Management of Chondral Lesions

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Disclosure

• No personal conflict of interest
• Off label use of some products will be discussed

Focal Chondral defects

• Incidence 5-10% in hemarthrosis
• Curl et al: retrospective review
  - 63% of over 31,000 arthroscopies
  - 23% of acute ACL injuries
  - 54% of chronically ACL lax knees
• Most asymptomatic
• Traumatic vs insidious etiology
• Symptoms variable
  • Asymptomatic to disabling
  • Progression over time?

1Noyes JBJS 1980
2Curl Arthroscopy 1997
Should we Treat?

- Natural History
  - still need long term f/u
  - Shelbourne: 123 incidental chondral lesions
    - Lower subjective scores after ACL than normal controls
    - Lateral chondral injuries worse outcome
  - Linden: 30 year f/u on adults with OCD
    - Progression to painful OA with symptoms 10 years earlier than the rest of the population
  - Wolfe: Once early changes occur on radiograph – progression toward OA is likely

1Shelbourne JBJS 2003
2Linden JBJS 1977
3Wolfe J Rheum 2002

Should we Treat?

- Symptomatic cartilage lesion
  - likely to persist or worsen without treatment
- Incidentally noted cartilage lesion
  - Symptomatic progression depends on:
    - Location
    - Depth
    - Geographic pattern
    - Patient demand
    - Comorbidities
  - Affected by
    - Ligamentous instability
    - Meniscal status
    - Malalignment

Shoulders
Where does the pain come from?

- Elevated chondral flaps
  - 15% immediately better
- Loose chondral pieces
- Defect itself does not cause pain
- Patient may have acute pain when chondral piece breaks off
- Overlap with
  - Deformity
  - Instability
  - Meniscal deficiency

Dye AJSM 1998

Evaluation

- History
  - Mechanism of injury
  - Onset and pattern of symptoms
  - Prior treatments
    - Cartilage restoration: 2.1 previous treatments¹
  - Co-morbidities: Ligamentous stability, patellofemoral tracking, mechanical alignment
  - Obesity, gait patterns
  - Employment and activities
  - Patient expectations
Radiographic Evaluation

- Patellar skyline (Merchant)
- PA Weightbearing 45 degree flexion
- MRI
- Arthroscopic evaluation

Types of Cartilage Repair

1) Bone-marrow stimulation
   - abrasion, drilling, microfracture
2) Transplantation of osteochondral grafts
   - OATS, mosaicplasty, allografts
3) Implantation of autologous cells
   (chondrocytes)
   - ACI
4) Matrices / scaffolds
   - +/- cells, +/- growth factors

Prerequisites for Healing of Articular Cartilage

1) Source of cells
2) Provision of a matrix
3) Removal stress concentration
4) Intact subchondral plate
5) Mechanical stimulation
Marrow Stimulation Techniques

- Goal: initiate bleeding
  - in the hope of forming fibrocartilaginous scar
  - Goal blood = Fibrin clot = primitive undifferentiated mesenchymal stem cells
    Fibrocartilage
  - non hyaline repair tissue results

Marrow-Stimulating Techniques

- Abrasion Arthroplasty
  - Remove 1-2mm of sclerotic bone down to vasculature of subchondral plate
  - Fibrin clot -> fibrocartilage
  - Debridement vs. Abrasion arthroplasty¹
    - 33% worse HSS score than before surgery
    - Technique sensitive
    - Not recommended

¹ Bert Arthroscopy 1999

Microfracture

- Improvement upon abrasion
- Subchondral architecture left intact except areas broached with small metal picks
- Fibrin clot = Fibrocartilage
Microfracture

• Low demand larger lesions
• High demand smaller lesions
• Important violate calcified layer Frisbie et al.
• Shouldered defects

Indications for Microfracture

• Both traumatic and degenerative full-thickness defects
• Both unipolar and “kissing” (bipolar) lesions
• Both primary treatment and revision settings
• Ideal size < 400mm²
• Ideal timing
  – < 12 weeks from injury
• Ideal location
  – femoral, trochlear lesions

Contraindications to Microfracture

• Most “relative” rather than “absolute”
• Tibial or patellar lesions somewhat less predictable
• > 400 mm² tend to have more pain (? 2nd looks > 3cm)
• > 5-10 mm depth
• Osteochondritis dissecans
  – No bleeding
  – > 10mm deep
• Mal-aligned / maltracking
• Chronicity
### Define / Debride Unstable Rim

