Articular Cartilage Injury of the Knee: Evaluation and Management

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Disclosures

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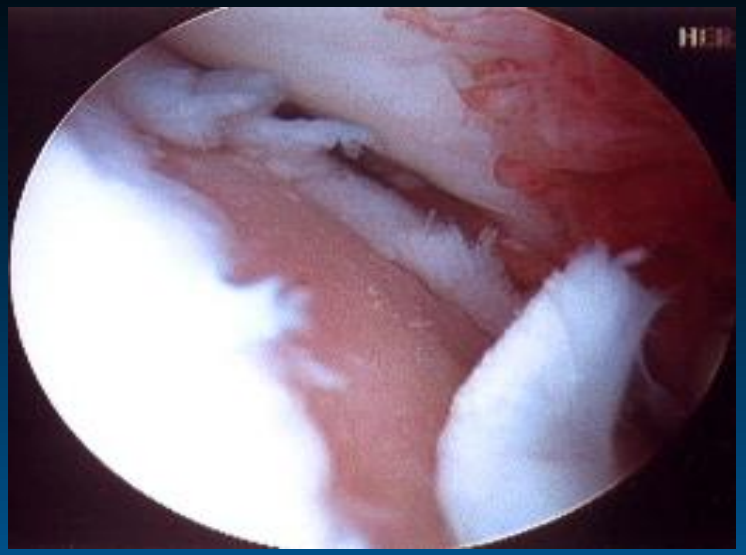
Etiology of Chondral Injuries

- Sports trauma
- Work related or other trauma
- Chronic instability
- Malalignment
- Meniscal pathology
- OCD
- Obesity

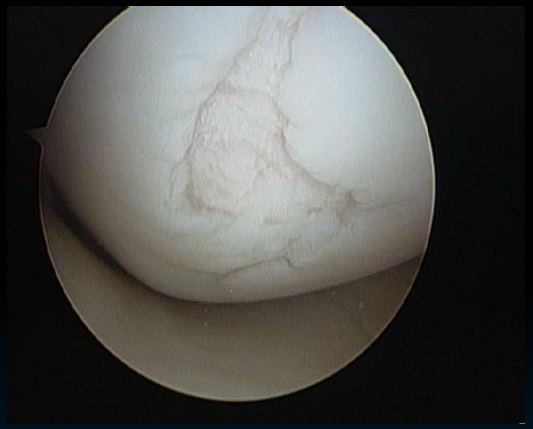


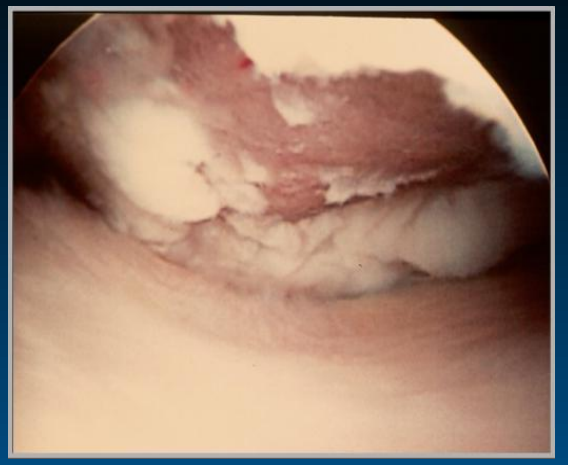
Clinical Challenge

- Articular cartilage has poor intrinisic capacity for healing and repair
- Avascular chondrocytes cannot migrate to area of repair
- Causes significant disability by limiting employment,sports participation, and ADL's
- Determines outcome of reconstructive surgery
- May progress to end stage osteoarthritis

Incidence of Chondral Injury

- 5-10% of acute knee hemarthrosis[1]
- 31,516 knee arthroscopies[2]
  - 60% Outerbridge grade III-IV lesions
  - 5% of grade IV lesions in patients < 40 years old.
- 61% of 1000 knee arthroscopies[3]
  - 42% w/ ACL or MM injury
  - 58% chondral lesions on MFC





Staging of Chondral Injuries

- Based on diagnostic arthroscopy findings

- **<u>Outerbridge</u>**

  Type I. Softening, swelling

  II. Fragmentation and fissuring, ≤ 1.5 cm

  III. Fragmentation and fissuring, > 1.5 cm

  IV. Cartilage erosion to subchondral bone

Staging of Chondral Injuries

- **ICRS**

  Normal

  Grade I. Superficial fissures

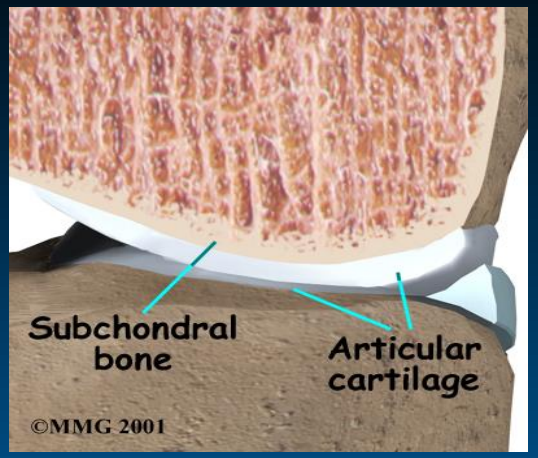
  II. ≤ 50% cartilage depth

  III. > 50% cartilage depth to subchondral plate

  IV. OC lesions through subchondral plate

Biomechanics of Articular Cartilage

- Reduces contact stresses
- Reduces shearing and compression forces
- Reduces friction
- Low wear surface
- Distributes load



Articular “Hyaline” Cartilage

- One cell type - Chondrocytes
- Primarily extracellular matrix
- Nourished by synovial fluid
- No blood supply
- No nerves
- No lymphatics

Structure and Composition

Porous Biphasic Material

Fluid

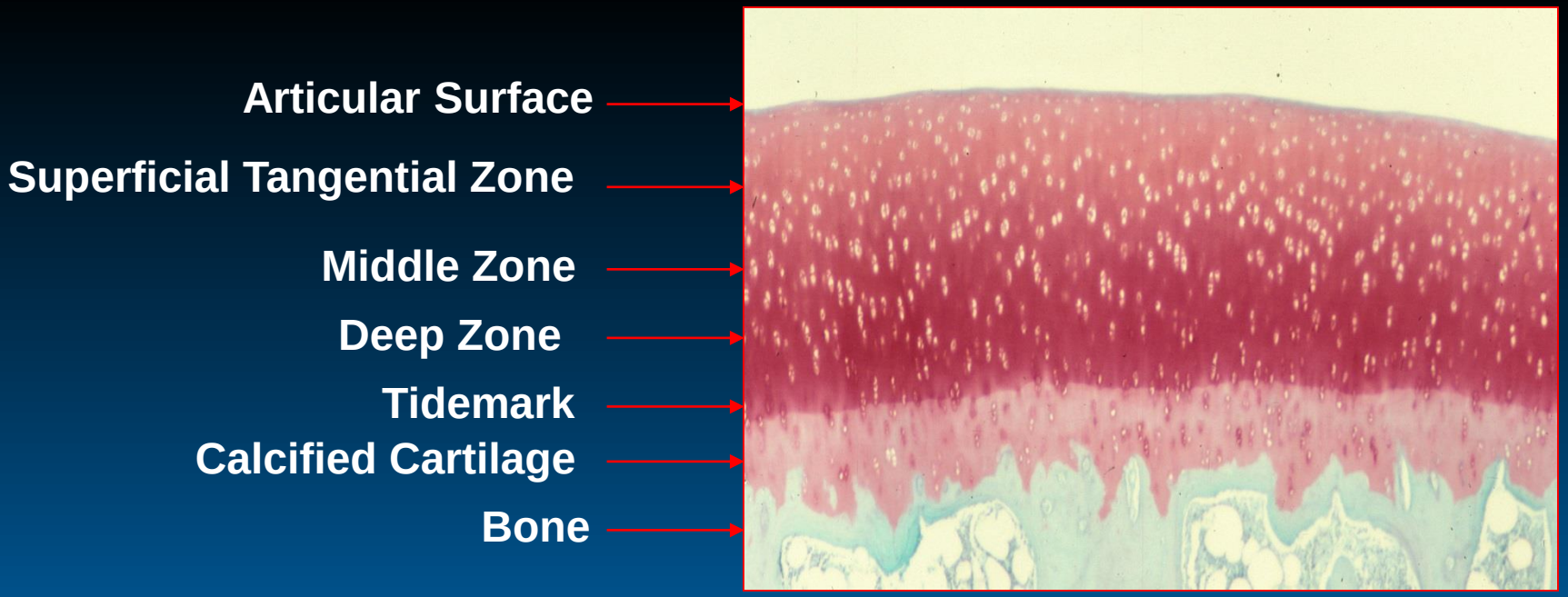
- 65-80% water
- Flow
  - Resistance to flow pressurizes supports load
  - Nutrient Transport

Solid

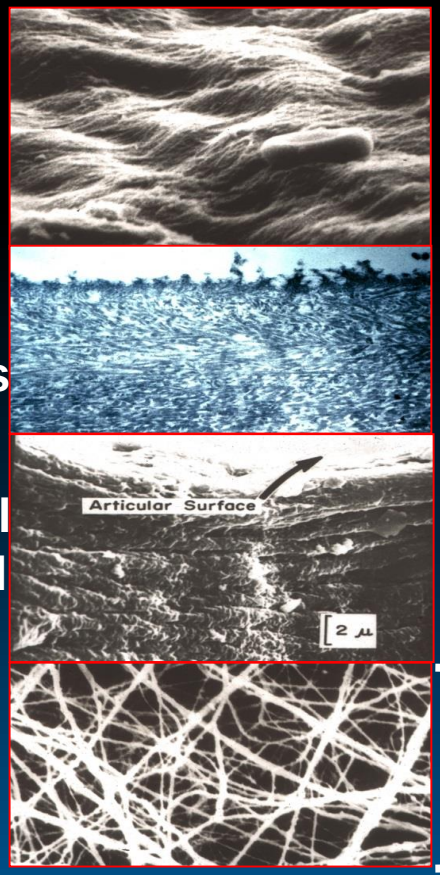
- 60-70% collagen (dry weight)
  - Majority Type II (also V, VI, IX, X, XI)
- 5-15% PG (dry weight)
  - Chondroitin, Keratan and Dermatan sulfate
- 10-25% chondrocytes

