Management of Small Articular Cartilage Lesions

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Articular Cartilage Injury
Natural History

Cartilage Defects in Athletes
- Prevalence >2x General Population
- 86% Symptomatic
- Progressive Reduction:
  - Competitive Sports
  - Impact/Team Sports
- Limitation of Lifestyle in 41-90%
- Swelling and Pain
- 57-80% Radiographic Signs of OA

Cartilage Repair Algorithm

Size < 3cm
Deeper (1cm)
Superficial
Superficial
OATS
Microfracture
ACI
CACI
OC-Allograft
ACI

Size > 3cm
Deeper (>1cm)
Superficial
Superficial
Microfracture
OATS
Mosaicplasty
ACI
CACI
OC-Allograft
ACI

Cartilage Repair Procedure Frequency

Hybrid Fibro-Hyaline Repair Tissue with Limited Col-II and Aggrecan Content

Microfracture
Surgical Technique
**Microfracture**

**Clinical Efficacy**

- Improvement <2yrs: 75-100%
- Improvement >2 yrs: 67-86%
- Functional Deterioration: 47-80%
- Improvement over Baseline at 10 yrs: Gudas AJSM 2012, Mithoefer, AJSM 2009

**Articular Cartilage Repair**

Treatment Option-Microfracture

Return to Professional Sport: 67-100%

- Mithoefer and Steadman, Cartilage 2012
- Knarran, AJSM 2008
- Riyami, J Orthop Surg Res 2009
- Mithoefer, AJSM 2009
- Steadman, J Knee Surg 2003
- Ramappa, J Knee Surg 2007

**Microfracture**

Decrease of Function

- MRI Results
  - Complete Fill: 18-95%
  - Poor Fill: 17-57%
  - Complete Integration: 4-8%
  - Function Correlates with Fill

- Blevins Orthopedics 1999
- Mithoefer JBJS 2005
- Kon, AJSM 2009+2011
- Kreuz, Osteoarthritis Cartilage 2006
- Mithoefer, AJSM 2009
- Ramappa, J Knee Surg 2007

**Microfracture**

Complications/Failures

- Failure/Revision
  - <2 years: 2.5%
  - 2-10 years: 2-38%
  - Higher Failure Rate with:
    - Lower Repair Tissue Quantity
    - Lower Repair Tissue Quality
    - Smoking
    - Longer Duration of Symptoms
- Results at 10 years above Baseline: 48% OA at 15 yrs

- Mithoefer JBU 2015
- Knarran, Osteoarthritis Cartilage 2006
- Mithoefer, AJSM 2009
- Ramappa, J Knee Surg 2007
- Knutsen JBJS 2016
- Salzmann KSSTA 2012
- Mithoefer AJSM 2009
Microfracture

Subchondral Bone Overgrowth
- Incidence: 63%
- Influencing Factors:
  1. Lesion Location
  2. BMI
  3. Surgical Technique
- Increased Failure Rate
  - 25% vs. 3%

Microfracture
Technique Modification

Microfracture Awl: “Sealing Effect”

Microfracture
Innovation

Drilling and Nanofracture
- Drilling:
  - No Bone Compaction
  - No Fracture
  - No Sealing Effect
  - Less Necrosis
- Nanofracture:
  - Deeper Marrow Access

Microfracture
Improvement

Augmentation Strategies
- Hyaluronic Acid Injection
- PRP
- Growth Factor Augmentation
  - Factors: BMP-2, BMP-7, BMP-4, FGF-18, IGF-1
  - Stimulation of: MSC Differentiation, Proliferation, Metabolism
- Cytokine Modulation
  - IL-1ra + IGF-1
  - Inhibition of Inflammatory Response

Mfx+Tissue Engineering

Scaffold Augmentation (MASS)
- Collagen Membrane
- Chitosan/Hydrogel
- Micronized Allograft (Chondrons)
  - Chemotactic (MSC Recruitment)
  - MSC Differentiation
  - Clot Stabilization
  - Proanabolic, Effect
- Improved Quality/Quantity

MASS
Autologous Matrix Induced Chondrogenesis (AMIC®)

