

The Athletic Knee

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The Problem

- Young active patients with articular cartilage defects!
 - Which defects progress to OA ?
 - Which defects are symptomatic ?
 - How do we most effectively treat these defects?





The Biology

- Physiologic role of articular cartilage
 - Minimize stresses on the subchondral bone
 - Reduces friction on the weight bearing surface
- Critical in proper joint function





Goals of Treatment

- Restore integrity of load bearing surface
- Obtain full range of motion
- Obtain pain free motion
- Inhibit further degeneration







Treatment Considerations

- Age of the patient
- Defect size
- Knee stability
- Knee alignment
- Level of activity







Partial Thickness Defects

- Articular cartilage lacks the capacity to repair structural damage
- Progresses when exposed to mechanical wear







Full Thickness Defects

- Do not heal with hyaline cartilage
- Healing by subchondral stimulation leads to the formation of fibrocartilage
 - Lacks physiological role of hyaline cartilage
 - Poor wear characteristics
- Progress to osteoarthritis







Non-Surgical Options

- Activity modification (decrease load)
- Muscle strengthening (load absorption)
- Bracing (selective joint unloading)
- Aspiration (decrease painful joint distention)





Non-Surgical Options

- Pharmacological
 - Oral
 - Non-steroidal anti-inflammatory medication
 - Chondrotin sulfate
 - Glucosamine
 - Injectable
 - Corticosteroids decrease the inflammatory response but have no mechanical benefit
 - Synvisc may improve the status of the articular surface by improving chondrocyte "health"





• Arthroscopic lavage - remove debris

- Arthroscopic shaving smooth surface
- Drilling or microfracture create fibrocartilage scar
- Osteotomy realignment to unload diseased compartment
- Osteochondral autograft replace a damaged surface
- Autologous chondrocyte transplant replace injured cartilage
- Allograft osteochondral transplantation



Arthroscopic Lavage

- Remove debris and inflammation mediators
- Temporary relief
- Not a definitive procedure not curative
- Not normally sufficient for athletic or active patients





Arthroscopic Debridement

- Lavage and chondroplasty
- No sub-chondral stimulation
- May lead to improvement for up to 5 yrs.
- 10-20% may become worse
- Debridement does nothing to promote repair
- Malaligned or unstable knees do poorly





Thermal Chondroplasty

- New procedure
- Requires bi-polar or ultrasonic device
- "Seal" the articular surface with heat
- Keplan L,M.D. reported no injury to the chondrocytes of the involved or peripheral cartilage. "Radio-frequency energy appears to be safe for use on articular surface." Arthroscopy, Jan-Feb. 2000, pp 2-5.





Abrasion Arthroplasty

- Debridement and stimulation of subchondral bone
- 1 1.5mm deep results in fibrocartilage repair
- intracortical rather than cancellous





- Johnson 399 patients
- 66% with continued pain
- 99% with activity restriction





Results : Abrasion Arthroplasty

- Unpredictable
- May not be better than debridement alone
- Rand noted 50% of patients who had an abrasion underwent TKR within 3 yrs.





Drilling or Microfracture

- Debride lose cartilage
- Subchondral bone penetration drill or pick, 3/cm squared
- Results in fibrocartilage repair
- Lacks durability
- Lacks the mechanical properties of hyaline cartilage









Drilling Results

Joseph Tippet, M.D.

- 62 month follow up
- 71% Excellent
- 15% Good
- 14% Fair / Poor





Results:

- Richard Steadman, M.D. reported improvement in 364 of 485 patients (75%) at 7 years post-op
 - 90 100% of the defects were healed at 4 wks. with 30% hyaline cartilage
 - 12 mos. 42% hyaline cartilage
- Myron Spector, M.D. demonstrated complete filling of the lesions at 3 months in an animal model





Microfracture Results :

- Unpublished

 75% improvement
 50% returned to sports
- Steadman / Hawkins





Osteochondral Grafting

- Autologous plugs of bone with hyaline cartilage cap
- Best done for small lesions (< 2cm.)
- New technique
- Limited data at follow-up







Osteochondral Autografting

Indications

- Full thickness (grade IV) lesions in the weight bearing surface of the femoral condyles
- Well circumscribed lesion sharp transition zone
- <2 cm diameter lesion</p>
- Young patient (< 45 yrs.)
- Normal alignment and stability



Osteochondral Autografting Contraindications

- Axial malalignment (varus / valgus)
- Arthritis : poor transition zone and or bicondylar lesions
- Age : patients > 55 60 poor results despite other inclusion criteria





Osteochondral Autografting Contraindications

- Lesions > 2cm. (rare)
- Osteochondritis dessicans
- Large OCD usually exceed donor area limitations & large bony defects w/ no subchondral reference points
