Structure and Composition

Zonal Distribution



Structure and Composition



Articular Surface

Densely Packed Collagen Fibrils Low Porosity

Lamina Splendens

Superficial Tangential Zone

High Water High Collagen Low Proteoglycan Low Porosity

Middle & Deep Zones

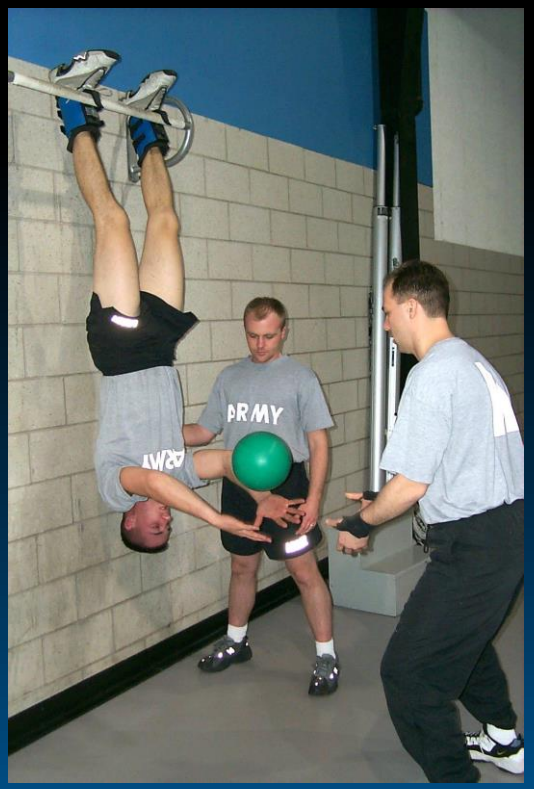
Lower Water Lower Collagen Higher Proteoglycan High Porosity

Goals of Treatment

- Restore articular cartilage surface
- Relieve patient symptoms and improve function
- Match biomechanical properties of normal hyaline cartilage
- Prevent or slow progression of focal chondral injury to DJD

Patient Evaluation

- Symptoms
  - Pain
  - Catching
  - Crepitus
  - Effusion
- Patient expectations

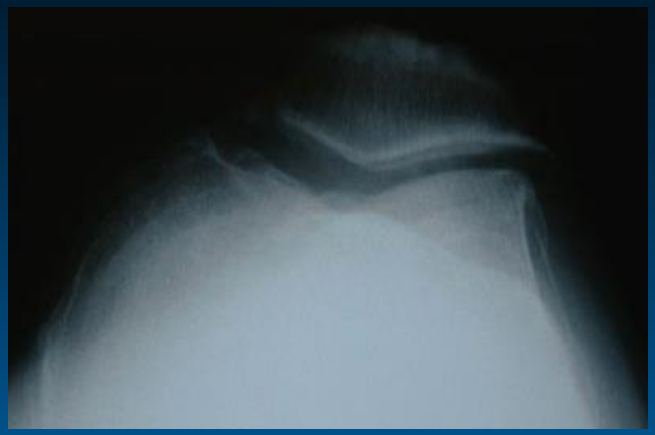


Physical Examination

- Inspection
  - Stance/alignment
  - Gait
  - Incisions
- Palpation
- Range of motion
- Laxity
- Effusion
- Strength

Radiographic Evaluation

- Plain radiographs
  - Weight bearing AP
  - Flexion PA weight bearing
  - ***Long leg alignment***
  - Sunrise view

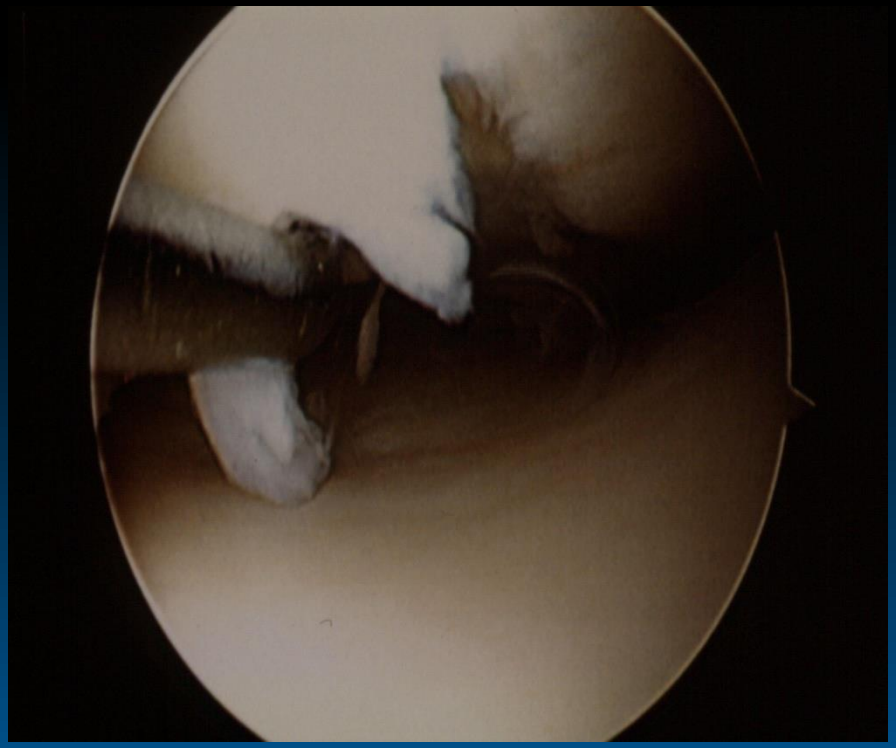


Radiographic Evaluation

- MRI – Articular Cartilage Imaging
  - Fat suppressed, 3D spoiled gradient echo images
  - Modified fast spin echo techniques
  - Lesions 1 mm deep and/or 3 mm wide can be visualized

Radiographic Evaluation

Diagnostic Arthroscopy



Identify the Pain Generator!

- Asymptomatic chondral lesions of the knee are VERY common…
  - 47.5% of asymptomatic athletes - Kaplan et al 2005

- Use history and physical exam to confirm the cartilage lesion you are seeing on imaging is the source of their pain
  - Location
  - Mechanical Symptoms
  - Effusions
  - Response to corticosteroid inj

Treatment of Chondral Injuries

- Non-operative
- Operative

Non-Operative Treatment

- NSAIDs
- Cortisone injections
- Viscosupplementation
- Unloader braces

Operative Treatment

- Lavage and debridement
- Fragment Fixation
- Marrow Stimulating Techniques
- Cartilage Transfer/ Osteochondral Grafts
- Cell Based Treatments

Dressed for Success…

- Environment must be conducive to Chondral Health
  - Best to treat isolated chondral injury
  - Opposing articular surface ≤ grade I-II chondromalacia
  - Ligamentous stability
  - Normal alignment
  - Meniscus integrity
  - Patient compliance
    - Rehab protocol

Lavage and Debridement

- Arthroscopic Lavage & Debridement
  - Removal of degenerative articular cartilage debris
    - Remove unstable flaps
    - Decreases degradative enzymes

Lavage and Debridement

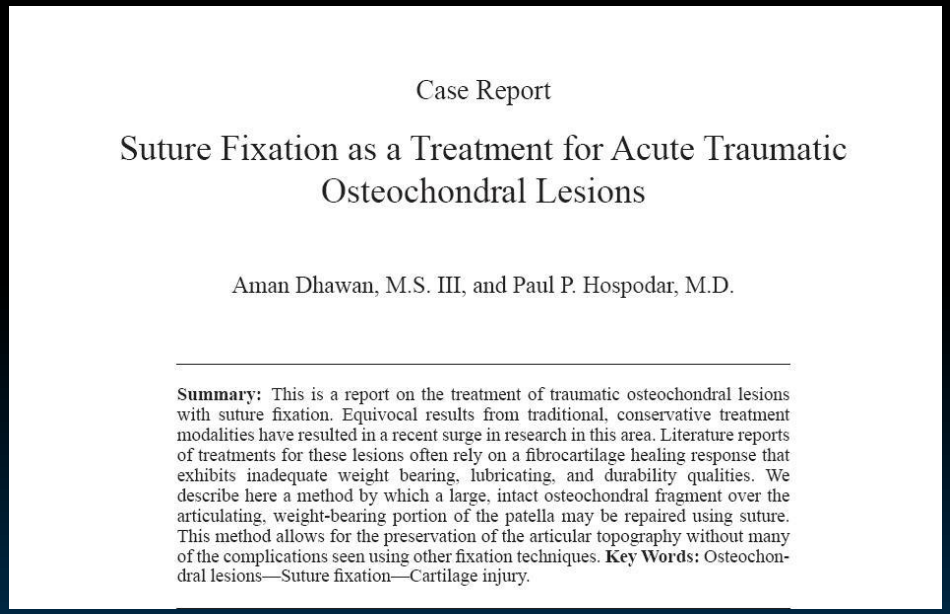
- Arthroscopic Lavage & Debridement
  - Indications
    - Lesions < 1 cm^2
    - Failure non-operative treatments
  - Techniques
    - Removal of unstable cartilage
    - Mechanical debridement

Lavage and Debridement

- Arthroscopic Lavage & Debridement
  - Results
    - 74% good at 14 months.[4]
    - 66% improved at average 3.5 yr follow-up.[5]
    - 63% good at 4 years.[6]
    - > 50% improved at 4.5 years.[7]

Fragment Fixation

- Subchondral bone attached
- Fixation options to include chondral darts, pins, compression screws, suture
- Implant may have to be removed at a later date – espec if non-absorbable



Case Report

Suture Fixation as a Treatment for Acute Traumatic Osteochondral Lesions

Aman Dhawan, M.S. III, and Paul P. Hospodar, M.D.

