Controversies in Cartilage repair and osteoarthritis: 2016
COI Disclosure

Research Grant Support

• Linvatec
• Arthrex
• Ossur

Consultant:

• Arthrex Inc
• Arthrosurface Inc
OUTLINE

• WHAT IS A CARTILAGE DEFECT?
• WHAT CAUSES OSTEO-ARTHRITIS?
• WHAT IS JOINT PRESERVATION?
• NEW TECHNIQUES
• CASE PRESENTATIONS
• DISCUSSION
• CONCLUSIONS
Advanced OA: How to treat in 2016?
HOLE IN THE CARTILAGE = OCD

• Less cushion
• Look for
  Loose Body
  do
  Arthroscopy
Osteo Chondral Defect = OCD

Defect- may be asymptomatic

Osteoarthritis ?
Not always
Buckwalter JA, CORR 2002
How common is OCD?

A recent prospective survey of 993 consecutive knee arthroscopies demonstrated evidence of articular cartilage pathology in 66%.

How common is OCD in Athletes? What is the long term effect?

Articular cartilage defects of the femoral condyles have been observed in up to 50% of athletes undergoing anterior cruciate ligament (ACL) repair with an increased propensity in female athletes.


Injuries to the articular cartilage of the knee have been shown to present one of the most common causes of permanent disability in athletes.

OCD Long term results in active individuals

The National Institutes of Health (NIH) consensus conference on osteoarthritis demonstrated a relative risk of 4.4 to 5.3 for knee osteoarthritis in high-demand, pivoting athletes.


Prospective study of osteochondral lesions reported poor results with strenuous athletic activity in 38% and moderate to severe radiographic evidence of osteoarthritis in 45% at an average of 34 years.

End Result: Chondropenia

Studies indicate that the dose-response curve reaches a threshold and that activity beyond this threshold can result in maladaptation and injury of articular cartilage.

Kiviranta I et al
Articular cartilage thickness and glycosaminoglycan distribution in the canine knee joint after strenuous running exercise.
Outcome of Untreated Traumatic Articular Cartilage Defects of The Knee: A Natural History Study

• 101 ACL patients + Chondral defect: 48 medial & 53 Lateral-No Cartilage Treatment.
• Control group: ACL no Chondral defect.
• IKDC rating/ X-rays @ mean 8.7 years.
• Control group scored better on Subjective scale. 95.2 versus 92.8 (lateral defect)
• No difference in Objective data or X-rays
• 79% return to high impact activity
JOINT PRESERVATION: KNEE

1. BONE: OSTOETOMY
2. ACL/ MPFL
3. MENISCUS REPAIR/ TRANSPLANT

1. CARTILAGE REPAIR
BONE RECONSTRUCTION : HIGH TIBIA OSTEOTOMY (HTO)

- Isolated medial compartment DJD
  - Young and active
  - Flexion $\geq 90^\circ$; flexion
  - Flexion Contracture $< 15^\circ$
  - ACL intact

- Chondral resurfacing: adult OCD/ adult AVN

- Congenital tibia vara

- Varus +PLC instability

Phisitkul smar 2006
Patient satisfaction after medial opening high tibial osteotomy and microfracture.


- 61 patients. Mean age= 52.
- Open wedge HTO + microfacture
- Retrospective study with 2 years follow up
- The mean preoperative lysholm score of 49.9 improved postoperatively to 75.4 ($p < .001$)
- Mean satisfaction score was 7.6 (1 = not satisfied, 10 = very)
JOINT PRESERVATION: ANKLE

Prerequisites:

1. Unipolar Lesion
2. Stable Joint
3. Good Alignment
4. Good Healing Potential
5. Compliant Patient
CARTILAGE REPAIR

- Articular = hyaline cartilage
- Meniscus = fibrocartilage
- Auricular
- Nasal
JOINT CARTILAGE

• Chondrocytes/ matrix
• No vessels/nerves
• **No healing**
• Subchondral bone penetration produces healing response
JOINT CARTILAGE