AMIC Results (Registry/Systematic Review)
- Single stage, Bilayer Membrane, Clot Stability ↑
- MSC Migration+ Differentiation ↑↑
- Repair tissue quantity ↑↑
- No effect on repair tissue quality
- No effect on biomechanical properties
- Subchondral bone effects
- Clinical Results similar to (M)ACI
- Better Durability
**MASS**

**Chitosan Scaffold (BST-CarGel®)**

- Chitosan (D-Glucosamin Polysaccharide)
- 3-D injectable liquid scaffold
- Increases chondrogenic differentiation
- Arthroscopic and mini-open technique
- Randomized Trial: ↑Fill and Quality
- Clinical Outcome similar at 60 Mo

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**MASS**

**Biocartilage**

- Repair Cartilage Tissue
  - ↑↑Histologic Quality
  - ↑↑Tissue Volume

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**MASS**

**Biocartilage-Arthroscopic Implantation**

- Combination Techniques
  - Perforated allograft cartilage
  - Combined with Microfracture
  - Principle: Chondrons + MSC
    - Viable Cells
    - Chondrogenic Effect (TGF-β, IGF, BMPs)
  - Minimally Invasive Technique
  - Single-step Procedure
  - 2-year shelf life

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**Chondral Allograft+MSC**

- Cartiform 6 Months

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Repair Techniques

Mosaicplasty

Clinical Results
- Hyaline Cartilage
- Good/Excellent Results 79-92%
- 52% Durability 7-10 yrs
- Short Rehabilitation
- Donor site: Fibrocartilage
- Donor Site Morbidity 3-36%
- Limited Plug availability
- Single plug: Best results

Biphasic-Scaffolds
Trufit®/Porous Tissue Matrix™

Clinical Results:
- Knee Function Scores ↑
- Return to Sport worse than OATS
- Limitations:
  - Fibro-Hyaline repair tissue
  - Slow Incorporation/Bone restoration
  - Persistent Effusion
  - 20% Revision Rate
  - 70% Failure Patella
- Stem Cell Augmentation!

Osteochondral Allograft

Clinical Results:
- Survival: 95% (5y) → 82% (10y) → 74% (15y) → 66% (20y)
- Return to sport 76%
- Reoperations 47%
- Limited Fresh Graft Availability
- Gradual Incorporation
- Shell Grafts

Chondrofix

- Human OC-Allograft
- Decellularized, Sterile
- Off Shelf Use
- Intact Mechanical Properties
- Early Loading
- Delamination Risk
- Failure Rate 72% at 2 years!!

Chondral Allograft

- Juvenile Minced Cartilage
- Single Stage/Off Shelf
- Superior Cell Activity
- 100x Faster Matrix Production
- Femur and Patellar Defects
- KOOS improvement @ 2 years
- MRI-T2 similar to normal cartilage
- Fibrohyaline Tissue, High Col-II
- 30% Overgrowth
- Graft Delamination

Stem Cells: BMAC

Autologous Bone Marrow Aspirate (MSC):
- MSC Effects:
  - Progenitor Cell
  - Growth Factors
  - Anti-Inflammatory Effect
- Experimental Studies:
  - BMAC > MF

Farr AJSM 2016
Degen Cartilage 2016
Levy CORR 2013
Krych AJSM 2012
Bugbee J Knee Surg 2012
Adkisson AJSM 2010
Farr AJSM 2014
Tompkins 2013
Fortier JBJS 2010
Hindle 2013
Bekkers 2013
Joshi 2012
Krych 2016

Stem Cells: BMAC

Clinical Results:
- No Microfracture, MSC-CFU ↑↑
- Significant Knee Function Score Improvement
- Better < 45 Years, Small, isolated defects
- Results comparable to MACI
- MRI 80% Complete Fill
- Hyaline Like Histology

Gobbi AJSM 2014
Gobbi KSSTA 2016

Summary

Treatment of Small Cartilage Defects
- High Clinical Demand
- Good results with 1st Generation techniques
- Extensive Scientific Growth
- Evolving Cartilage Restoration Technologies
- Increasing Cartilage Quality+Quantity
- Promise for Further Clinical Improvement

Thank You!