Osteochondral Autografting

- Advantages
 - Potential for physiologic hyaline cartilage
 - Single stage procedure
 - Can be done all arthroscopically





Osteochondral Autografting

- Disadvantages / Concerns
 - Damage to the subchondral plate
 - Creates bleeding and fibrocartilage
 - Donor site morbidity
 - Incongruence of the plugs / articular surface





Donor Site Morbidity : Osteochondral Autografts

 Morgan, Carter & Bobic 104 cases - no donor morbidity



Osteochondral Autograft
 Biopsy Proven Survival :
 Hyaline Cartilage, Tidemark &
 Bone

- Wilson 10 years
- Outerbridge 9
 years
- Hangody 5 years
- Bobic 3 years
- Morgan 1 year



Osteochondral Autografting : Results

- Bobic
 - 12 Cases
 - Lesion 1 2.2cm.
 - 10/12 excellent results at 2 yrs.



Osteochondral Autografting : Results

- Morgan & Carter
 - 52 Cases
 - IKDC evaluation
 - Pain
 - 65% improved 2 grades
 - 31% improved 1 grade
 - 4% no change (failure)





LIMITATIONS OF OATS

- Potential for DJD at donor site is real
- No clinical support for repair of single or multiple plugs
 - -Prophylactic surgery
- Difficult to justify the procedure





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Contact Pressures at Osteochondral Donor Sites in the Knee

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Figure 3. A gray-scale drawing of the relative mean color density measurements at each of the donor sites, the darker the color, the greater the pressure. *, significantly different from sites of greatest pressure.

• ALL TEN SITES OF OSTEOCHONDRAL HARVEST

- Articulated and demonstrated significant contact pressure
- Rim stress concentration may lead to DJD
- Osteochondral donor sites do not heal normally







Osteochondral Autograft

- Post-op
- Early motion
 - Immediate active, active assisted, and passive ROM
 - NWB x 2 weeks
 - Thigh muscle strengthening & stretching 3 months
 - Avoidance of sports & running for 3 months





RECOVERY FROM OATS

- Allow 6 weeks for plug to heal
- Desk job RTW 1-2 weeks
- Laborer RTW 3-4 months





Autologous Chondrocyte Implantation

- First procedure : biopsy
 - Arthroscopic chondrocyte harvest from upper medial femoral condyle
- Cultivation of cells 14-21 days
- Second procedure : implantation
 - Arthrotomy & debridement of lesion
 - Defect covered with periosteal flap
 - Cultured chondrocytes injected into defect



First Surgery-Arthroscopy





Second Surgery-Arthrotomy





Defect contained bealthy cartilage.



Step 1: Use an open ring curette to excise damaged cartilage from the defect.

Good stable vertical borders.











Inject \$10,000 worth of cells!











Autologous Chondrocyte Implantation : Indications

- Age 15-55
- Defect location femoral condyle
- Defect size 1-10cm.
- Defect type Grade IV
- Ligament stability
- Biomechanical alignment





- Contraindications
 - Kissing lesions
 - Inflammitory arthritis
 - Total meniscectomy
 - Over 50 (psychologic)
 - Unstable knee
 - Generalized degenerative disease
 - Unhealed lesion through subchondral bone



Dedifferentiation / Radiffarantiation Biopsy enzymatic digestion Chondrocytes redifferentiation **Released from Matrix** agarose/alginate suspension cultures in vitro **Monolayer Culture** defect in femoral condyle in vivo dedifferentiation

Articular Cartilage: Science Review

© genzyme tissue repair, 07/95











Autologous Chondrocyte Implantation: Advantages

- Less donor site morbidity
- Larger and multiple defects can be addressed
- Good results with longer follow-up
- No violation of host's subchondral plate
- FDA approved





Autologous Chondrocyte Implantation : Disadvantages

- Requires 2
 procedures
- Not arthroscopic
- Expensive
- No long term results





Autologous Chondrocyte Implantation

- Post-op
 - -CPM
 - Active ROM
 - Toe touch weight bearing for 6 weeks
 - week 7-12 closed chair exercises
 - Jogging at 6 months
 - Sports at 1 year



Autologous Chondrocyte Implantation US Clinical Experience

- 121 patients 6 month follow-up
- 42 patients 12 month follow-up
- 85% improved overall condition
- 80% improved pain scores at 12 months



Autologous Chondrocyte Implantation Swedish Results NESM 1994

- 23 patients 14-48
- Defects 1.6 6.5cm
- 14/16 Good excellent results with 2 year follow-up
- Biopsy has appearance of hyaline cartilage



Autologous Chondrocyte Implantation Swedish Results 1997

- 100 patients 2-9 year follow-up
 - 90% improvement with femoral condyle lesions
 - 74% with femoral condyle and ACL reconstruction
 - 58% for trochlear lesions
 - 75% for multiple defects