Matrix:
• 70% water
• 18% type II collagen
• 9% proteoglycans

Chondroitin sulphate/glucosamine

• Age + injury
**Table 1. The Zonal Variation Seen in Articular Cartilage**

<table>
<thead>
<tr>
<th></th>
<th>General Comments</th>
<th>Superficial Zone</th>
<th>Midzone</th>
<th>Deep Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cells</strong></td>
<td>Chondrocyte morphology varies throughout depth of cartilage; no inflammatory cells present</td>
<td>Elongated, single, and aligned parallel to the surface</td>
<td>Rounded/oval and single</td>
<td>Rounded/oval cells; lacunae may be obvious; cells may be ordered into columns, depending on species, age, and location within joints but not in adult human knee/hip articular cartilage</td>
</tr>
<tr>
<td><strong>Extracellular matrix</strong></td>
<td>Homogeneous in appearance; contains no blood vessels or nerves</td>
<td>Collagen fibers parallel to surface when visualized by PLM; smooth surface</td>
<td>No obvious collagen fiber orientation when viewed with PLM</td>
<td>Collagen fibers perpendicular to the tidemark when viewed with PLM Expresses mineralization-related molecules such as alkaline phosphatase in deep aspect close to the bone</td>
</tr>
<tr>
<td><strong>Major matrix molecules</strong></td>
<td>Collagen I</td>
<td>May be present in superficial layer</td>
<td>Absent</td>
<td>Absent (although reported sometimes in osteoarthritis in very lowest region)</td>
</tr>
<tr>
<td></td>
<td>Collagen II</td>
<td>Throughout; may be absent in few upper microns</td>
<td>Throughout</td>
<td>Throughout</td>
</tr>
<tr>
<td></td>
<td>Proteoglycans (PGs): most abundant is aggrecan; demonstrable by IHC and/or metachromasia by staining with, for example, toluidine blue or safranin O; ratio of keratan sulfate (KS):chondroitin sulfate (CS) increases towards bone</td>
<td>Throughout; may be absent in few upper microns</td>
<td>Throughout</td>
<td>Throughout</td>
</tr>
<tr>
<td><strong>Calcified cartilage</strong></td>
<td>Layer of calcified (mineralized) cartilage below the tidemark forms a collagen type II+ undulating interface between the articular cartilage and lamellar bone and contains round chondrocytes that express collagen type X; the tidemark (or mineralization front) is located between the calcified and noncalcified zones and is demonstrable in adults as a fine, basophilic line(s) on H&amp;E staining; it is not completely characterized but contains calcium phospholipid</td>
<td></td>
<td></td>
<td>Collagen type II fibers from hyaline tissue extend into calcified cartilage</td>
</tr>
</tbody>
</table>

• 1. What is the (average) thickness and volume of the repair cartilage?
• 2. Is any implanted (foreign) material still present?
   Are there any signs of inflammatory or immune response to the implanted material?
• 3. What portion of the repair cartilage is hyaline?
• 4. Is the articular surface smooth and intact? Is the overall structure intact or disintegrated?
• 5. Does the repair tissue have zonal organization, uniform collagen type II, little or no collagen type I, and appropriate collagen fiber orientation?
• 6. Are there viable cells with the appropriate morphology to form and maintain a hyaline extracellular matrix?
• 7. Does the repair tissue (animal studies) have good lateral integration with adjacent cartilage?
• 8. Is the repair cartilage fully integrated with sub-chondral bone, and has the tidemark been regenerated?
• 9. Does the sub-chondral bone plate and underlying bone have a normal structure?
Figure 1. Different features of the osteochondral junction in normal and repair cartilage are revealed by hematoxylin and eosin (H & E) (A, C, E, G) and Safranin O/fast green/iron hematoxylin (SafO) (B, D, F, H). In normal human cartilage (A and B, adult hip surgical waste, femoral neck fracture), H&E clearly stains the tidemark (A, white arrows), while SafO readily discriminates cartilage from fast green–stained bone (below the black arrows, B). For heterogeneous human repair cartilage (C and D, biopsy taken 1 year postmicrofracture\textsuperscript{71,121}), H&E is better for determining the cartilage-bone boundary (black arrows, C) and abnormal mineralization (dashed circle), while Safo discriminates fibrocartilage from fast green–stained fibrous repair and bone (D). In hyaline cartilage repair elicited in a sheep model (E-H, 6 months posttreatment\textsuperscript{43}), the tidemark is beginning to form (white arrows, 10x magnification for E and F, 40x magnification for G and H). White arrows = tidemark; black arrows = cartilage-bone interface; AC = articular cartilage; cc = calcified cartilage; FC = fibrocartilage; HC = hyaline cartilage; b = bone.
CARTILAGE DAMAGE

