OSTEOCHONDRAL ALLOGRAFT RECONSTRUCTION FOR MASSIVE BONE DEFECT

Angelo J. Colosimo, MD
- Head Orthopaedic Surgeon University of Cincinnati Athletics
- Director of Sports Medicine University of Cincinnati Medical Center
- Associate Professor of UC College of Medicine
- Medical Director Holmes Sports Medicine

INTRODUCTION

"Ulcerated cartilage is a troublesome thing, once it is destroyed it is not repaired"  

Hunter, 1743
INTRODUCTION

- Focal cartilage defects in the knee pose a difficult clinical challenge
- Repair, regeneration and transplantation
- Treatment remains an unsolved clinical and scientific problem

INTRODUCTION

- The goal of articular cartilage repair is to:
  - Restore joint congruity
  - Provide full pain-free motion
  - Prevent further tissue deterioration
  - Stimulate healing

INTRODUCTION

- Despite numerous attempts at addressing the problem of chondral lesions, treatment options remain limited and the long-term outcomes uncertain.
INTRODUCTION

- Current treatment options provide, at best:
  - Temporary pain relief
  - Diminished clinical symptoms
  - Temporary functional improvement

Articular cartilage functional properties:
- Load bearing distribution
- Reduces peak stresses on subchondral bone
- Joint lubrication

ARTICULAR CARTILAGE - COMPOSITION

- Hyaline Cartilage:
  - Resists compressive forces
  - The collagen structure gives the tissue its form, strength and durability
  - Type II Collagen
  - Primary function is load bearing
  - Withstands cyclic load and shearing forces
  - Articular cartilage is designed for long term performance
ARTICULAR CARTILAGE - COMPOSITION

- Fibrocartilage (repair cartilage):
  - Resists tension forces
  - Histological studies show unorganized cellular pattern
  - Not structured for efficient load bearing
  - Lower concentration of proteoglycans
  - Long-term performance is inferior to normal articular cartilage
  - No type II collagen

ARTICULAR CARTILAGE LESIONS

- Two Categories:
  - Partial thickness Defects
  - Full thickness Defects

AVAILABLE SURGICAL OPTIONS

I. Debridement & Curettage
II. Drilling
III. Microfracture Technique
IV. Osteochondral Autograft Transplantation
V. Osteochondral Allograft Transplantation
VI. Autologous Chondrocyte Implantation
VII. Growth Factors
FULL-THICKNESS INJURY

AUTOLOGOUS OSTEOCHONDRAL TRANSPLANTATION (MOSAICPLASTY)

Mosaicplasty:
- Osteochondral plugs transplanted from non-weight bearing articular cartilage to chondral defect in weight bearing area
The closer repair cartilage comes to restoring hyaline cartilage the more durable.

Limited surgical techniques

Osteochondral autograft transplantation (OATS):
- Restore height
- Restore shape
- Hyaline cartilage
- Intact tidemark
- Firm carrier - subchondral bone - nutrition

OBI Plugs

OATS - MOSAICPLASTY

No disease transmission

Good chondrocyte survival

Reliable bony union

Limited donor size

Graft size

Ideal Lesion:
- Small (10-30mm)
- Full thickness
- Femoral condyle (medial or lateral)
- Stable surrounding articular cartilage

INDICATIONS FOR OATS
Why OATS??
- Microfracture and abrasion easier
- OATS:
  - Repair with autologous hyaline cartilage
  - Cell viability/survival
  - Restore height and shape of defect
  - Long term survival (tidemark)

Contra-indications:
- Deep, crater like defect
- Loss of subchondral bone
- Difficult to cover large defect
- No appropriate harvest sites
- Severe Malalignment
OATS SURGICAL TECHNIQUE

Step 1: Selection of donor site

Step 2: Chondral defect sizing

Step 3: Recipient defect preparation
**OATS SURGICAL TECHNIQUE**

**Step 3: Recipient Defect Preparation**

**OATS SURGICAL TECHNIQUE**

**Step 4: Determine depth of recipient defect**

**OATS SURGICAL TECHNIQUE**

**Step 5: Donor core harvesting**
Step 6: Donor core insertion

Step 7: Final donor core seating

OATS – Plug placement
Mosaicplasty appears to be a viable alternative for full-thickness cartilage defects.
Regeneration of hyaline or hyaline-like cartilage.
Longevity???
INTRODUCTION

- First used in 1908 by Lexer
  - He reported a 50% success rate
- In the 1940s and 1950s they were thought to be a biologic alternative to the total joint replacement
- In the 1970s fresh osteochondral allografts were used for limb salvage after large tumor resections
- Today they are used more widely due to increased availability

OSTEOCHONDRAL ALLOGRAFTS

- Used for large focal osteo-articular defects and bone loss
- Mature hyaline cartilage and bone
- Success = cell viability
- Fresh, Fresh frozen or cryopreserved

OSTEOCHONDRAL ALLOGRAFTS

- Immunology:
  - Studied extensively
  - Intact hyaline cartilage
  - Immunologically privileged
  - No donor match
OSTEOCHONDRAL ALLOGRAFTS

Cell Viability
- Fresh (99%)
- Fresh Frozen (10-15%)
- Cryopreserved (35-40%)
- Use of cryoprotective agents increases chondrocyte viability compared to fresh frozen grafts
- Cell viability decreases over time

