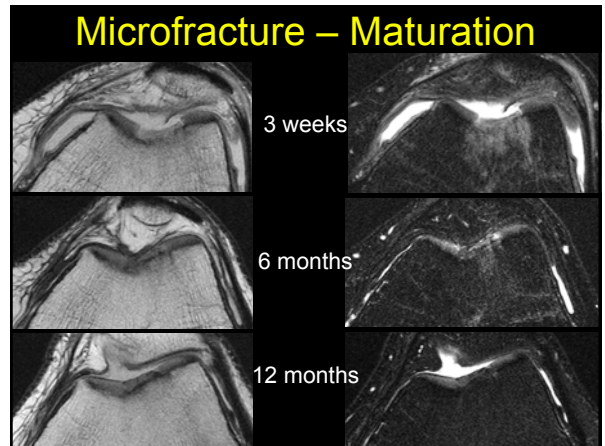
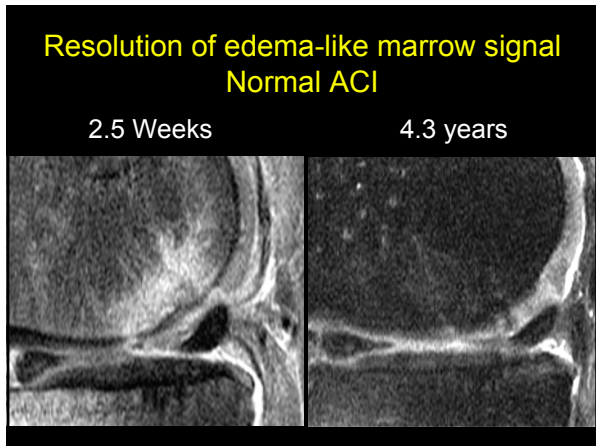


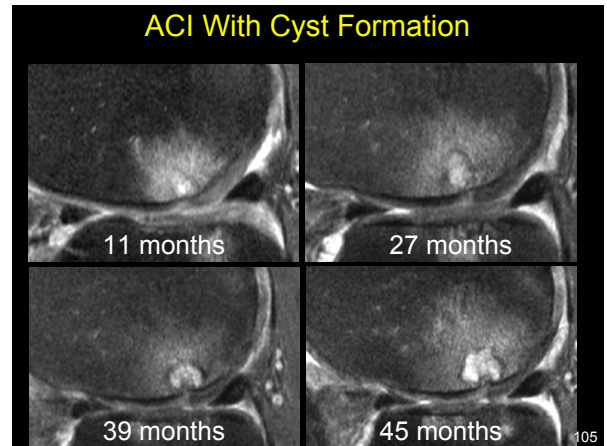
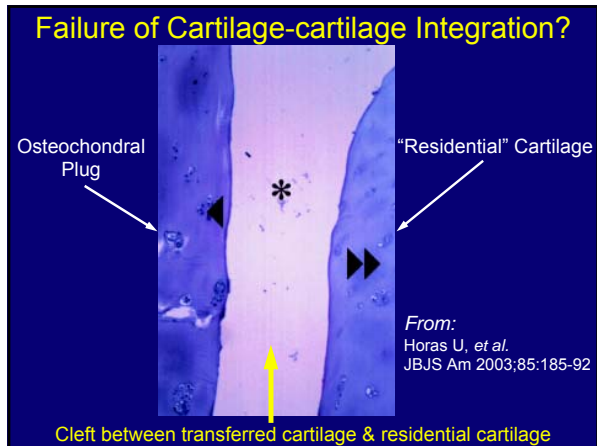
Failed Repair-Bone Integration



