TREATMENT OF CARTILAGE INURIES IN THE KNEE

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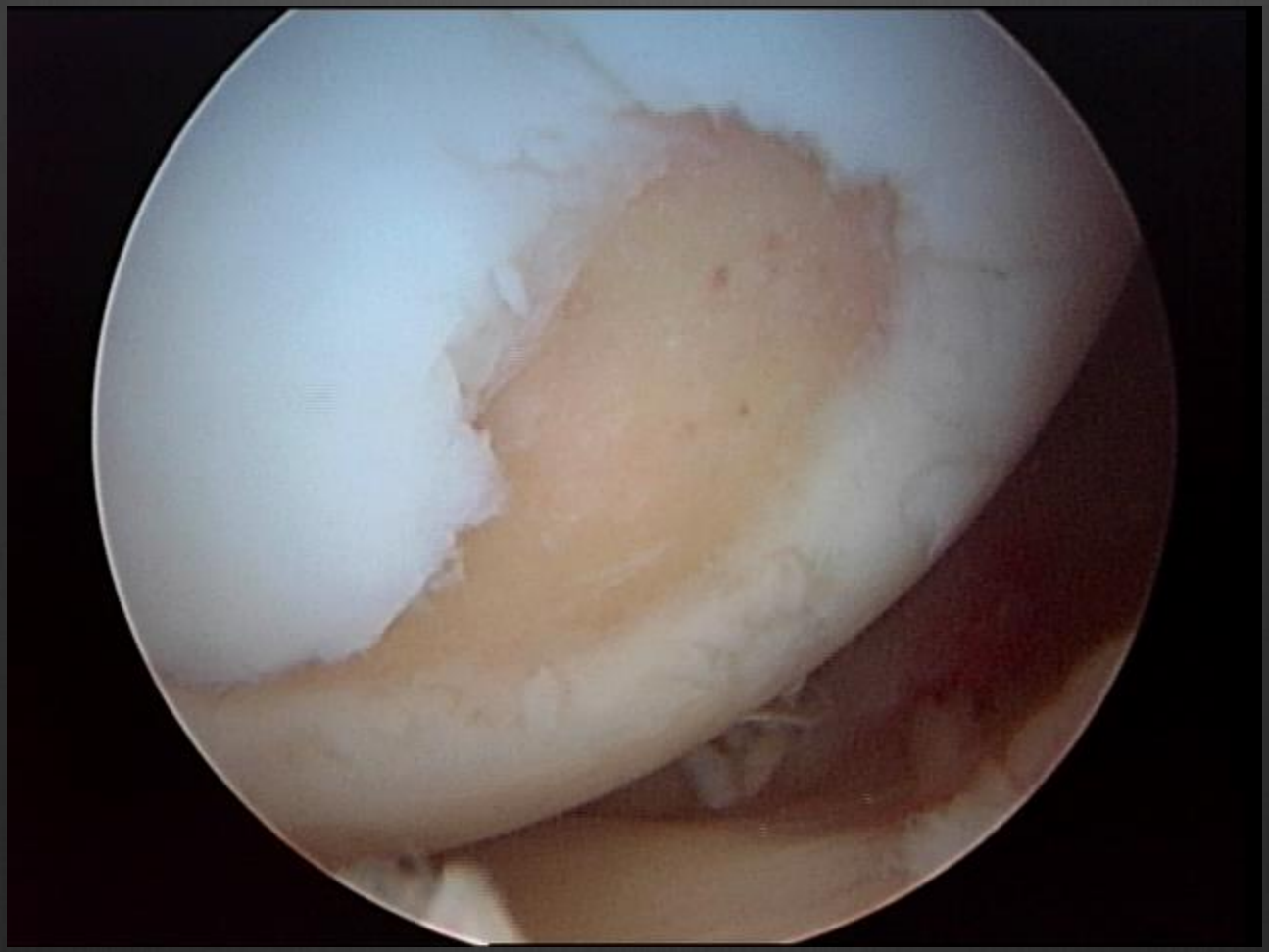
WHAT I HOPE YOU GET FROM THIS TALK…….