• Acute injury:
  Impaction = bruise
  Shear = defect
  Hemoarthrosis- 20% cartilage defects

• Repetitive injury:
  overuse
  Instability?
CLINICAL PICTURE

- Sports Injury
- Pain
- Swelling
- Clicking/ Locking ?
  Loose Body
- Instability ?
IMAGING

- NORMAL X-RAY
  Loose Body?

- MRI: DIAGNOSTIC
  Ask For Cartilage Sequence

- Physiologic MRI
  Replaced 2nd Look Scopes
  H. Potter, 2006
WHICH CARTILAGE DEFECT TO REPAIR?

- Symptomatic: Pain/ Mechanical
- Joint effusion
- Isolated (Multiple) – Unipolar (Femoral)
- Joint: Stable ( +ACL)
- Limb: No Deformity ( + HTO)
- Patient: Younger Than 50 Years (Now 60 Ys ??)
HOW ABOUT THE ANKLE?

Osteochondral lesions of the talus (OLT) are lesions involving the talar articular cartilage and subchondral bone.
ICRS or
International Cartilage Research Society grading (Brittberg JBJS AM 2003)

- Grade 0: Normal
- Grade I: Softening and/or superficial fissures & cracks
- Grade II: Lesions extending down < 50% of cartilage depth
- Grade III: No bony involvement. Lesions extending > 50% of cartilage depth. This includes cartilage blisters.
- Grade IV: Bony involvement (this is not quantified)
Using the ICRS grading system

**Grade I lesions:**
- Cartilage softening, fissures, cracks, intact cartilage cap; no bony lesion

**Grade II lesions:**
- Cartilage lesion <50% depth; no bony lesion

- Arthroscopic debridement to a stable border and restaging post-debridement

- Retrograde drilling if cartilage cap intact

- Excision and curettage with microfracture if bone exposed post debridement

**Grade III lesions:**
- Cartilage lesions >50% depth or full thickness lesions post debridement; no bony lesion

- Arthroscopic debridement to a stable border and restaging post-debridement

- Excision and curettage with microfracture if bone exposed post debridement

**Grade IV lesions:**
- Full thickness cartilage lesion or blister with bony involvement OR For patients with failed microfracture or retrograde drilling

- <10mm cartilage lesion with bony involvement

- >10mm cartilage lesion with bony involvement / subchondral cyst

  - OATS — single osteochondral autograft plug

  - Mosaicplasty

  - Large Fresh osteochondral allograft transplant
HOLY GRAIL

REPAIR DEFECT

• Hyaline Cartilage
• Congruent = perfect match
• Stable

PERFECT FIT
OPTIONS: LAVAGE & DEBRIDEMENT

- Jackson et al, 1986: Retrospective
  1 Year  88% Better
  3 Years  68% Better

- Moseley et al, 2002: RCT
  Lavage – Debridement - Placebo

- Kirkely et al, 2008: RCT
  NO DIFFERENCE over 2 Years
OPTIONS: MICROFRACTURE

• FIRST LINE TREATMENT FOR SMALL LESIONS < 200 mm
• Remove Calcified Layer
• Awl Pick Holes
• CPM/ NWB 8 WKS
• Recovery= 12 Months
RESULTS & PERFORMANCE AFTER MICROFRACTURE IN NBA ATHLETES
NAMDARI. AJSM, May 2009

• 24 players: 1997 – 2006
• Average age 28 yrs. 33% All Star
• Case Control Study
• 33% retired
• Rest: Limited playing time, less points and field goal percentage
CARTILAGE REPLACEMENT/RESURFACING

BIOLOGIC

• CARTILAGE AUTOGRAFTS (Plugs, CAIS)
• CARTILAGE CELL CULTURE (ACI)
• CARTILAGE ALLOGRAFT (JEUVINILE CARTILAGE)
• FRESH BULK OSTEO-CHONFRAL ALLOGRAFTS