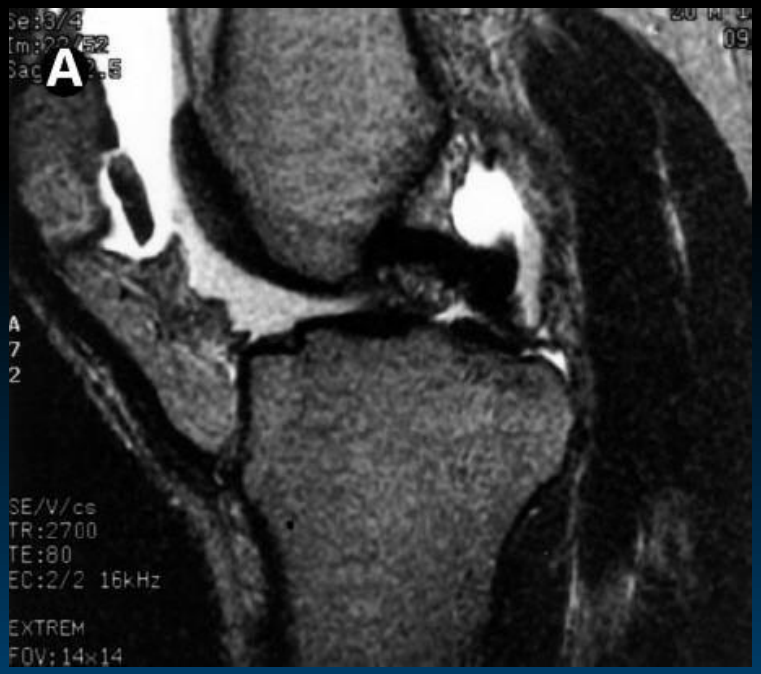
Summary: This is a report on the treatment of traumatic osteochondral lesions with suture fixation. Equivocal results from traditional, conservative treatment modalities have resulted in a recent surge in research in this area. Literature reports of treatments for these lesions often rely on a fibrocartilage healing response that exhibits inadequate weight bearing, lubricating, and durability qualities. We describe here a method by which a large, intact osteochondral fragment over the articulating, weight-bearing portion of the patella may be repaired using suture. This method allows for the preservation of the articular topography without many of the complications seen using other fixation techniques. **Key Words:** Osteochondral lesions—Suture fixation—Cartilage injury.

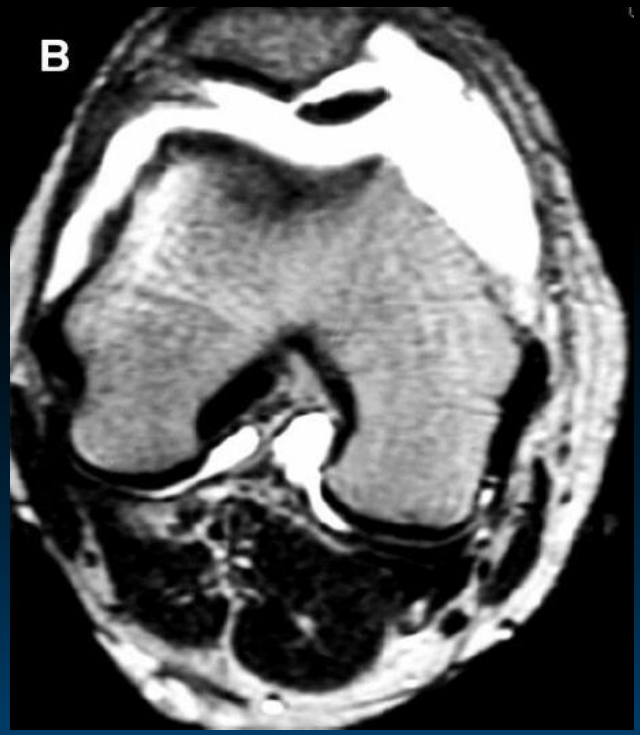
Dhawan A, Hospodar PP. Suture Fixation as a Treatment for Acute Traumatic Osteochondral Lesions. Arthroscopy 1999; 15: 307-311

Case Report

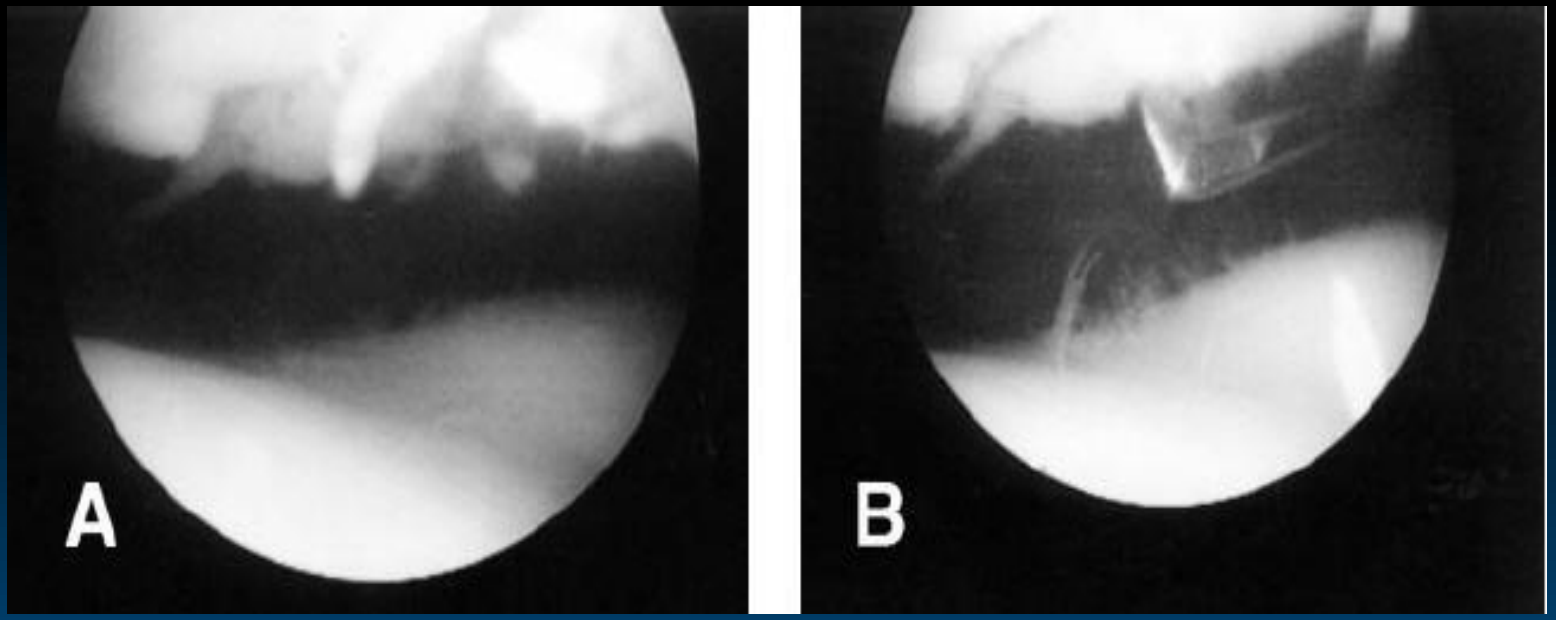
- 19 yr old male injured right knee playing basketball