- DEVELOP UNDERSTANDING OF WHY CARTILAGE REPAIR IS DIFFICULT TO MANAGE
- SEE THE MANY MANY OPTIONS THAT ARE USED TODAY
- FUTURE STRATEGIES IN CARTILAGE REPAIR
- RETURN TO PLAY AFTER SURGERY
- UNDERSTAND WHY SOME PEOPLE DON'T DO AS WELL WITH THERAPY AFTER A KNEE SCOPE


JUST
DO IT
JUST
DID IT

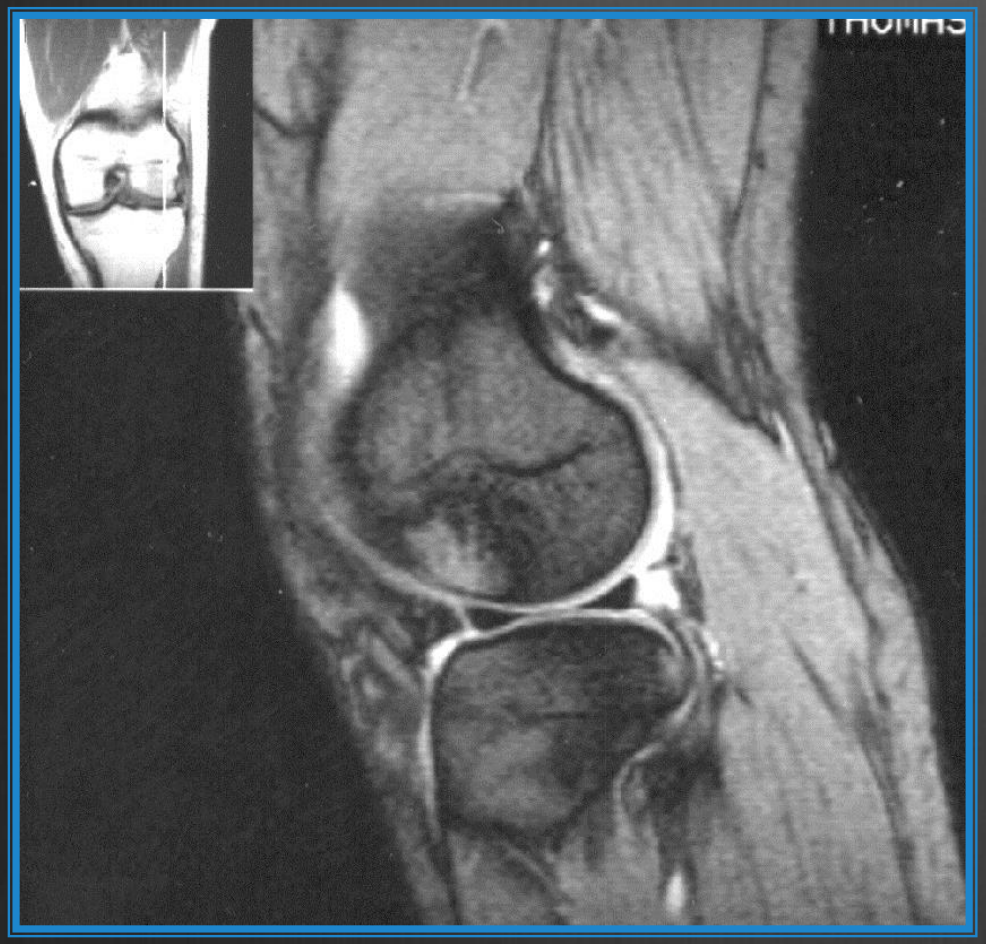
THIS CARTILAGE LESION NEEDS A SOLUTION….