NON BIOLOGIC

• METAL RESURFACING
BIOLOGIC: AUTOGRRAFT PLUGS
(OAT, Mosaicplasty)
AUTOLOGUS OSTEOCHONDRAL GRAFTS

- Mosaicoplasty/ AOTS/ COR
- Open/ arthroscopic
- Harvest site morbidity increase with size & number of plugs. 2 - 30%
- Configuration/ congruency
- Topographic matching is better
AUTOLOGOUS OSTEOCHONDRAL GRAFTS

POSITIVE:
• Available, Safe
• Single procedure
• Hyaline cartilage

NEGATIVE:
• Limited availability
• Donor site morbidity 10-25%. Less with small plugs
• Difficult Match

Fig. 2: Autologous osteochondral mosaicplasty on the lateral talar
31 YEARS OLD MALE
6 MONTHS S/P BASKETBALL INJURY
ARTHROSCOPIC OATS = SINGEL PLUG
JUVENILE OCD
Statistically significantly better results were detected in patients in the OAT group compared with those in the MF group at 10 years (P < .005).

At 10-year follow-up, there were 15 failures (26%), including 4 failures (14%) of the OAT and 11 failures (38%) of MF treatment (P < .05).

Seven patients (25%) from the OAT group and 14 patients (48%) from the MF group had radiographic evidence of Kellgren-Lawrence grade I osteoarthritis at 10 years, but these differences were not significant (P = .083) or related to the clinical results.

The ICRS and Tegner scores of younger athletes (<25 years at the time of primary surgery) remained significantly higher after 10 years compared with older patients (P < .05); 15 of 20 patients (75%) in the OAT group and 8 of 22 patients (37%) in the MF group maintained the same physical activity level.
Osteochondral Autograft Transfer Achieves Higher Activity Level and Lower Failure Rates than Microfracture in the Knee: A Meta-Analysis of Randomized Controlled Trials. AJSM 2016

Results:
Six randomized controlled trials satisfied eligibility criteria and included 306 patients (186 male, 120 female) with an average age of 26.4 years and follow-up of 67.2 months. Tegner scores were superior in patients treated with OAT compared to MFX (ΔOAT-MFX for pre-post scores=0.94 Tegner points, SMD=0.469, P<0.01).

Failure rates of MFX were higher than OAT (OAT=11%, MFX=32%, RR=2.42, P<0.05).

OAT was superior to MFX at 3 years in relation to subjective outcome scores (SMD=0.404, P<0.01).

When assessing OAT lesions larger than 3cm², OAT was superior to MFX with respect to activity level (SMD=0.506, P<0.05).

Conclusion: Overall, OAT is superior to MFX with patients achieving a higher activity level and lower clinical failure rate. Larger lesion size improves the outcome of OAT over MFX for treatment of cartilage defects in the knee.
Figure 10  Autologous chondrocyte implantation technique. Articular cartilage is procured, and its chondrocytes are enzymatically released and expanded in cell culture. When a sufficient number of cells are obtained, a second operation is performed for implantation of the cultured cells. A peristeal flap with matching geometry is harvested and sutured in place with the cambium cell layer facing the defect (down). The edges of the flap are sealed with fibrin glue. Inset, Care must be taken when harvesting peristeum to ensure that the cambium cells remain attached to the peristeal fibrous layer.
ACI- PERIOSTEAL PATCH
ACI- INJECTING CELLS
ACI Cartilage Repair Quality

- The stiffness of ACI hyaline-like tissue (2.77 N) more closely approximates hyaline cartilage (3.07 N) than fibrocartilage seen after microfracture (1.27 N).108

- This is important because reduced stiffness leads to fissures in tissue texture and progressive degradation.
Problems with ACI

• Even when successful, chondrocyte implantation results in “hyaline-like” tissue rather than true hyaline tissue, and glycosaminoglycan profiles of the implanted cartilage differ from that of native hyaline tissue.


• Apoptotic Cell Death may contribute to delamination of the graft in the setting of chondrocyte implantation.