MRI

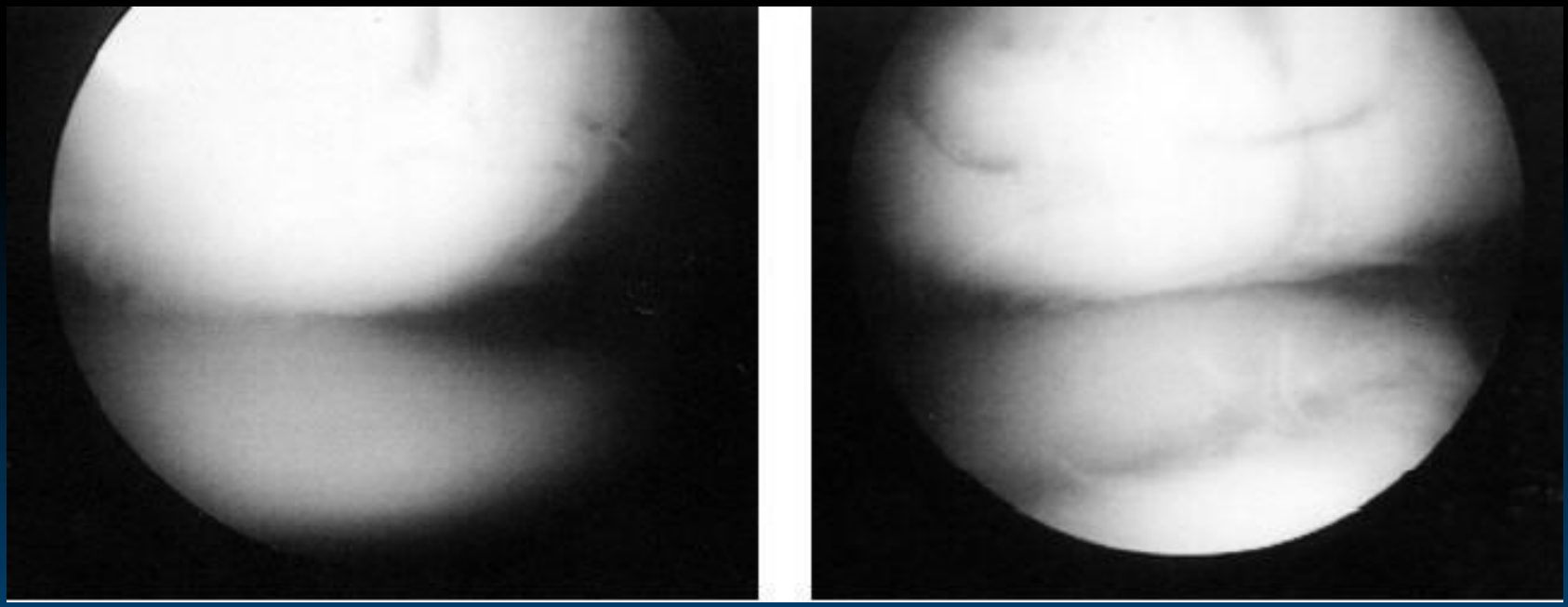




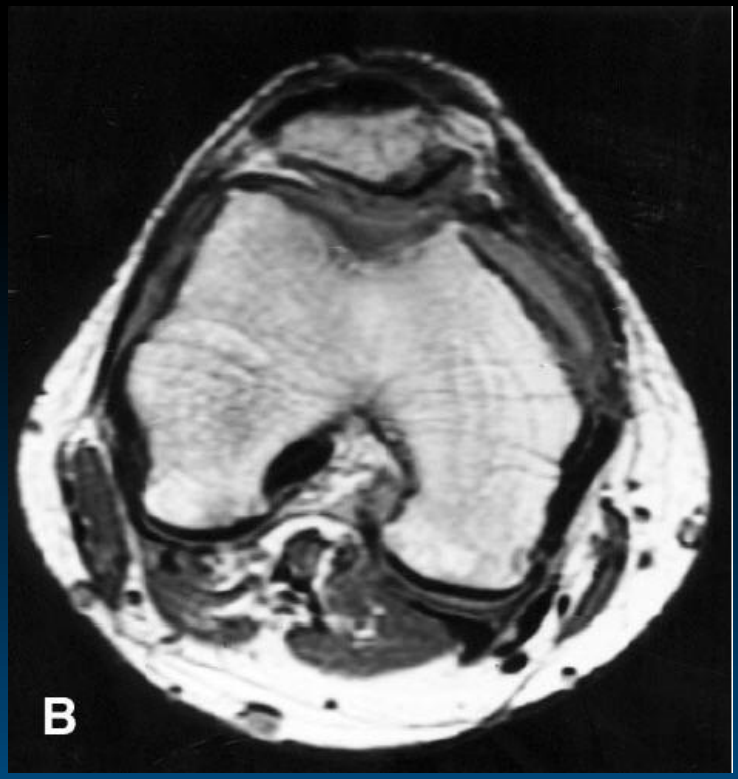
Scope Pics



Scope Pics post suture fixation



6 month postop MRI



8 month postop pickup game

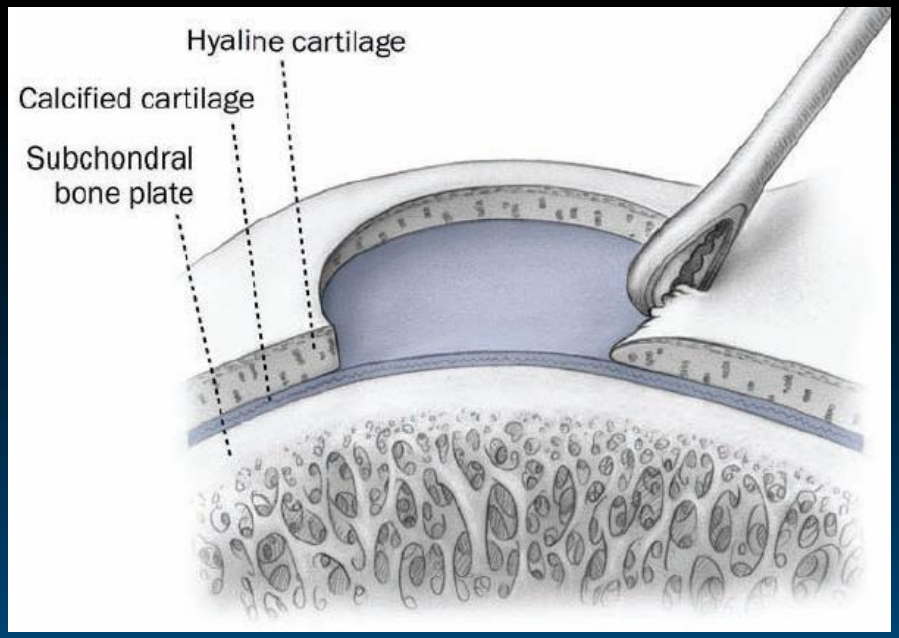
Marrow Stimulating Techniques

- **Principle:** Delivery of pluripotential marrow stem cells to articular surface with fibrocartilage coverage of lesion.
- Methods:
  - Drilling
  - Abrasion chondroplasty
  - Microfracture

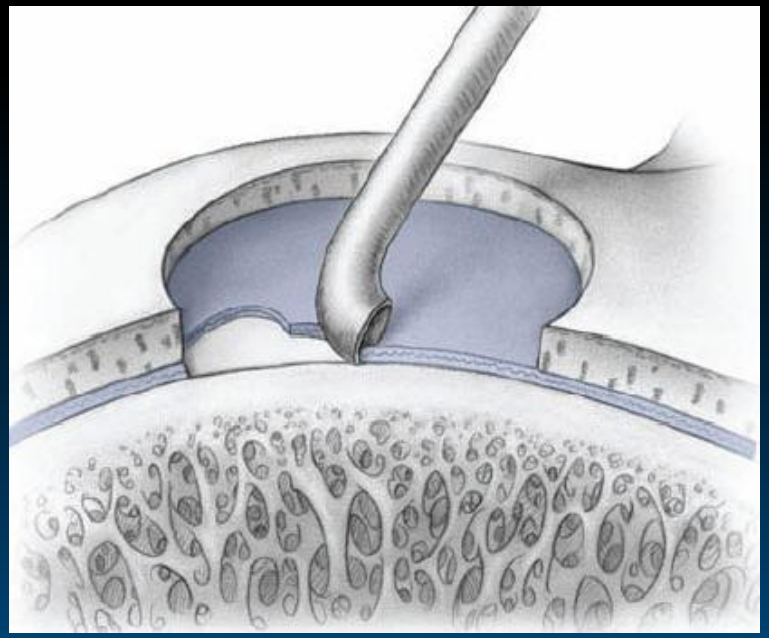
Microfracture

- Microfracture
  - Indications
    - Ideal for lesions < 2 cm^2 located on femoral condyle.
      - Lesions < 4 cm^2 tend to have less post-op pain.
    - Better outcome if within 12 weeks of injury.
    - More predictable “fill” of FC & trochlea lesions than patella or tibia.