- Defects always bigger than they first look
- Can NOT leave unstable rim
- Repair needs to heal to host

### “Functional Grade IV”

### Remove Calcified Cartilage Layer

- Barrier to nutrition
- Currette, not burr
- Don't destabilize
Equine Study

(McIlwraith et al, J Vet Surg, 2000; Frisbie et al, AJSM, 2006)

- 10 horses - midcarpal and femorotibial joints
- Full-thickness chondral defects made arthroscopically
- 50% Microfracture, 50% Untreated
- 5 horses harvested at 4 months
- 5 horses harvested at 12 months

Equine Study:
Effect of Calcified Cartilage Layer

Control group

Removal of calcified layer

Microfracture

- Start in periphery
- 2-3 mm
- Don’t converge
- Preserve subchondral lattice
Confirm Bleeding

- Lower pump pressure
- Suction
- If no bleeding, re-do
- Confirm clot

Surgical Technique

- Arthroscopic pump turned off
- Marrow bleeding observed filling defect

Post-Operative Rehabilitation: Patellofemoral

- WBAT - hinged brace with 30° flexion-stop
- Prevents excessive pressure in defect
  - patella does not engage trochlear groove until 30°
- CPM from 10° to 90° at least 8 hours / day
- Cycle knee over edge of a table 1500 times / day
Post-Operative Rehabilitation:
Medial / Lateral Compartments

• TDWB (15%)
• No brace
• CPM for 8 hours / day using the largest ROM that the patient finds comfortable
• WBAT as early as six weeks
• Depends on the size, location
• No cutting, twisting or jumping for 4 months

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Basic Science Microfracture

• Minimal repair tissue at 6 weeks
• Better fill by 12 weeks in protected regions
• Mix of fibrocartilage and hyaline cartilage

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Maturation of Microfracture

(Gill et al, AJSM, 2005)

6 weeks

12 weeks
Results of Microfracture (Early)

- Gill 2000
  - Prospective study - 103 patients < 35 years old
  - 73 men, 30 women
  - Age - 26 years (range 13-34)
  - Defect size - 256 mm²
  - Minimum follow-up - 2 years
  - 24 professional athletes, 16 competitive, 63 recreational

Clinical Outcome

- Pre-operative score - 45.2 (range 10-80)
- Post-operative score - 75.1 (range 45-100)
- Significant improvement (p<0.0008)

Subjective Outcome

- Pain - 3.2 to 1.9 (p<0.05)
- Swelling - 2.9 to 1.6 (p<0.05)
- Improvement in symptoms of pain and swelling continued to be seen until 2 years post-operatively
Return to Sports

- 86% - normal to nearly normal knee
- 43% - previous level without restrictions
- 43% - previous level with few restrictions
- 14% - level of sports participation reduced

Second-Look Arthroscopy:

40 Patients

- 68 weeks (range 8 to 256 weeks)
- Firm, well-fixed, normal appearing tissue with 100% fill - 50%
- Mildly fibrillated - 16%
- 100% filled: uneven / slightly fragmented - 18%
- Exposed bone in base - 16%

Complications

- Arthrofibrosis (1)
  - ACL reconstruction
  - resolved with rehab only
- Pain / disability (1)
  - varus deformity
  - subsequent HTO
Longer Term Studies

- Mithoefer, 2009
  - Effective in all studies during first 2 years
  - Conflicting data on duration of improvement
  - MRI, macroscopic view of repair correlated with outcome
  - Histologic effect unclear

Isolated Defect Outcome

(Steadman Arthroscopy 2003)

- 72 patients (75 knees)
- 7 to 17 year follow-up (mean 11 years)
- 30.4 yo (13-45), Mean defect 2.8 cm²
- Inclusion criteria
  - 1) traumatic full-thickness chondral defect
  - 2) no menisci or ligament injury
  - 3) under 45 years (range, 13 to 45)

Results

(Steadman et al., 2003)

- Lysholm score
  - preop - 58.8
  - follow-up - 88.9
- Tegner score
  - preop - 3.1
  - follow-up - 5.8
- SF-36
- WOMAC
- 15% unchanged from preop scores
- 80% rated themselves as "improved"
- Multivariate analysis
  - Age predictor of functional improvement
Results
(Steadman et al., 2003)

Over the 7 to 17-year (average 11.3 years) follow-up, patients 45 years and under who had the microfracture procedure for full-thickness chondral defects, without associated ligament or cartilage pathology, demonstrated statistically significant improvement in pain and function.