Courtesy of Brian Cole, MD

SOLUTION TO THIS .. Weight loss and therapy

The“Bone Bruise”



OCCURS WITH ACL INJURIES

VERY UNPREDICTABLE

WHY YOU CANT TREAT ALL ACL INJURIES THE SAME

CARTILAGE

- NO NERVES
- NO BLOOD SUPPLY
- NO LYMPHATIC SYSTEM
- FEW CELLS

- AND WE WONDER WHY ITS HARD TO TREAT!!!!!!!

CARTILAGE

- FUNCTIONS TO PROTECT SUBCHONDRAL BONE
- LOW FRICTION SURFACE DISTRIBUTES LOAD
- COMPOSED OF CHONDROCYTES SURROUNDED BY EXTRACELLULAR MATRIX
  - COLLAGEN TYPE 2
  - PROTEOGLYCAN
  - WATER

ARTICULAR CARTILAGE: LAYERS

SUPERFICIAL
- Flat cells
- High collagen content
- High water content
- High tensile strength

TRANSITIONAL
- Spherical cells
- More proteoglycans
- Low water content
- Fibrils bent to form arcades

RADIAL
- Active groups of cells
- Perpendicular fiber orientation

CALCIFIED CARTILAGE
- Anchor point of collagen

CLASSIFICATION SYSTEM

Table 1 Classification of articular lesions by severity

Grade	Outerbridge	Modified outerbridge	ICRS
0	Normal cartilage	Intact cartilage	Intact cartilage
I	Softening and swelling	Chondral softening or blistering with intact surface	Superficial (soft indentation or superficial fissures and cracks)
II	Fragmentation and fissures in area less than 0.5 inch in diameter	Superficial ulceration, fibrillation, or fissuring less than 50% of depth of cartilage	Lesion less than half the thickness of articular cartilage
III	Fragmentation and fissures in area larger than 0.5 inch in diameter	Deep ulceration, fibrillation, fissuring or chondral flap more than 50% of cartilage without exposed bone	Lesion more than half the thickness of articular cartilage
IV	Exposed subchondral bone	Full-thickness wear with exposed subchondral bone	Lesion extending to subchondral bone

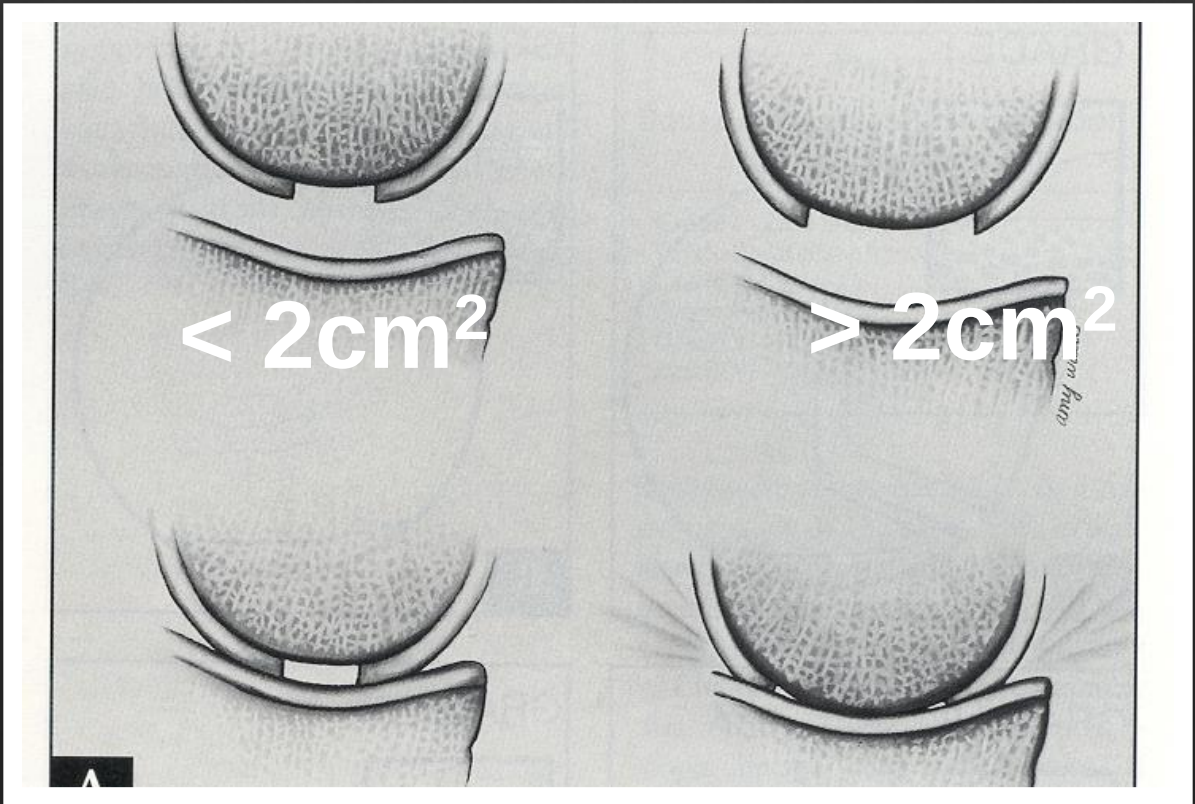
CRS: International Cartilage Repair Society.