• Expensive/Requires 2 surgeries
ACI: LONG TERM RESULTS

- Autologous Chondrocyte Implantation: Biomechanics and Long-Term Durability
  Peterson et al: AJSM, 30:2-12, 2002
- 61 patients, F/U mean of 7.4 years
- 81% Good to Excellent @ 2 years
- 83% Good to Excellent @ 5-11 years
- 16% failure rate. All in first 2 years
- Femoral 90%, Patellar 72%, Multiple 76%

- Microfracture 43%
- Debridement 31%
- Non operative 13%
- OATS 6%
- Allograft 4%
- ACI 3%
Return To Sports Stats

RTS Duration

Microfracture: 8-17 months

OATS: 6.5 – 7 months

ACI: 8 – 25 months

ACI DID NOT DETERIORATE WITH TIME

RTS at Preoperative level

Microfracture: 55- 60% and 57%

• OATS: 91-93% and

• ACI: 33-96% and 60-80%

• 224/341 patients. Case series; Level of evidence 4. Mean Follow up 12.8 years
• 74% of the patients reported their status as better or the same as the previous years.
• 92% were satisfied
• the KOOS score was on average 74.8 for pain, 63 for symptoms, 81 for activities of daily living (ADL), 41.5 for sports, and 49.3 for quality of life (QOL).
Articular Cartilage Repair in Soccer Players with Autologous Chondrocyte Transplantation
Mitohofer et al. AJSM 33: 1639,2005

• Case Series: Level 4
• 45 Soccer players
• ACI for lesion size 5.7 cm on average
• F/U 41 months
• 72% good to Excellent
• 33% returned to competitive soccer. 80% at the same level
• Good: Young age and Short Duration of Symptoms
Osteochondral Allografts

- Large Bone & Cartilage Uncontained Defects > 2cm².
- Young patients—Fresh Harvest
- Indications: Trauma > OA > AVN
- Infection Risk – Viral/ Bacterial?
- Rigid Fixation + Osteotomy
- NWB for 8 weeks, Low impact @ 6 months
Allograft Contraindications

• Multicompartment arthrosis
• Inflammatory arthritis
• Limb malalignment
• Ligamentous instability
• Altered bone metabolism
  – Chronic steroids
  – Smoking
  – Previous infection
Osteochondral Allografts

• Hyaline cartilage is ideal for transplantation
  – Avascular
  – Metabolic needs met by diffusion from synovial fluid
  – Aneural
  – Immunoprivileged
  – Viable chondrocytes able to survive hypothermic storage
Osteochondral Allografts

- Osseous structure
  - Underlying structural support
  - Allows fixation to host
  - Originally vascularized
  - Cells do not survive hypothermic storage
  - Scaffold for creeping substitution
Graft Acquisition

- Age criterion: 15-40 years old
- Joint surface passes visual inspection
- Size match
  - Radiographs taken with a magnification marker
  - +/- 2 mm acceptable match
- Typically not HLA or blood type matched
  - Hyaline cartilage immunoprivileged
  - 50% individuals can develop anti-HLA antibodies with unknown significance
Graft Safety

- Recovery, processing and testing established by American Association of Tissue Banks
  - Hold tissue for 14 days for microbiologic testing
  - No published data quantifying risk of transmission for osteochondral allografts

- AAOS Musculoskeletal Allograft Tissue Safety Statement
  - 75th Annual Meeting, March 5-9, 2008
Graft Storage

• Fresh-frozen
  – -80°C
  – Prolonged storage, increased availability
  – Reduces immunogenicity
  – Eliminates >95% of viable chondrocytes
  – Articular matrix degenerates over time
  – Used primarily in bulk allografting

• Fresh cold-storage
  – 4°C – BETTER
  – Chondrocyte cell density, viability and mechanical properties of matrix unchanged with up to 14 days of storage
  – Deteriorate significantly after 28 days
Knee Osteochondral Allografts

• Surgical Technique
  – Knee placed in 70°-100° of flexion
  – Diagnostic arthroscopy
  – Realignment osteotomy if indicated
  – Midline incision from inferior patella to tibia tubercle
  – Medial or lateral arthrotomy depending on lesion
  – Appropriate flexion/extension to expose lesion
  – Preparation of defect
  – Implantation of allograft
    • Dowel vs. shell graft technique
39 yrs old with Large OCD
Allograft Resurfacing
Final Result
Postoperative Management