Effect of Cultured Autologous Chondrocytes on Repair of Chondral Defects in a Canine Model^{*}

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Investigation performed at the Department of Orthopedic Surgery, Brigham and Women's Hospital, Harvard Medical School, Boston

ABSTRACT: Articular cartilage has a limited capacity for repair. In recent clinical and animal experiments, investigators have attempted to elicit the repair

The forty-four defects were divided into three treatment groups. In one group, cultured autologous chondrocytes were implanted under a periosteal flap. In the second group, the defect was covered with a periosteal flap but no autologous chondrocytes were implanted. In the third group (the control group), the defects were left empty.

thinning of the zone of calcified cartilage, or, rarely, small localized penetrations into subchondral bone. The forty-four defects were divided into three

With the numbers available, we could detect no significant difference among the three groups with regard to any of the parameters used to assess the quality of the repair. In the two groups in which a periosteal flap was sutured to the articular cartilage surrounding the defect, the articular cartilage showed degenerative changes that appeared to be related to that suturing.



- Little proof that \$10,000 worth of cells do anything
- Cartilage that regrows is not normal
- Ideal patient is rare
 - Young, isolated lesion, no meniscal tear or instability
- Difficult to justify procedure





Osteochondral Allograft Transplantation

• Joint resurfacing with fresh or fresh frozen cadeveric tissue




Allograft Procedure

- Open procedure
- Expose the degenerative lesion
- Remove the defective articular cartilage and a "thin" bony base
- Utilize allograft tissue to replace and restore the articular surface





Allograft Advantages

- Replaces articular hyaline cartilage with hyaline cartilage
- Single procedure





Allograft Disadvantages

- Cost
- Risk of disease transmission from fresh
 allograft tissue





Allograft Results







































What to do??





- Low demand patients
- Small focal lesion (<2cm)
- Arthroscopic chondroplasty
 - 50% relief up to 5 years
- Autograft Osteochondral or chondrocyte if failed chondroplasty





- High demand patient
- Small focal lesion (<2cm)
- Debridement plus drilling / fx
 - 75% success with all
 - 50% success with sports
- Osteochondral grafting or chondrocyte transplant if failure





- Low demand patient
- Large lesion (>2cm)
- Debridement or microfracture with chondrocyte harvest
- If persistent pain osteochondral or chondrocyte transplant





- High demand patients
- Large lesion (>2cm.)
- Chondrocyte transplant 1st line treatment yields 90% success



Long History No Acute Symptoms Varus Knee Marked DJD

> Arthroscopic Results Unpredictable Little Improvement



Conclusions

- Articular cartilage does not repair itself
- Numerous treatments with varying results
- Most treatments fail in the long term due to articular cartilage's inability to produce hyaline cartilage





Conclusions

- Osteochondral auto grafts and chondrocyte transplants show promising results
- Osteochondral auto grafts allow transplantation of bone capped with hyaline cartilage
- Autologous chondrocyte implantation allows near normal hyaline cartilage growth into defects





Meniscal Allograft Indications

- Patient age young 20-40
- Previous meniscectomy
- Painful compartment
- Minimal Arthritic Changes
- Correct alignment
- Stable knee





Sterilization

- Viral contamination risk 1:1.6 million to 1:1.2 billion
- Radiation
 - -> 2.5 mrads destroys collagen
 - <2.5 mrads does not kill viruses</p>
- Sterile harvest and storage with donor screening











Meniscal Allograft Technique

- Bone anchors for anterior and posterior horns
 - Plugs for medial meniscus
 - Slot for lateral meniscus
- Increases the difficulty










Meniscal Allograft Technique

- Open
 - Easier
- Arthroscopic
 - Less morbidity
 - More technically demanding
- Collateral ligament release if necessary

 Increases exposure & facilitates graft
 passage under condyles



Allograft Meniscal Transplant

- Postoperative protocol
 - Not completely elucidated
 - Reflect meniscal repair protocols
 - Most incorporate early full ROM
 - Restricted weight bearing (6 weeks)
 - CPM early in post operative course



Allograft Meniscal Transplant: Results

- 5 year follow-up cryolife 37 grafts
- Medial (27)
- 20 (74%) intact
- 4 (15%) partial meniscectomy
- 2 (7%) Total meniscectomy
- 1 (4%) non-removal failure



Allograft Meniscal Transplant : Results

- Goble 69 allografts
- 40 patients > 2 yr. follow-up
- 11 (16%) failures
- 70% of patients had subjective improvements with pain





Cryo-Life 5 Year Results

- Lateral (10)
- 5 (5%) intact
- 4 (40%) partial meniscectomy
- 1 (10%) total meniscectomy