Favorable Indications

- Age < 35 – 40 years
- Size < 2cm
  - Contained
  - “Shouldered”
- “Less” weight bearing surface
- Femur > trochlea > patella > tibia
- BMI < 25

Asik 2008; Gill 2000; Kreuz 2006

Potential Limitations

- Diminished resilience and stiffness
- Poor wear characteristics
- Lacks zonal organization

- Inferior results with bigger lesions > 4cm²
- Incomplete/poor fill (17-57%)
  - Correlates with worse results
- Intralosomal Osteophytes (25-49%)
- Deterioration > 24 months?
  - Still better than baseline

Mithoefer AJSM 2009
Second Looks

31 y.o. female mountaineer at 1.5 year f/u

Second Looks

26 y.o. female skier at 2 years follow-up

Autologous Osteochondral Transfer

- OATS
  - osteochondral autograft transfer system - Arthrex: Bobic ‘96
  - Mosaicplasty
    - Smith and Nephew: Hangody ‘96

Only technique to restore height and shape of defects with:
- Hyaline cartilage
- Intact tidemark
- Subchondral bone
Disadvantages of OATS

- Donor site availability
- Donor site pain
- Graft subsidence
- Lack of integration
- Recipient site pain
- Recipient deterioration with time

Autogenous Osteochondral Grafting: Problems

- Size and depths of defects
- Dead spaces between circular grafts
- Integration
- Different position / contours / mechanical properties

Mosaicplasty

- Multiple small grafts
- Transplant more tissue
  - 60% - 80% fill
- Maintain donor site integrity
- Allow progressive recipient contouring
  - Re-creates curved surface
  - Avoids "flat" reconstructions
**Indications**

- **Historical**
  - small focal, isolated defects
- **PFJ, femoral condyles**
  - Tibia difficult to deliver plugs
- **Intact articular cartilage elsewhere**
- **No DJD**
- **Recent indications**
  - talus
  - tibial plafond
  - capitellum
  - femoral head

**ORIF of OCD**

**O.C.D. Repair Using Transfers**
(Miniaci, 2007)

- 3.5 - 4.5 mm plugs to fix unstable lesions
- Place at junction of intact surface and lesion
- Central plug for stability
- Results: 20 cases (II/III)
  - 100% healing by 6-9 months
  - sports by 3-4 months
Surgical Technique

- Open
  - both condyles available for donor
- Arthroscopic
  - medial trochlear donor
  - lateral possible

Surgical Technique

- Multiple small-sized grafts
- “Less weight-bearing”
  - periphery of femoral condyles at level of PFJ
- Notch
- Sulcus terminalis

Donor Site Contact Pressures
Garretson et al, AJSM, 2004

<table>
<thead>
<tr>
<th>Load</th>
<th>89.1N Load</th>
<th>178.2N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central trochlea</td>
<td>5.80 (kgf/cm²)</td>
<td>9.47</td>
</tr>
<tr>
<td>Lateral trochlea</td>
<td>2.56</td>
<td>5.81</td>
</tr>
<tr>
<td>Medial trochlea</td>
<td>1.60</td>
<td>2.75</td>
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</table>
Surgical Technique

• Must be perpendicular
• 15mm for chondral defects
• 25mm for osteochondral defects
• Tap and toggle
• Chisel guard to remove graft
• Don’t push articular surface to remove graft

Effect of Transfer on Plugs
Kuroki et al, AJSM, 2004

• Porcine model
• 5mm and 6mm plugs
• No effect on:
  – Stiffness
  – Surface irregularity
  – Thickness of cartilage

Second look

• Central aspect in tact
• Peripheral incorporation?
Histology
(Hangody et al., 2000)

- Histology - viable hyaline cartilage
- Second Looks
  - 51/59 good gliding surfaces
  - Fibrocartilage filled donor sites
- 3 chondral and 5 OCD’s had DJD
- Artscan 1000 - elasticity similar

Rehabilitation of Isolated Defect

- Immediate ROM
- 0-3 weeks: NWB
- 3-6 weeks: PWB, bicycle
- 6-9 weeks: WBAT, eccentric strengthening
- 9-12 weeks: Activity-specific conditioning
- 12+ weeks: Return to sports

Results
(Lahay 2006)

- 16 knees at 40 months
- 13 patients (86%) would have surgery again
- Age did NOT correlate with IKDC evaluation
Results
Hangody, JBJS, 2003

831 patients at 10 years
• Femoral condyle: 92% G/E
• Tibia: 87%
• Patella / Trochlea: 79%
• Talus: 94%

Complications

• 36 painful hemarthroses (8%)
• 4 deep infections
• 3% donor site morbidity
• 2 DVT
• Worse results over 35 y.o.