• ROM as tolerated immediate postop
• Quad strengthening immediate postop
• Toe touch weight bearing 8-12 wks
  – Radiographs confirming osseous incorporation prior to advancing WB status
• Closed chain exercises at 4 weeks
• Avoid impact loading activities for 1 yr
Knee Allograft Results

  – 66 knees in 64 patients
  – Mean age 28.6 years
  – Mean follow-up 7.7 years
  – Mean allograft size 7.5 cm²
  – Merle d’ Albubigne and Postel scale improve 13.0 -> 16/4
    • 72% G/E, 11% fair, 2% poor
  – 10 patients underwent reoperation at an average of 56 months
Knee Allograft Results

  – 43 patients
  – Mean followup 4.5 years
  – Mean allograft area 5.88 cm$^2$
  – Merle d’ Aubigne and Postel scale
    • 88% G/E
Knee Allograft Results

  – 60 patients at 10 year followup
  – 41 realignment osteotomies
  – Mean Hospital for Special Surgery Score 83 points
  – 12 reoperations at 10 years
    • 3 removal of allograft, 9 conversion to TKA
  – Radiographic analysis at 10 years for 38 patients
    • 48% no or mild OA, 26% mod OA, 26% severe OA
Ankle Allograft:
29 Ys Old: TALUS ALLOGRAFT IMPLANTATION
Postoperative Management

• Non weight bearing 10-12 weeks
  – Advance weight bearing with radiographic signs of graft incorporation
• Begin ROM exercises in sagittal plane when incision healed
• Formal physical therapy program at 6 weeks
• Avoid impact activities 1 year
Results

  - 15 patients
  - Mean volume 6059 mm$^3$
  - Average followup 54 months
  - Visual analog pain score 8.5 -> 3.3
  - AOFAS score 38 -> 83
    - 5 pts Ex, 6 pts Good, 2 pts fair, 2 pts poor
  - 2 ankles converted to arthrodesis
Results

  – 11 patients
  – Average followup 33 months
  – Bipolar transplant in 9 ankles
  – AOFAS score 55 -> 73
  – 5 failures
    • 3 revision allograft, 1 arthroplasty, 1 no further surgery
Summary

• Osteochondral allografts are a viable option for young, active patients with massive osteochondral lesions of the femur or talus
  – Transplant viable chondrocytes, a stable matrix and osseous support
  – Long term survivorship
  – Able to treat uncontained defects
  – Option for patients who have failed microfracture, ACI, OATS
  – No donor site morbidity
  – Does not prevent future arthroplasty or fusion
JUVENILE ALLOGRAFT CARTILAGE TRANSPLANTATION
Juvenile Cartilage transplantation

- 2 - 13 years old donors
- scaffold-free, living cartilage implant
- Applied to defects of the joint surface using a protein-based adhesive
Preliminary and Anecdotal Results

• Displays biochemical properties similar to articular cartilage found in young, healthy joints

• Expected to heal and regenerate damaged joint cartilage more effectively than technologies that use adult cells
Case Example: 15 ys old s/p Lateral Menisectomy

• Pain 8/10- IKDC = 47
• 17mm anterior to posterior x 14mm medial to lateral chondral lesion of the lateral femoral condyle was assessed

• 50% of the lateral meniscus was intact???
Surgical Procedure cont’d

- Chondral lesion was debrided and curettage was performed to prepare the subchondral bone.
- Knee was positioned at 90 degrees flexion to maintain a vertical orientation of the lesion.
Surgical Procedure cont’d

• Tin foil was used to create a mold of the lesion
Surgical Procedure cont’d

• 2 bags of De Novo chondral chips were mixed with fibrin glue in the tin foil to create a 2mm wafer in the shape of the lesion
Surgical Procedure cont’d

- Fibrin glue was then applied to the base of the lesion and the graft was placed.
Follow-up

• At 6 weeks
  – Presented in post op brace on crutches.
  – Attending physical therapy 2 times a week
  – Pain 1/10
  – Able to perform SLR
  – Progress weight bearing, full weight bearing in 1-2 weeks
  – Discontinue post op brace as tolerated
Follow-up

• At 18 months.
  – Presented weight bearing with no assistive devices
  – Full range of motion
  – Pain 0/10
  – Reports no problem with knee
  – Continue with moderate impact activities.
  – Back to Soccer?