Microfracture

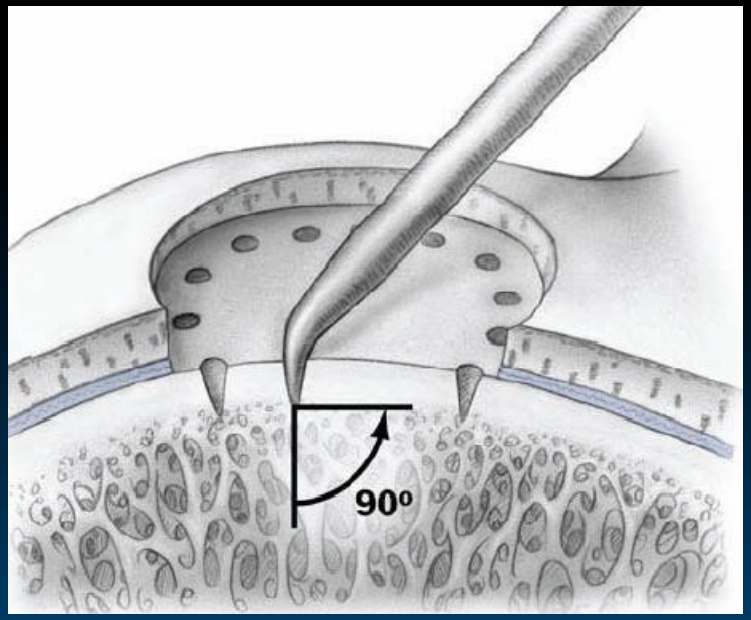


Remove unstable cartilage

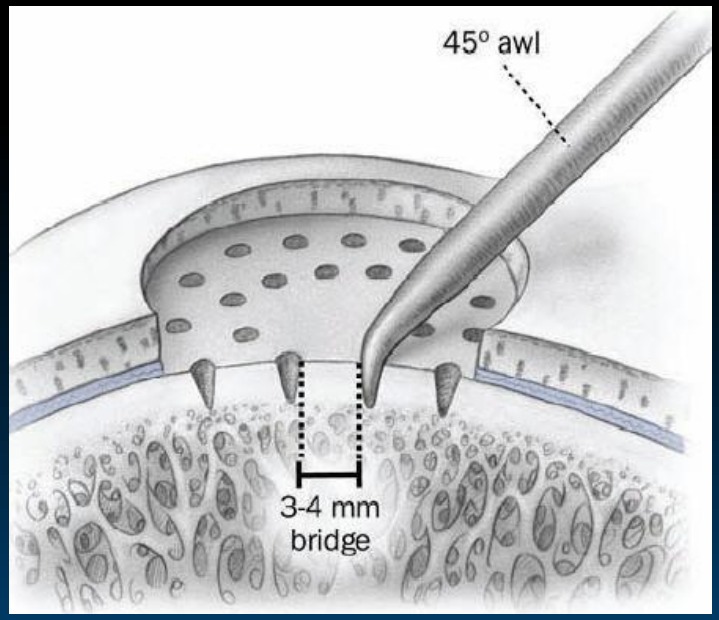


Remove calcified cartilage layer

Microfracture

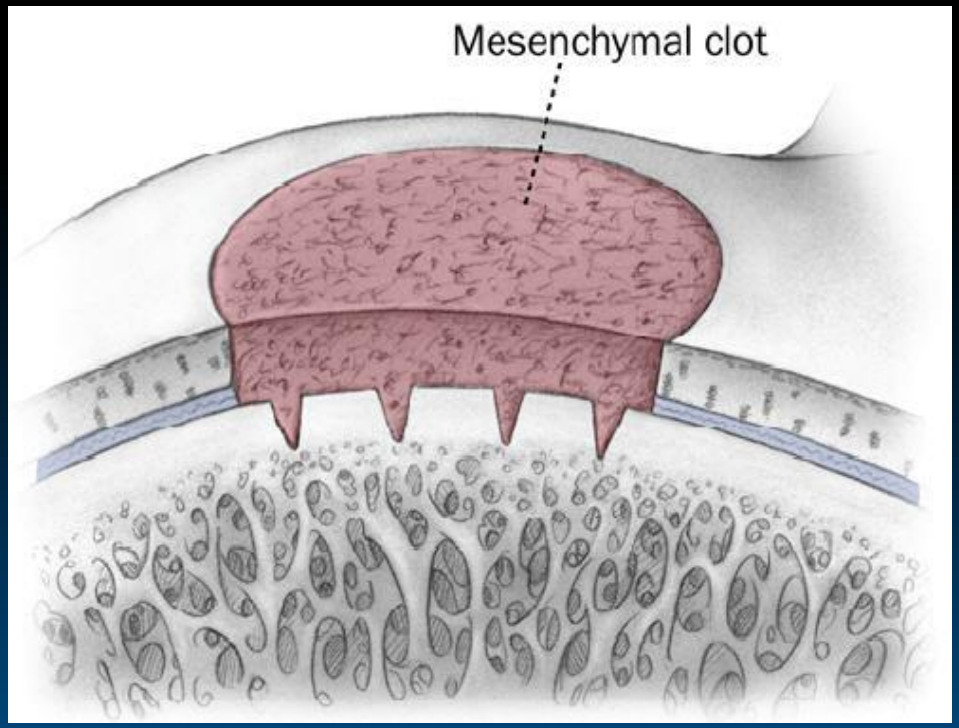


Penetrate subchondral bone using awl



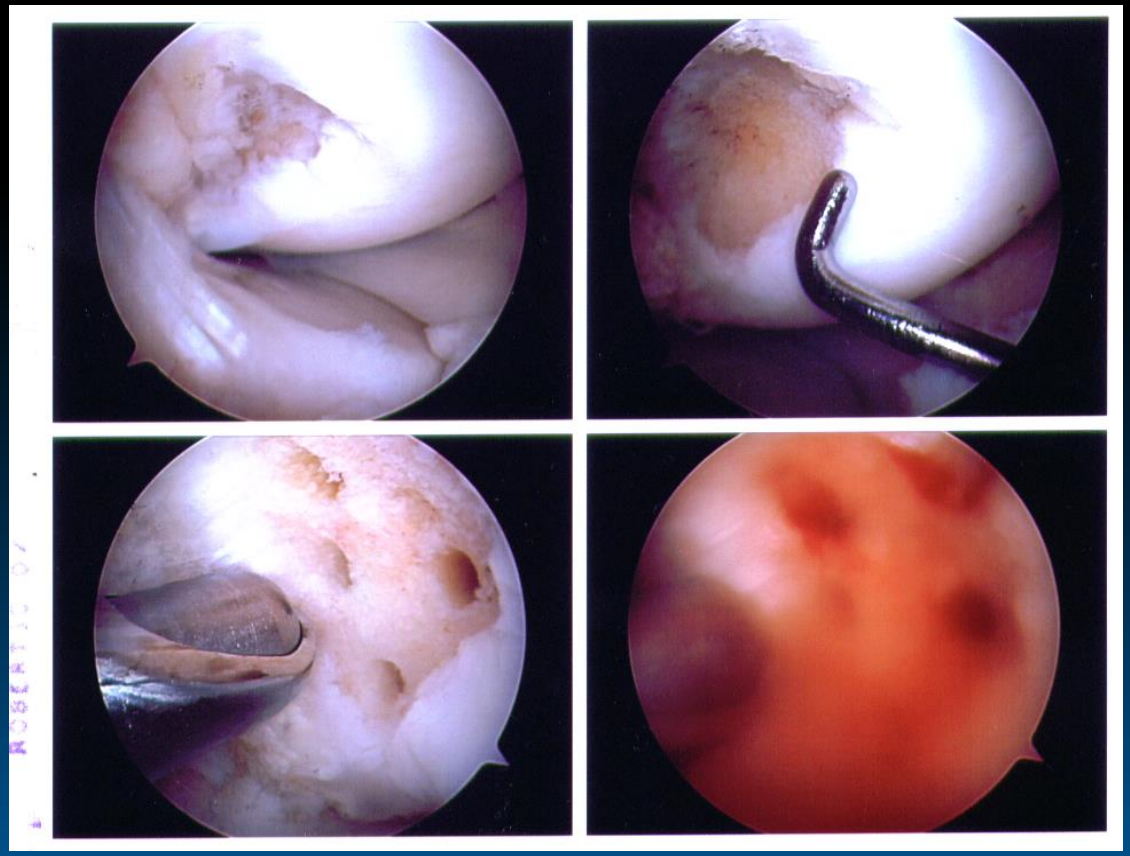
Spread penetrations approximately 3-4 mm apart. Begin at periphery.

Microfracture



Pluripotent mesenchymal clot fills defect

Microfracture



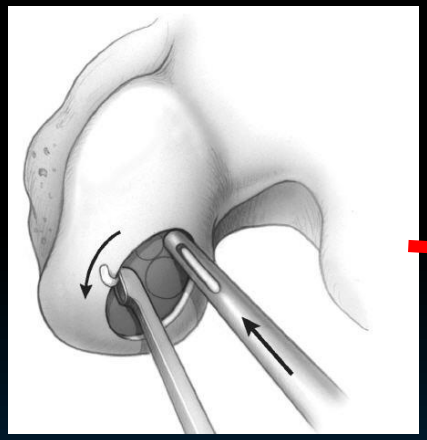
Microfracture

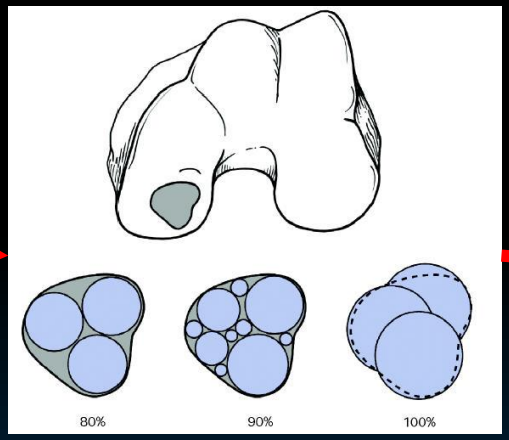
- Microfracture
  - Results
    - *Steadman, 2003:* 75 knees, @ follow-up 11.3 years; 80% improved, 15% same, 5% worse.[11]
      - Most consistent results in pts < 45 years old, with full-thickness chondral defect.
    - *Gobbi, 2004:* 53 patients, @ follow-up 6 years, 80% w/ eventual decline in sports activity.[13]

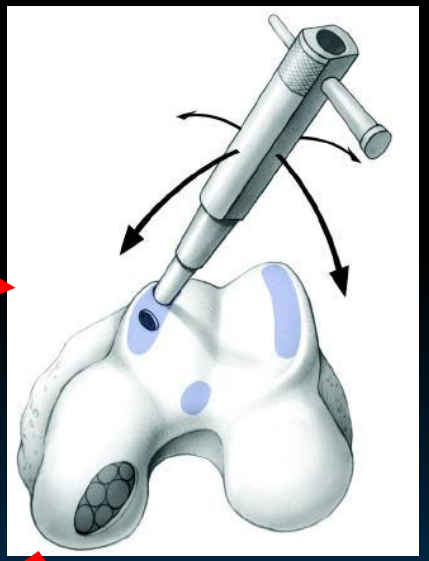
Osteochondral Grafting

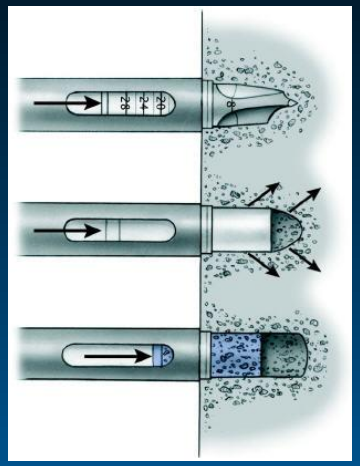
- Autografts (OATs procedure / Mosaicplasty)
  - Restores the height and shape of articulating surface with autologous material. Has already formed microarchitecture and inherent Time Zero strength
  - Main disadvantage - limited availability of donor tissue.

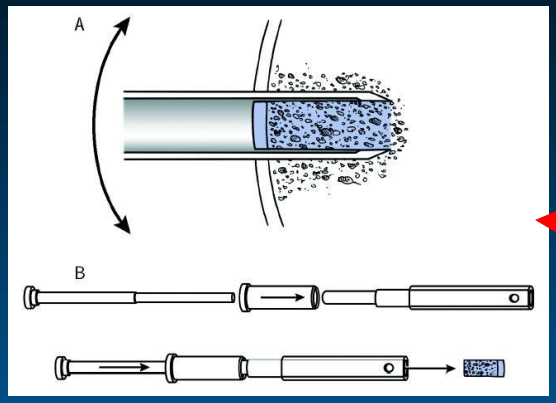
OATs / Mosaicplasty





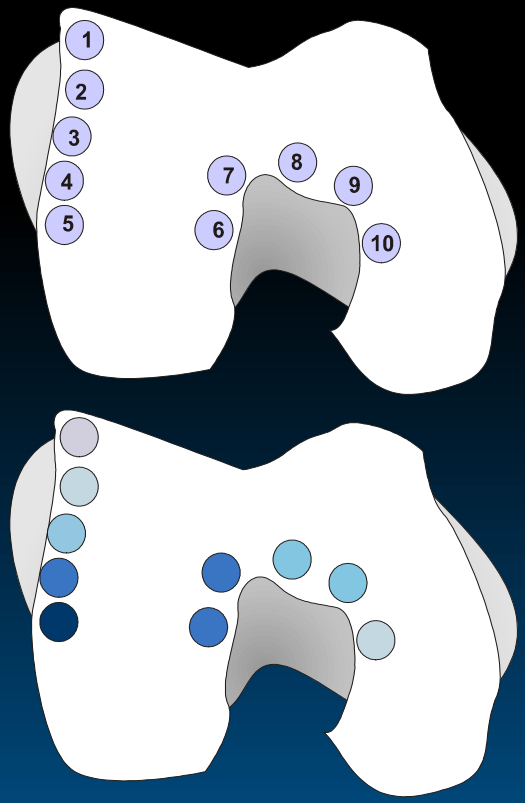






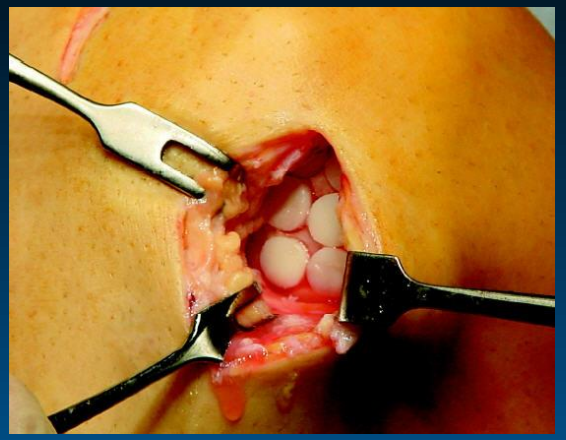
OATs / Mosaicplasty

- Harvest site contact pressures
  - Least @ outer MFC, notch, and inferior LFC near sulcus terminalis.[14,15]