Harvest Site

• Back fill
• Bone graft
• OBI plugs
• OsseoFit plugs
Osteochondral Allografts Results

- Success ranges from 76-86%
- Garrett Corr '94 16/17 asymptomatic at 3 years
- Long term survivorship
  - 95% - 5 year
  - 71% - 10 years
  - 66% - 20 years

Ghavazi JBJS 1997
Osteochondral Allograft Summary

- Resource intense
- Medium to large lesions with depth
- Femoral condyle with > 85% success
- Moderate morbidity
- Demanding rehabilitation
- Availability issues
- Preservation issues

Autologous Chondrocyte Transplantation

- Transplantation of cells grown in culture
- method of introducing new cell population into osteochondral defects

Defect Selection

- Large Lesion, >2cm²
- OCD Lesions
- Failed Prior Surgical Repair Procedure
- Trochlea Lesion
Remodeling Phases and Rehabilitation

The rate of progression may vary depending on the lesion location, size and concomitant procedures. If symptoms occur, patients should reduce activity to reduce pain and swelling.

### Proliferation Phase
- Weeks 0-12
  - NWB 0-2 weeks
  - Advance WB 3-12 weeks

### Matrix Remodeling
- Weeks 13-36
  - Low Impact Sports

### Maturation
- Weeks 36-52
  - High Impact Sports

ACI Results

**Peterson, AJSM 2010**

- 224 patients at 12.8 ys (10-20)
- Age 33.3 (14-61)
- Defect size 5.3 cm²
- 74% same or better 92% satisfied
- Worse outcomes for bipolar lesions

- Histology - 14/19 hyaline or “hyaline-like”
- Indentation probe: hyaline = control

Complications of ACI (FDA)

**Wood et al, JBJS, 2006**

- 497 adverse events in 294 patients (7500 lots, 3.8%)
  - 96% femoral condyle
  - Mean interval to AE was 240 days
- Graft failure – 73 (25%)
- Delamination – 65 (22%)
- Tissue hypertrophy – 52 (18%)
- Infection – 18
  - 11 joint, 7 wound
**ACI Complications**

Complications:
- Stiffness/Arthrofibrosis (5-10%)
- Periosteal hypertrophy (20-50%)
  - 5% with collagen membrane
- Graft failure (<10% primary, 20-30% after marrow stimulation)
- 1 out of 3 had reoperations
- Complications reduced in 2nd generation ACI

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**ACI Versus Microfracture**

Knutsen JBJS 2004, 2007

80 patients randomized (4 surgeons did 10 of each)
- Defect 5.1cm² (ACI) v 4.5 cm² (MF), all femoral condyles
- Better SF-36 physical component at 2 yrs
  - no differences at 5 yrs
- Similar failure rate (23% at 5 yrs)
- Microfracture lesion > 4 cm² worse results
  - no similar trend with ACI

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**Treatment Algorithm**

<table>
<thead>
<tr>
<th>Small defects (&lt;2-4cm²)</th>
<th>Large defects (&gt;2-4cm²)</th>
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<tr>
<td><strong>Very small (&lt;2cm²)</strong></td>
<td><strong>Small</strong></td>
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<tr>
<td>OATS</td>
<td>Microfracture</td>
</tr>
<tr>
<td>+ native articular cartilage + primary bone healing + quicker recovery and return-to-play than microfracture + technically difficult (min-open) + donor site morbidity with multiple plugs + no donor site morbidity + arthroscopic procedure + complex rehab (CPM and TDBR-S6-18) + prolonged Return-to-play 6-9 months + in less demanding individuals + reasonable success in larger lesions + ACI 80% if this fails + no size limitation + hyaline-like cartilage + short m-up rate + complex rehab + prolonged RTP 12-18 months + cost + no size limitation + hyaline cartilage + arthroscopy + graft availability + disease transmission + bone fails + complex rehab + prolonged RTP 9-12 months + longevity cost</td>
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Summary

• Define patient goals and set expectations
• Careful rehabilitation
• Recognize the natural history
• Don’t “burn bridges”

The Future

• Growth factors / Biochemical modulators
• Mechanical factors / surgery
• Templates, “cell seeding”, transplants
• Bioabsorbable materials

Thank You