- This case study of 4 patients followed for at least 2 years was conducted to evaluate a cartilage repair procedure that involves transplanting particulated juvenile allograft cartilage. **Design:** A multicenter, prospective, single-arm, 25-subject case study was designed to evaluate clinical outcomes such as IKDC and KOOS scores as well as the extent and quality of repair with MRI. In addition, there is an option for the transplants to be biopsied at various time points after implantation (up to 5 years). Currently, 25 patients with 1 or 2 chondral lesions on the femoral condyles and trochlea have been enrolled and treated in the prospective study. **Results:** The first 4 patients have completed an evaluation at 24 months postoperative follow-up. Improvements in clinical outcomes over the preoperative baseline data have been observed. **Conclusions:** The present report describes, for the first time, clinical intermediate-term results of a novel cartilage repair procedure that involves transplanting particulated juvenile cartilage tissue allograft into prepared cartilage lesions of the femoral condyles and/or trochlea. Clinical outcome data of 4 patients who have reached the 24-month postimplantation milestone indicate early positive outcomes and suggest that this technique is capable of improving clinical symptoms. MRI data suggest that defect filling is possible and persists to at least 2 years. Continued clinical evaluation of this technique is needed with extended follow-up of all 25 patients in the series.

- UKA in a 44 yrs old 3 years s/p HTO and Denovo
- OATS done at 1.5 years to salvage the repair.
Segment 1 plug region 2
Conclusion

• Jury is still out
• Pro: one stage – Durable Cartilage-like cover
• Con: Not Hayline – No long term results
Table 1. Return to Play Overview

<table>
<thead>
<tr>
<th></th>
<th>MF</th>
<th>ACI</th>
<th>OAT</th>
<th>Allograft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return rate</td>
<td>68%</td>
<td>74%</td>
<td>91%</td>
<td>84%</td>
</tr>
<tr>
<td>Same level return</td>
<td>67%</td>
<td>71%</td>
<td>70%</td>
<td>60%</td>
</tr>
<tr>
<td>Time to return, mo</td>
<td>8 (6-18)</td>
<td>17 (10-36)</td>
<td>7 (4-9)</td>
<td>N/A</td>
</tr>
<tr>
<td>Durability (&gt;3 y)</td>
<td>56%</td>
<td>77%</td>
<td>72%</td>
<td>N/A</td>
</tr>
<tr>
<td>Decreasing function</td>
<td>42%</td>
<td>0%</td>
<td>20%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note: MF = microfracture; ACI = autologous chondrocyte implantation; OAT = osteochondral autograft transfer; N/A = no data available.
## Factors Affecting RTS

### Table 2. Factors Affecting Return to Play after Cartilage Repair

<table>
<thead>
<tr>
<th>Factor</th>
<th>MF</th>
<th>ACI</th>
<th>OAT</th>
<th>Allograft</th>
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<tr>
<td>Age</td>
<td>+</td>
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<tr>
<td>Duration of symptoms</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Lesion size</td>
<td>+</td>
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<td>Lesion type</td>
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<tr>
<td>No. of previous surgeries</td>
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<tr>
<td>Athlete’s skill level</td>
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<tr>
<td>Concomitant procedures</td>
<td>+</td>
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<tr>
<td>Repair tissue morphology</td>
<td>+</td>
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Note: + = demonstrated effect on return to sport; MF = microfracture; ACI = autologous chondrocyte implantation; OAT = osteochondral
Outcomes After a Single-Stage Procedure for Cell-Based Cartilage Repair: A Prospective Clinical Safety Trial with 2 Year Follow up


• Randomized controlled trial; Level of evidence: 2.
• \((n = 29)\) were randomized \((1:2)\) with the intent to treat with either a control microfracture (MFX) or an experimental (CAIS) procedure.
• CAIS had significantly better IKDC and KOOS scores at 12 and 24 months
• SF 36 and MR; No significant difference.
Large Unstable Osteochondral Defect Involving the Medial Femoral Condyle

MULTIPLE TECHNIQUES- Biologic ORIF
History

• 18 y/o male
• Right knee pain and swelling for several months
• No acute or previous injury
• Playing basketball on 8/28/15
• Pain significantly increased, superior and medial to patella, intermittent
• Developed joint effusion and a limp
• Not able to fully flex
• Sensation of something moving around in his knee
• Went to ED, plain films show effusion, sent home with knee immobilizer
Physical Exam