OSTEOCHONDRAL ALLOGRAFTS

Incorporation
- Allograft bone is replaced by Host bone in 2-3 years
- Creeping substitution
- Gross et al reported 85% success rate in 126 knees with fresh allografts

OSTEOCHONDRAL ALLOGRAFTS

Immunology
- Chondrocytes are immuno-privileged
- Humoral antibodies cannot penetrate into the matrix
- Rejection is insignificant
- Tissue typing and immunosuppressants are unnecessary
- Possibility of immune response to allograft cells and marrow
OSTEOCHONDRAL ALLOGRAFTS

- Considerations:
  - Size of defect
  - Availability of size-matched quality donor
  - Extremity alignment
  - Monopolar vs bipolar defects
  - Ligamentous stability
  - Meniscal injury

OSTEOCHONDRAL ALLOGRAFTS

- Indications:
  - Large, deep, extensive osteochondral lesions
  - Bone loss
  - Skeletal maturity
  - No arthritic changes
  - <50 years old
  - Correctable alignment and ligamentous laxity

OSTEOCHONDRAL ALLOGRAFTS

- Optimal Outcomes:
  - Single defect
  - >2cm
  - 1 compartment
  - No angular deformity
OSTEOCHONDRAL ALLOGRAFTS

- Contraindications:
  - Inflammatory arthropathy
  - Uncorrected ligamentous instability
  - Uncorrected malalignment
  - Diffuse arthrosis
  - AVN

OSTEOCHONDRAL ALLOGRAFTS

- Grafts work best in post-traumatic changes and osteochondritis dissecans
- Age and size match

OSTEOCHONDRAL ALLOGRAFTS

- Advantages:
  - Readily available
  - Lack of donor site morbidity
OSTEOCHONDRAL ALLOGRAFTS

- Disadvantages:
  - Disease transmission
  - Donor procurement expense
  - Chondrocyte survival
  - Open procedure

OSTEOCHONDRAL ALLOGRAFT KS CASE

- Pre-operative findings

OSTEOCHONDRAL ALLOGRAFT KS CASE
OSTEOCHONDRAL ALLOGRAFT KS CASE

- Follow-up at 6 weeks

OSTEOCHONDRAL ALLOGRAFT KS CASE

- Follow-up at 1 year

OSTEOCHONDRAL ALLOGRAFT MH CASE

- Pre-operative radiographs
Follow-up at 2 months post-operatively for an osteochondral allograft of the LFC
OSTEOCHONDRAL ALLOGRAFTS

- Gross (1996): 92 fresh allografts for traumatic articular defects:
  - 75% successful at 5 yrs
  - 64% successful at 10 yrs
  - 63% successful at 14 yrs

OSTEOCHONDRAL ALLOGRAFTS

- Garrett (1994)
  - 17 patients with osteochondritis dissecans
  - Ages 16-46
  - Lateral femoral condylar defects
  - All had fresh frozen allografts
OSTEOCHONDRAL ALLOGRAFTS

- Garrett (1994)
  - Transplantation within 4 days of harvest
  - Herbert screw fixation and NWB 6 weeks
  - Follow-up 2 to 9 years
  - 16/17 (94%) had successful results

AUTOLOGOUS CHONDROCYTE IMPLANTATION

- Introduced:
  - Sweden (1987)
- Two stage procedure
- Open procedure
- Laboratory dependant
- MACI Patch
- FDA December 2016
AUTOLOGOUS CHONDROCYTE IMPLANTATION

- **Indications:**
  - Lesions 1-10 cm
  - Age < 50-55
  - Only femoral lesions are FDA approved
  - Osteochondritis dissecans
  - Concomitant correction of instability or malalignment

MACI PATCH

- **Approved by FDA December 2016**
  - Currently only for knees
- **Cellular sheet 3 cm x 5 cm**
- **ACI cells on a resorbable porcine collagen membrane**
  - Type I/III collagen
  - At least 500,000 cells/cm²

- **Clinical Outcomes**
  - SUMMIT Trial
  - 144 patients (18-54)
  - MACI vs MFX
  - 137 pts with FU @ 2 years
  - KOOS scales
  - MACI was clinically and statistically better for treating symptomatic cartilage defects than MFX

FUTURE CONSIDERATIONS

- **Growth Factors**
  - Insulin-Like Growth Factor-1 (IGF-1)
  - Fibroblast Growth Factor (FGF)
  - Transforming Growth Factor-beta (TGF-beta)
  - Hepatocyte Growth Factor (HGF)
  - Platelet-Derived Growth Factor (PDGF)
  - Bone Morphogenetic Proteins (BMP)
  - Interleukin-1 Receptor Antagonist (ILRA)
ARTICULAR CARTILAGE KEY POINTS

- Hyaline cartilage lasts longer than fibrocartilage
- Hyaline cartilage restores the normal function and durability of the joint
- Hyaline cartilage is better able to redistribute joint stress

ARTICULAR CARTILAGE KEY POINTS

- Fibrocartilage will fill the defect and promote relief of symptoms up to a given point in time
- Fibrocartilage lacks the composition, structure and durability of normal hyaline cartilage

SUMMARY

- Challenging problem
- Traditional treatment allows for only temporary relief
- New attempts at regeneration not reliable
- Studies must be > 6 mo. F/U
THANK YOU!