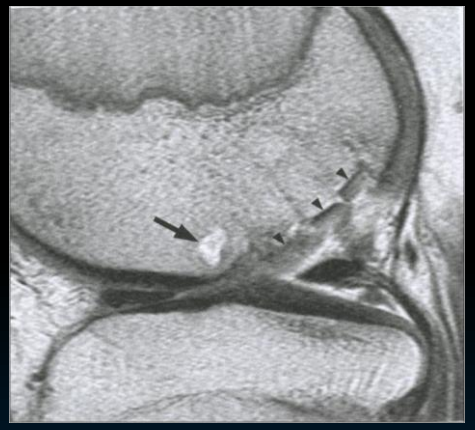
OATs / Mosaicplasty

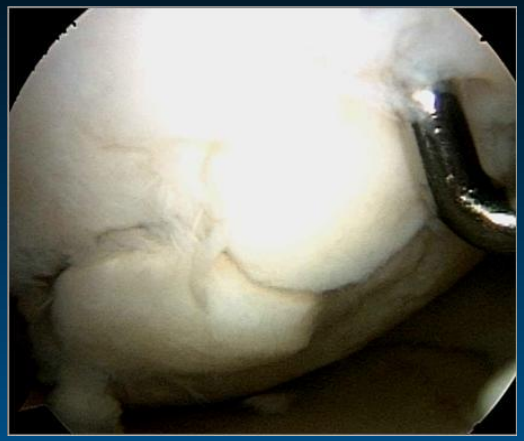
- Graft Curvature[16]
  - MFC and LFC articular defects
    - Grafts from convex surfaces of outer MFC or LFC
  - Trochlea defects
    - Best matched with notch harvest sites



OATs / Mosaicplast

- OATs procedure / Mosaicplasty
  - Complications
    - Hemarthrosis, effusion
    - ***Donor site pain***
    - Graft fracture
    - Graft delamination
    - Loose bodies
  - Marginal chondrocyte death.





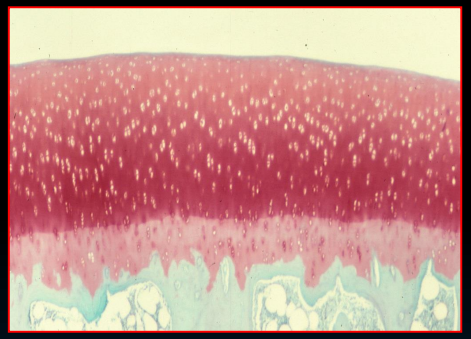
OATs / Mosaicplasty

- OATs procedure / Mosaicplasty
  - Results
    - *Hangody, 1997:* 102 “Mosaicplasty” patients @ 32 months follow-up, 102/107 rated good/excellent.[19]
    - *Koulalis, 2004:* 18 patients @ 27 months follow-up, mean defect size 252 mm^2, post-operative ICRS score normal for 12 patients.[20]
    - *Hangody, 2003:* 831 patients @ 2-10 years follow-up, good/excellent results in 92% femoral, 87% tibial, 79% patellofemoral, and 94% talar implants.[21]
      - 83 2nd look arthroscopies: 69/83 survival hyaline cartilage.
    - *Chow, 2004:* 33 patients @ 3.8 years; no difference between patients < 45 years old and > 45 years old (mean: 46 years old).[22]

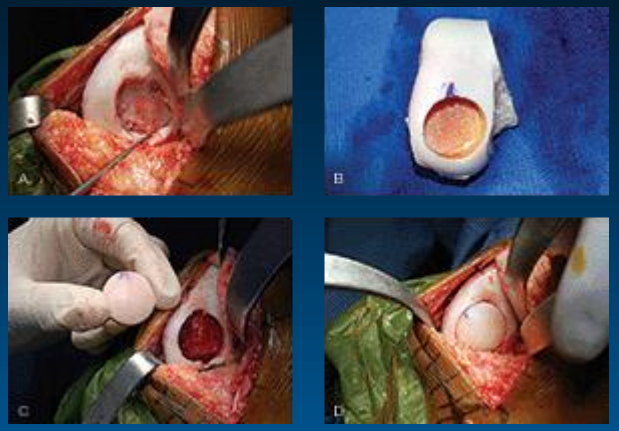
Osteochondral Allografts

- **<u>Major advantage:</u>** Transplantation of architecturally mature hyaline cartilage

  …..with NO donor site morbidity!!!!



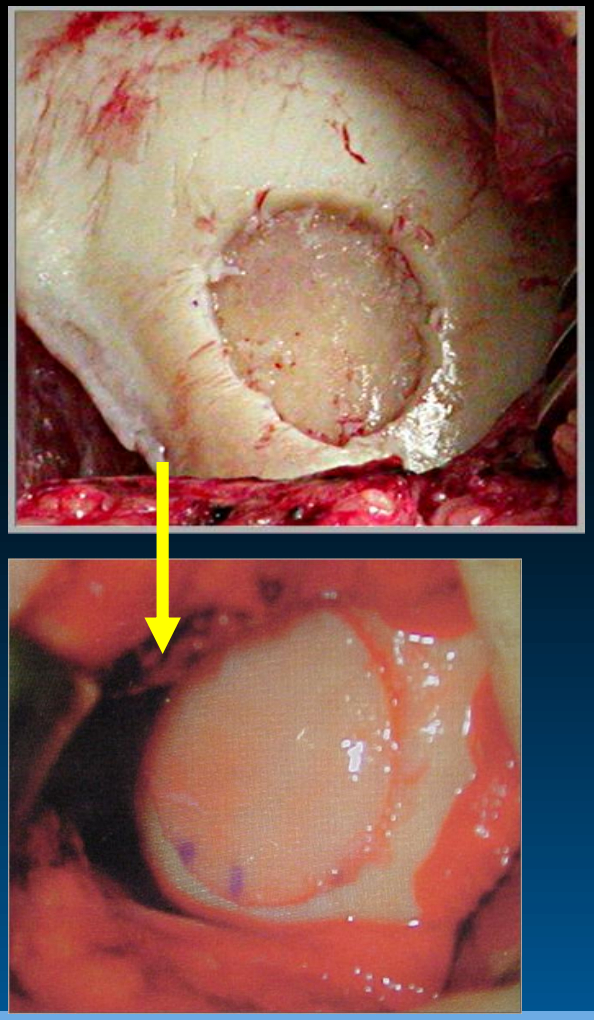
- Hyaline cartilage attractive for transplantation because:
  - Avascular
  - Aneural
  - Immunoprivileged



Osteochondral Allografts

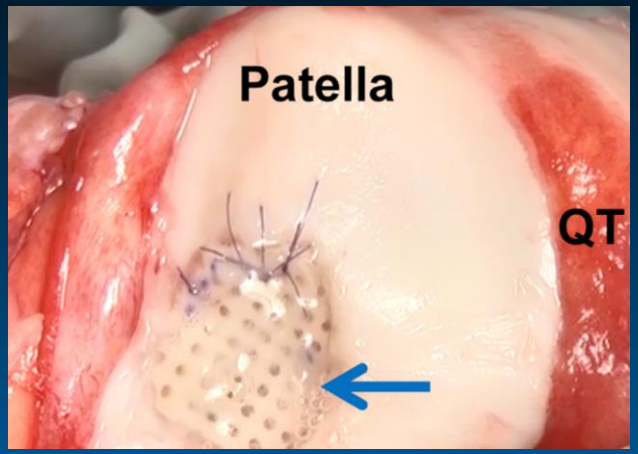
Allografts

- Indications
  - Young, high-demand patient
  - Localized, unipolar chondral lesion
  - Femoral condyle, trochlea, or patella
  - **Lesions > 2 cm^2**
    - Ideal for lesions >4 cm^2, that are uncontained large lesions w/ substantial bone loss



Osteochondral Allografts

- Viable Flexible Cryopreserved Osteochondral Allograft
- Contains chondrocytes, chondrogenic growth factors, and extracellular matrix proteins
- Perforations in the articular cartilage allow for flexible conformity and improved integration to the underlying subchondral bone

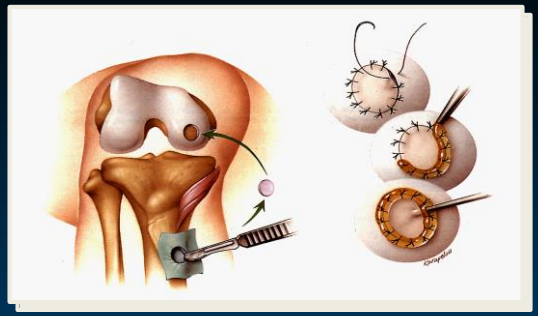


Cell Based Techniques

- Autologous Chondrocyte Implantation (ACI)
- Matrix Associated Chondrocyte Implantation (MACI)
- Particulated Juvenile Articular Cartilage Allograft (PJAC)