- Moderate effusion
- Moderate TTP medial femoral condyle
- Active ROM:
  - Extension: Normal
  - Flexion: 115 degrees with moderate pain
    Average 6/10
- Sensory index: normal
Pre-operative Imaging

- Large unstable osteochondral defect in the medial femoral condyle which measures 22 mm transverse and 33 mm AP
- Fluid undermines the OCD and there is significant underlying subchondral cystic change
Pre-operative Diagnosis

1. Chronic painful right knee massive osteochondral defect medial femoral condyle
2. Chronic painful right knee loose body formation secondary to number 1
3. Young Patient with Excellent Healing Potential
4. Viable tissue.
TREATMENT OPTIONS

• EXCISION ALONE ( NOT EFFECTIVE / REF??)
• EXCISION AND MICROFRACTURE ( TOO BIG)
• ORIF ALONE ( NO HEALING)
• OATS ALONE ( TOO MANY PLUGS/ DONOR MORBIDITY)
• COMBO ( WHAT WE DO/ ANY REFERENCES??)
• IF THIS DO NOT WORK: SECONDARY PROCEDURES
• DENOVO/ ACI
• FRESH ALLOGRAFTS ( BRIAN COLE)
Treatment Plan

• Surgical intervention
• Right knee ORIF, OATS, loose body removal, proximal tibia bone grafting
Surgical Procedure

• Right knee open osteochondritis dissecans debridement, bone graft and open reduction internal fixation.
• Osteochondral autologous graft augmentation.
• Right knee arthroscopy and arthroscopic loose body excision.
• Right proximal tibia bone graft harvest
Intra-operative Photos and Videos
Post Op Rehab

- Nonweightbearing for 6-8 weeks
- CPM: 0-90 degrees for 6 weeks, 8 hours per day
- Knee Hinge Brace locked from 0-90 degrees,
- PWB 6-12 weeks
- FWB 12 weeks/ ROM
- Sports 24 weeks
3 Weeks Postop

- Pain 0/10
- Compliant with weight bearing, range of motion, and CPM
- STLR: can perform
- Passive ROM:
  - Flexion: 90 degrees
  - Extension: -5 degrees
- Physical Therapy prescription provided
- Follow up in 4-6 weeks
4 Months Post op

- Pain 0/10
- No clicking or catching.
- PWB
- Full ROM
- Effusion +1
- Quads 4/5
Future Directions

1- Mesenchymal stem cells (MSCs), found in bone marrow, skin, and adipose tissue, are capable of differentiating into articular cartilage as well as other cells of mesenchymal origin.71

2- Third-generation ACI techniques have been developed that use implantation of 3-dimensional neocartilage generated from autologous chondrocytes in bioreactors.

3- Second-generation microfracture techniques may improve stabilization and adhesion of the microfracture clot by using different thrombogenic and adhesive polymers that also increase mesenchymal cell recruitment and 3-dimensional organization.
OrthoBiologics and Cartilage


• Platelet Rich Plasma increased proteoglycan and collagen synthesis while decreasing inflammation in joints. Sun et al, Int Ortho 2010

• Exact “Recipe” is still unknown.
CONCLUSIONS

• JOINT PRESERVATION IS INDICATED FOR YOUNG ACTIVE INDIVIDUALS WITH KNEE OR ANKLE DAMAGE

• JOINT ALIGNMENT SHOULD BE RESTORED

• JOINT STABILITY SHOULD BE RESTORED

• MENISCUS SHOULD BE PRESERVED OR REPLACED

• IN SELECTED CASES, SURGICAL RESTORATION OF ARTICULAR CARTILAGE DEFECTS IS INDICATED
CONCLUSIONS

- Microfracture is first line treatment for small cartilage lesions. Large lesions do not do as well.
- Biologic and non-biologic options are available and is tailored to each patient.
- In the short term, cartilage repair was shown to decrease pain and improve joint function.
- It remains to be seen if cartilage restoration will delay or prevent the onset of post-traumatic osteoarthritis.

- To-date, cartilage repair is not indicated for the treatment of advanced osteoarthritis.
THANK YOU
www.drsamlabib.com