Repair-Cartilage Integration

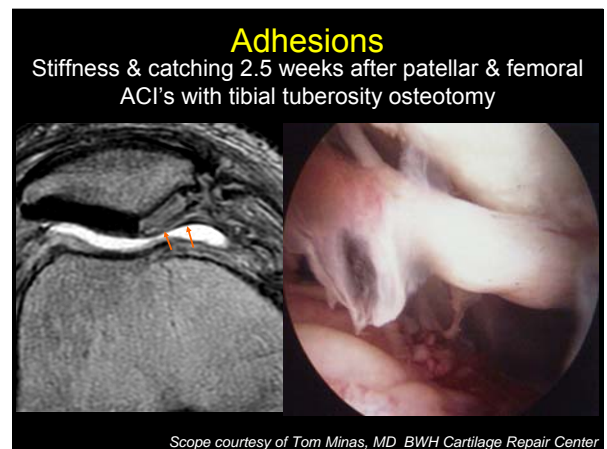
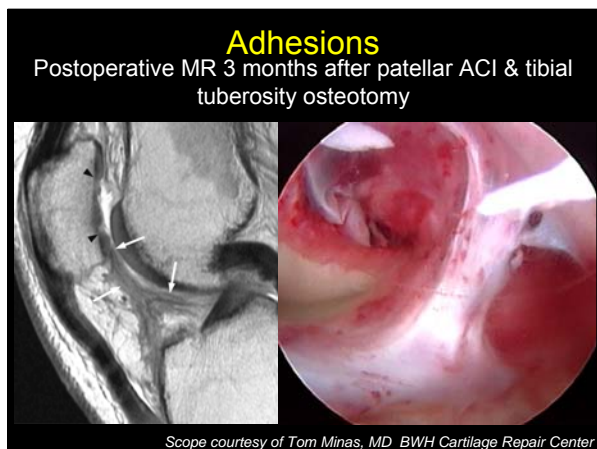
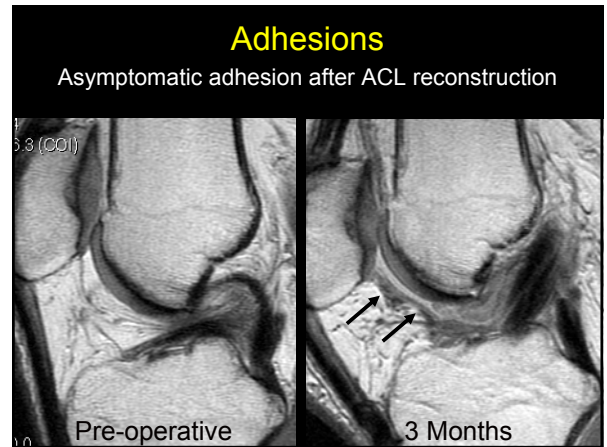


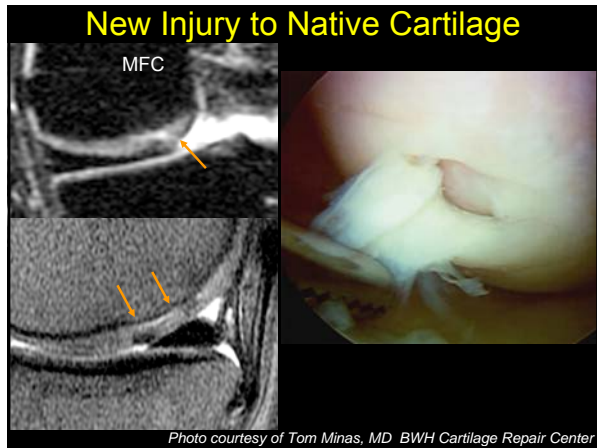




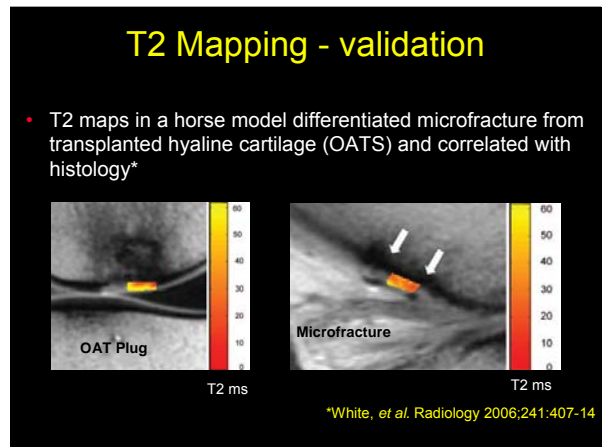
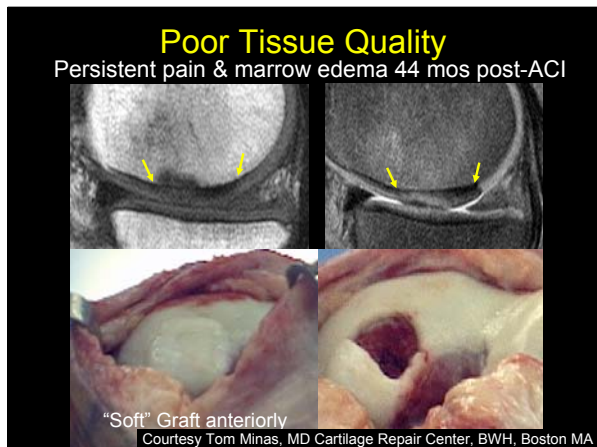
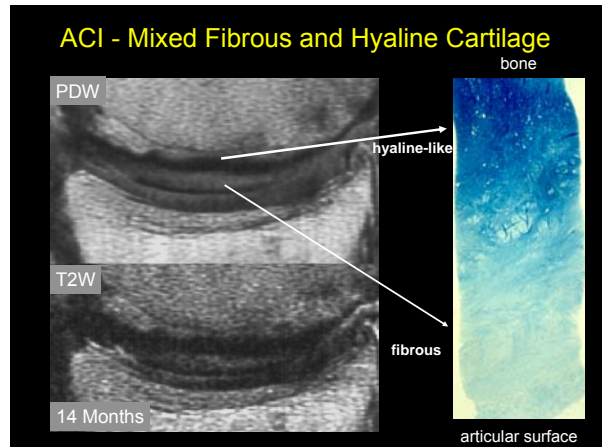
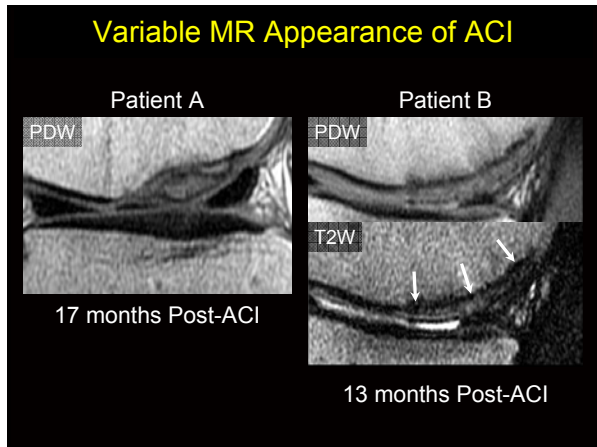
Non-Repair Site Complications