Autologous Chondrocyte Implantation

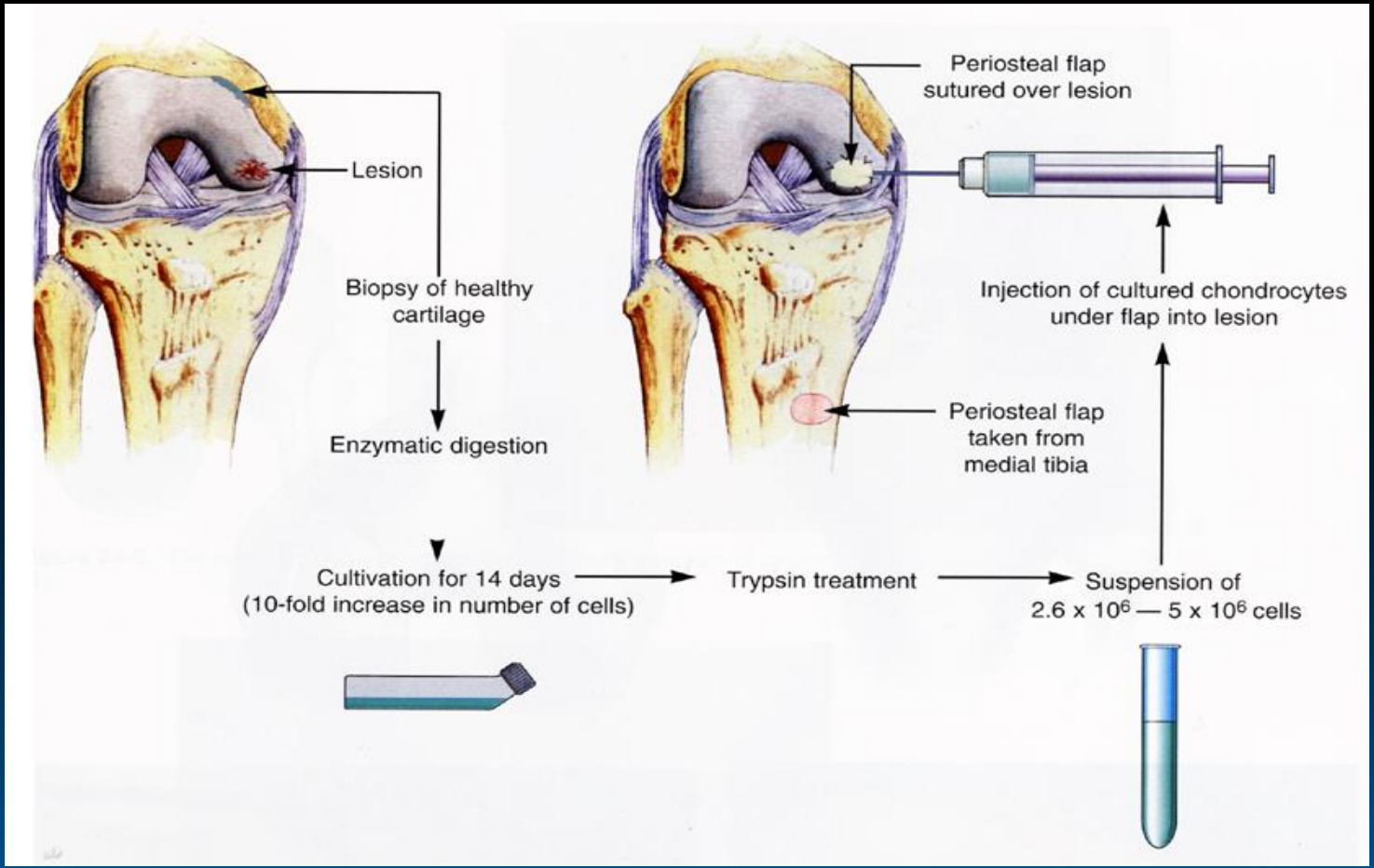
- Two stage procedure, first stage to harvest cells, second stage to reimplant the cells after expansion
- Primary goal of *ex vivo* cell manipulation is to increase the number of chondrocytes.
- Theoretical advantage: Reduced fibrocartilage and increased hyaline cartilage.



ACI

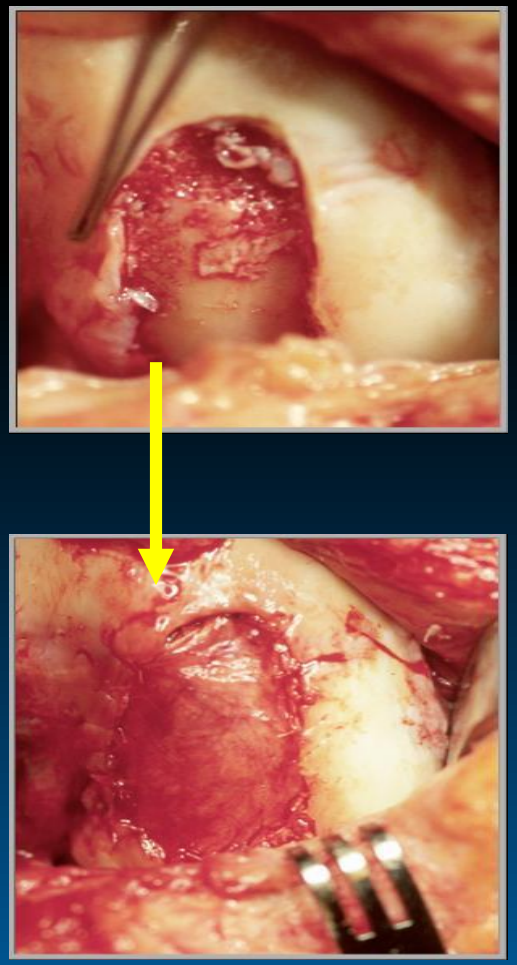
- Indications
  - Young active patients, 15-50 years old.
  - Symptomatic focal full thickness chondral defects of the femoral condyle / trochlea or OCD
  - > 2 cm^2 lesion Ideal for areas which are challenging to contour with structural osteochondral auto or allograft (Patella/Trochlea)

ACI


Lesion
Biopsy of healthy cartilage
Enzymatic digestion
Cultivation for 14 days
(10-fold increase in number of cells)
Trypsin treatment
Suspension of
2.6 x 10⁶ — 5 x 10⁶ cells
Periosteal flap taken from medial tibia
Injection of cultured chondrocytes under flap into lesion
Periosteal flap sutured over lesion

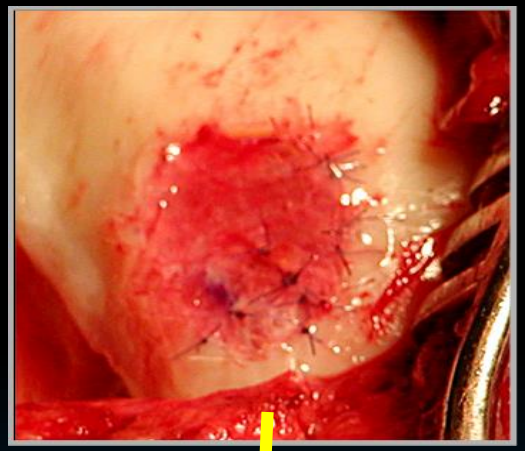
ACI

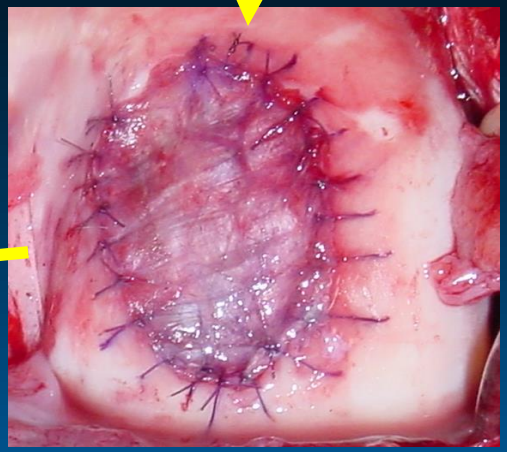
- ACI
  - Technique
    - Arthrotomy
    - Defect preparation
    - Periosteum procurement and fixation



ACI

- ACI
  - Technique (continued)
    - Water tight integrity testing
    - Fibrin glue sealant
    - Chondrocyte implantation
    - Wound closure





ACI

- Results
  - *Peterson, 2000:* First 100 patients w/ ACI, 92% successful outcomes @ 2-9 years follow-up.[26]
  - *Peterson, 2002:* 81 patients, follow-up @ 5-11 years:[27]
    - 82% good/excellent results @ 2 years.
    - 84% good/excellent results @ 5-11 years (mean 7.5 years).
    - Results best w/ condylar versus patellar lesions.
    - 8/12 biopsied patients→ normal hyaline cartilage.
    - All 10 failures at ≤2 years post-operative.
  - *Peterson, 2003:* 58 patients @ 5.6 years; normal graft integrity in 20/22 2nd look arthroscopies; MRI @ 3.5 years,13/15 similar to surrounding cartilage.[28]
  - *Gillogly, 2001:* 112 patients, 91% with good/excellent results.[29]
    - Better outcomes if treatment w/in 1 year from injury or onset of symptoms.
  - *Grigolo, 2005:* Biopsy specimens @ 2 years post-ACI demonstrate varying degrees of organization w/ some fibrous and fibrocartilaginous features.[30]

So what should we do?

Cartilage Restoration of the Knee

A Systematic Review and Meta-analysis of Level 1 Studies

Raman Mundi,* MD, Asheesh Bedi,† MD, Linda Chow,* BHSc, Sarah Crouch,‡ BSc, Nicole Simunovic,‡ MSc, Elizabeth Sibilsky Enselman,† MEd, AT, ATC, and Olufemi R. Ayeni,*# MD, MSc, FRCSC
Investigation performed at the Division of Orthopaedic Surgery, McMaster University, Hamilton, Ontario, Canada

AJSM 2016

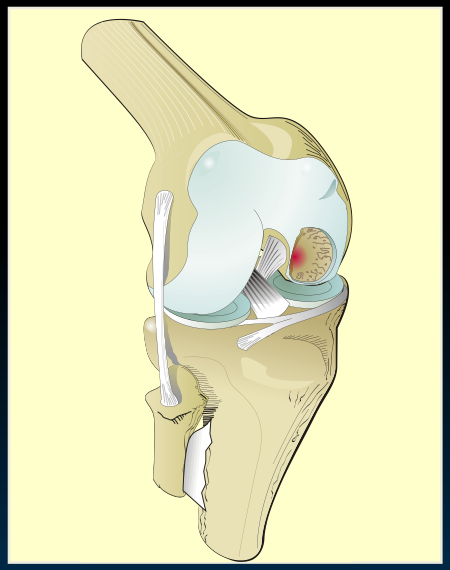
"There is no significant difference between MS, ACI, and OAT in improving function and pain at intermediate-term follow-up."

