OSTEOCHONDRAL ALLOGRAFT RECONSTRUCTION FOR MASSIVE BONE DEFECT

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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

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

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
- Smaller lesions <3 cm
- Minimal bone loss
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
- Presized osteochondral allografts
  - OBI TruFit Plugs
  - Chondrofix Plugs

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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)

30 months s/p OATS

INDICATIONS FOR OATS

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

OATS - SURGICAL TECHNIQUE
OATS SURGICAL TECHNIQUE

Selection of donor site

Donor core insertion

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???

OATS SURGICAL VIDEO

OATS SUMMARY

- Mosaicplasty appears to be a viable alternative for full-thickness cartilage defects
- Regeneration of hyaline or hyaline-like cartilage
- Longevity???
Arthroscopic mosaicplasty: Long-term outcome and joint degeneration progression

- 26 patients
- Mean age 29
- Mean BMI 23
- Treated with arthroscopic mosaicplasty of the femoral condyle
- 12 year follow up

- Significant improvement in all scores at 12 years
- Better results in patients with higher pre-injury activity levels and those requiring fewer plugs
- Increased Kellgren-Lawrence scores and reduction of joint space with more plugs but did not affect the clinical outcomes

OATS STUDY

Filardo et al Elsevier The Knee 22 (2015) 36-40

OSTEOCHONDRAL ALLOGRAFTS

- 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

INTRODUCTION
OSTEOCHONDRAL ALLOGRAFTS

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

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

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
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
- >2 cm
- 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

Advantages:
- Readily available
- Lack of donor site morbidity

Disadvantages:
- Disease transmission
- Donor procurement expense
- Chondrocyte survival
- Open procedure
OSTEOCHONDRAL ALLOGRAFT KS CASE

- Pre-operative findings

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

OSTEOCHONDRAL ALLOGRAFT MH CASE

[Images of knee joints and bone grafts]
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
OSTEOCHONDRAL ALLOGRAFTS

Long-Term Followup of Fresh Osteochondral Allografts
Prospective non-randomized
- 60 patients with femoral grafts
- Average followup 10 years
- 12 grafts failed
  - 3 grafts removed
  - 9 patients converted to TKR
- Kaplan-Meier
  - 95% graft survivorship at 5 years
  - 85% graft survivorship at 10 years
- 65 patients-tibial plateau grafts
- Average followup of 11.8 years
- 21 knees converted to TKR
- Kaplan-Meier
  - 95% graft survivorship at 5 years
  - 80% graft survivorship at 10 years
  - 65% graft survivorship at 15 years

Gross et al, June 2005 Clinical Orthop Vol 435 pp 79-87

AUTOLOGOUS CHONDROCYTE IMPLANTATION

- Two stage procedure
- Open procedure
- Laboratory dependant
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
  - Minimal bone loss

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)

FUTURE CONSIDERATIONS

- 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!