- Adhesions
- New lesions



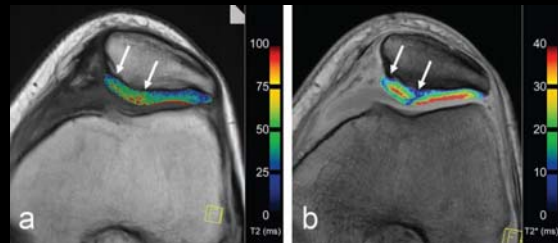


Repair Tissue Type



T2 - Clinical

- T2 information may be obtained using spin echo or gradient echo techniques. Arrows mark site of MACI



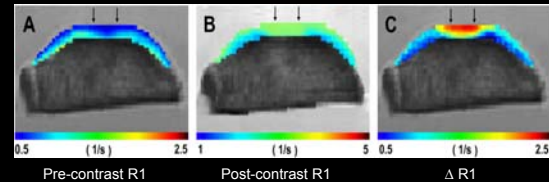
T2 map – spin echo using 6 echos
flip angle 180°

T2 map – gradient echo using 6 echos
flip angle 20°

*Trattig, *et al. Cartilage* 2011;2:5-26

dGEMRIC - validation

- dGEMRIC correlated with GAG in microfracture repair tissue in goat model.*
- T2 map did not correlate with biochemistry.*



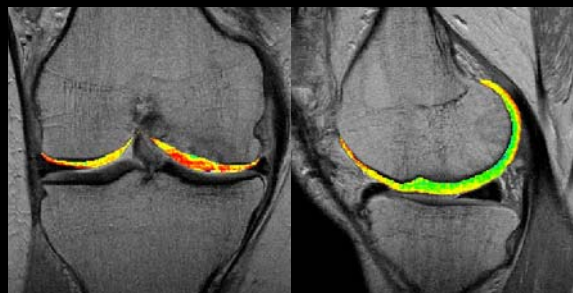
*Watanabe, *et al. OsteoarthritisCartilage* 2009;17:1341-9

ACI dGEMRIC Measurement of GAG

Gillis, *et al. Invest Radiol* 2001;12; p743-8

2 months post-op

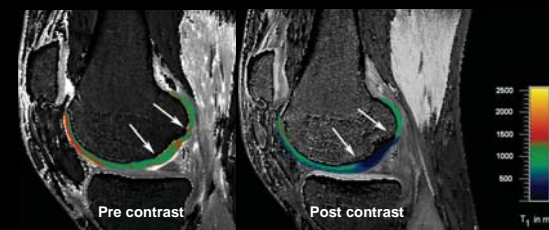
1.5 years post-op



Courtesy of D. Burstein, PhD BIDMC, Boston

dGEMRIC - Clinical 3D – dual flip angle T1 maps

- dGEMRIC demonstrates lower T1 in the MACI repair (arrows) postcontrast MR following ionic Gd-DTPA indicating GAG content of repair tissue is lower than native cartilage



*Trattig, *et al. J Magn Reson Imaging* 2007;26:974-82

Usefulness of MR in Evaluation of Cartilage Repair

- What is the cause of symptoms?
 - adhesions
 - delamination
 - hypertrophy
 - underfilling or tissue loss
 - poor integration of repair tissue
- Assists in planning surgical intervention or alleviating patient anxiety (continue rehab.)
- Determination of repair tissue type remains a work in progress

Close communication with Orthopedist

- Know graft locations & clinical questions *before* MR
- Post-MR, preoperative working conference with orthopedist
- Post arthroscopy correlation with MR findings