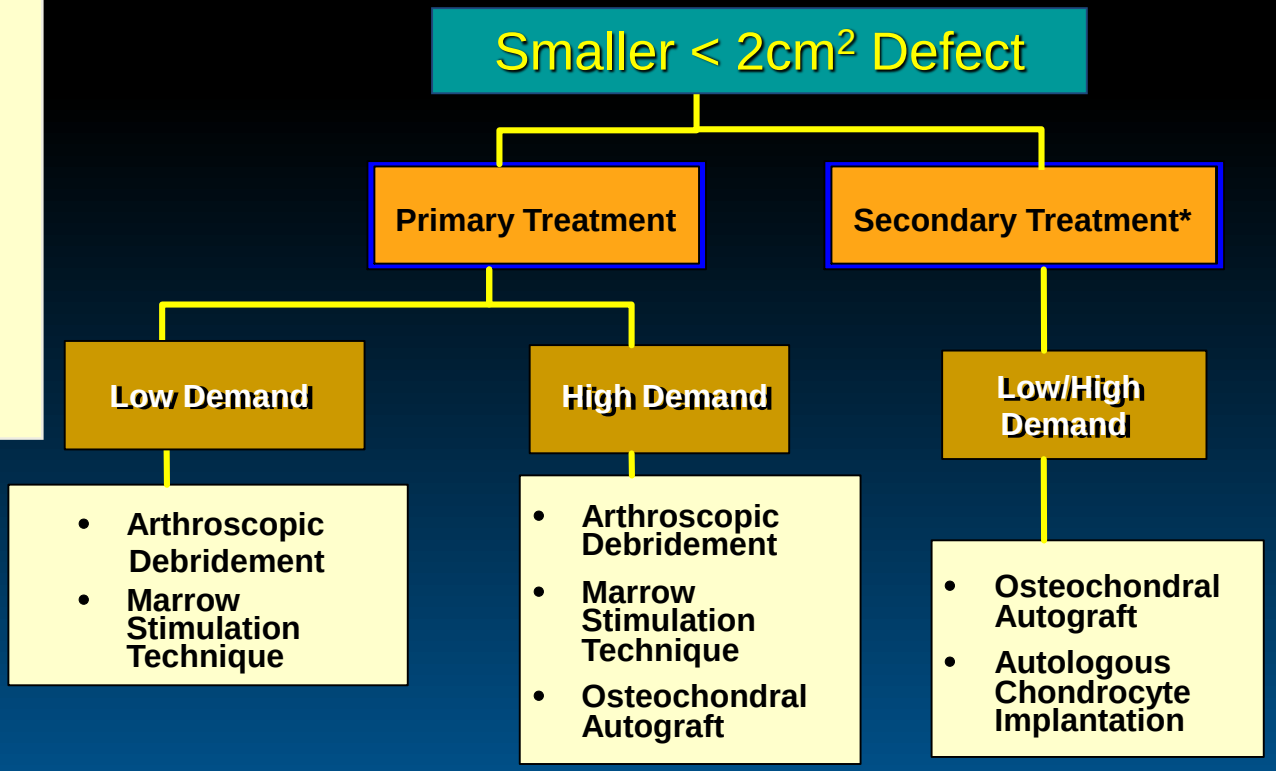
Operative Treatment

- Questions to guide operative treatment:

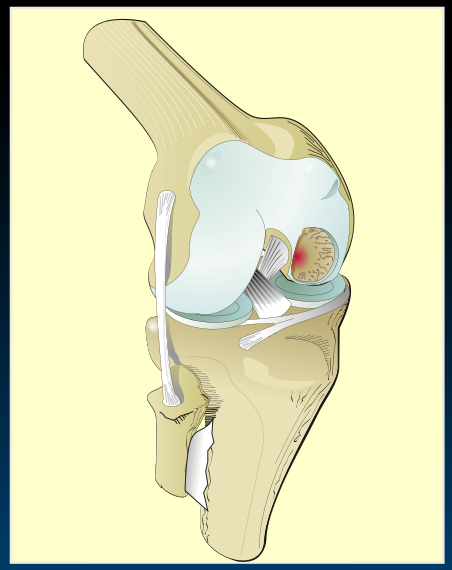
1. Age and Activity Level of patient
2. Patient's expectations and compliance
3. Size and depth of lesion
4. Lesion location
5. Surgeon's comfort level / experience
6. Do I need to optimize healing environment (correct instability/alignment/meniscal pathology)

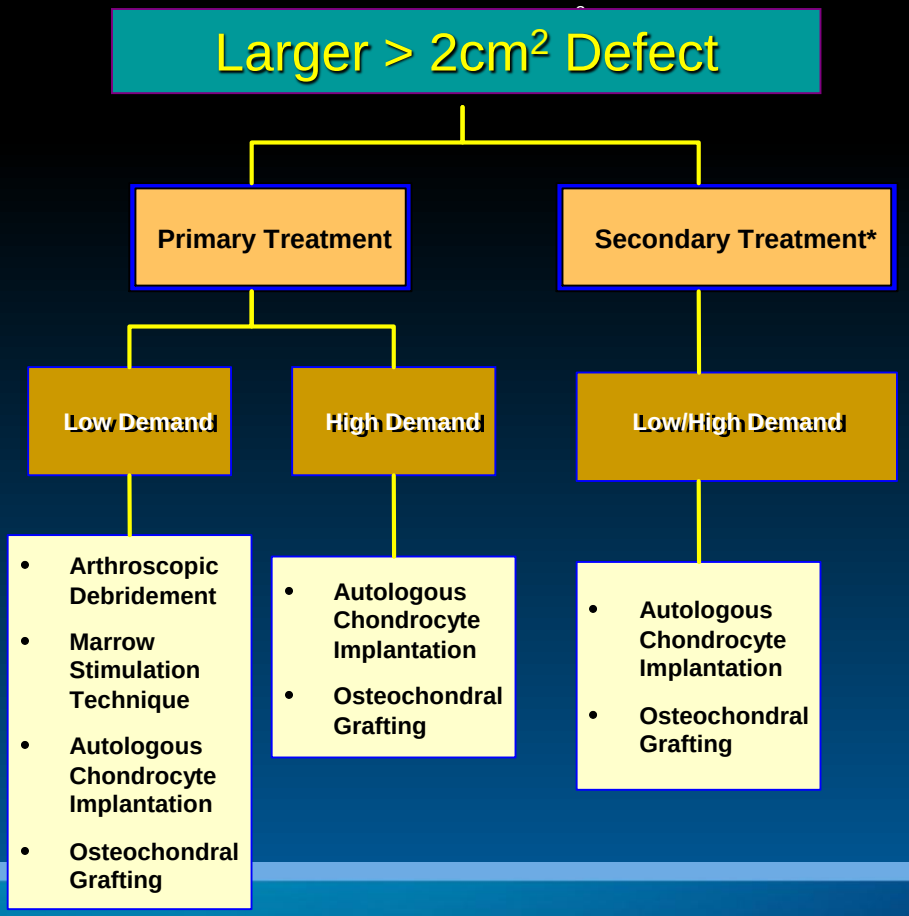
Chondral Injury Treatment Algorithm[35]





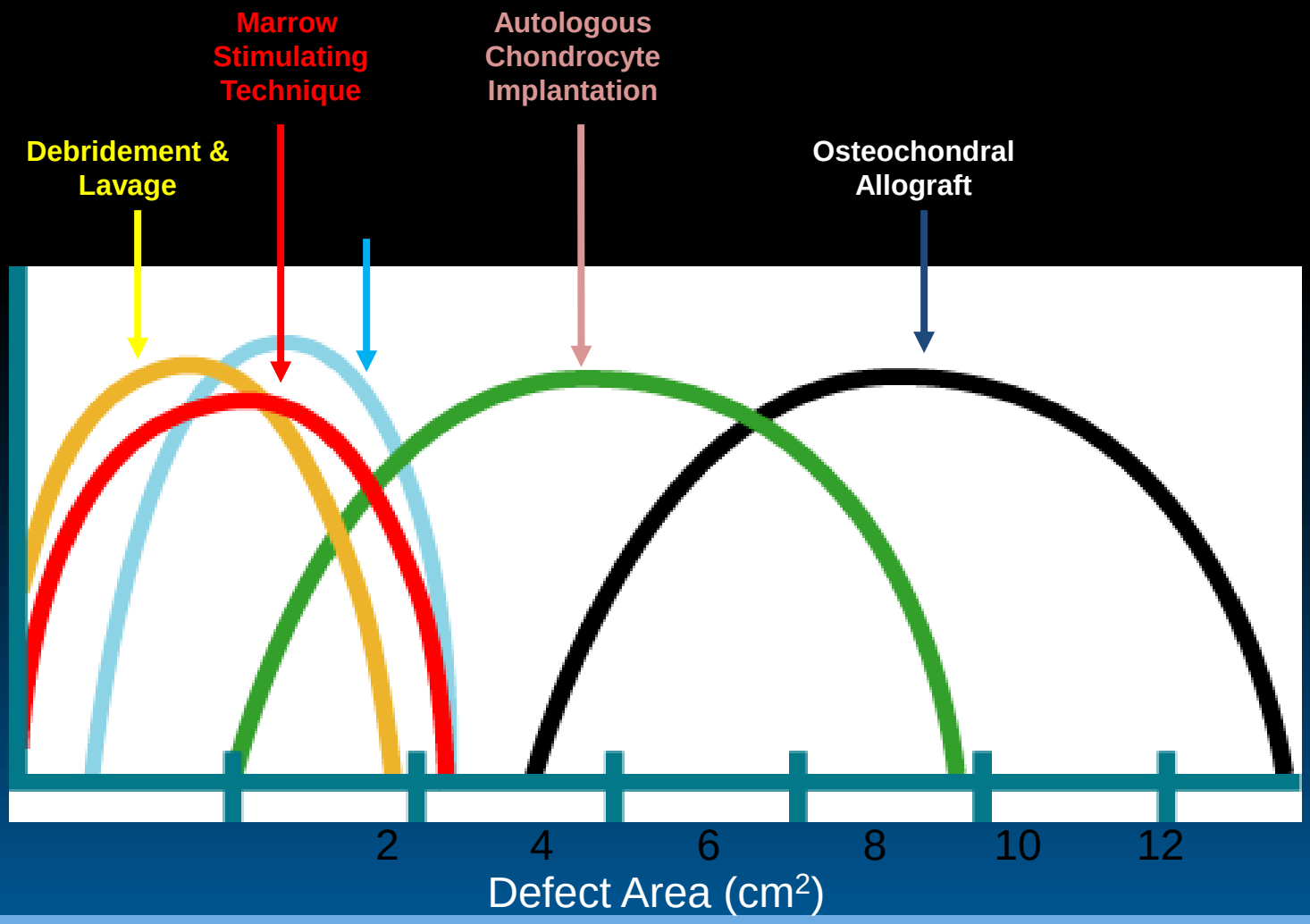
Chondral Injury Treatment Algorithm[35]





Treatment Algorithm

Clinical Applications



My Algorithm

- Small lesions debridement/MFx
- Larger Lesions Femoral Condyles OC Allograft
- Larger Lesions Patella/Trochlea Viable Flexible OC Allograft or Cell Based Techniques

Treatment needs be individualized

Thank You