HOW I APPROACH CARTILAGE REPAIR..

- DEFECT SPECIFIC FACTORS
- PATIENT SPECIFIC FACTORS
- JOINT SPECIFIC FACTORS

DEFECT SPECIFIC FACTORS

- SIZE
- DEPTH
- LOCATION
- DEGREE OF CONTAINMENT



SIZE , DEPTH, CONTAINMENT
65% more pressure on surrounding cartilage if > 1 cm2

PATIENT SPECIFIC FACTORS

- AGE – BETTER OUTCOMES IF LESS THAN 30Y/O
- ACTIVETY LEVEL
- EXPECTATIONS – 3 YEAR RESULTS BETTER THAN 10 YEAR OUTCOMES
- WEIGHT- WORSE IF BMI > 30 KG/M2

JOINT SPECIFIC FACTORS

- ALIGNMENT – WILL NEVER WORK IF VARUS AND VALGUS NOT CORRECTED
- STABILITY- WILL FAIL IF ACL DEFICIENT KNEE
- STATUS OF MENISCUS- IF LARGE MENISCECTOMY ..INCREASES CONTACT FORCES ON CARTILAGE AND ADDS INSTABILITY

Meniscectomy Vs. Repair

CARTILAGE OPTIONS

- ABRASION ARTHROPLASTY
- MICROFRACTURE
- ACELLULAR MATRIX INDUCED MICROFRACTURE
- OATS – OSTEOCHONDRAL AUTOGRAFT
- OSTEOCHONDRAL ALLOGRAFT
- ACI- AUTOLOGOUS CHONDROCYTE IMPLANTATION
- MACI

Table 2 Treatment options for articular cartilage lesions

Procedure	Indications	Outcome
Arthroscopic debridement and lavage	Minimal symptoms	Palliative
Marrow stimulation	Smaller lesions, low-demand patient	Reparative
Osteochondral autograft	Smaller lesions, low-or high-demand patients	Restorative
Osteochondral allograft	Larger lesions with bone loss, low-or high-demand patients	Restorative
Autologous chondrocyte implantation	Small and large lesions with and without bone loss, high-demand patients	Restorative
Genetic engineering	Investigational	Restorative

From Garrick JG, editor: Orthopaedic knowledge update: sports medicine, 3rd ed, Rosemont, IL, 2004, American Academy of Orthopaedic Surgeons.

Özmeriç A *et al*. New treatment algorithm in cartilage injuries

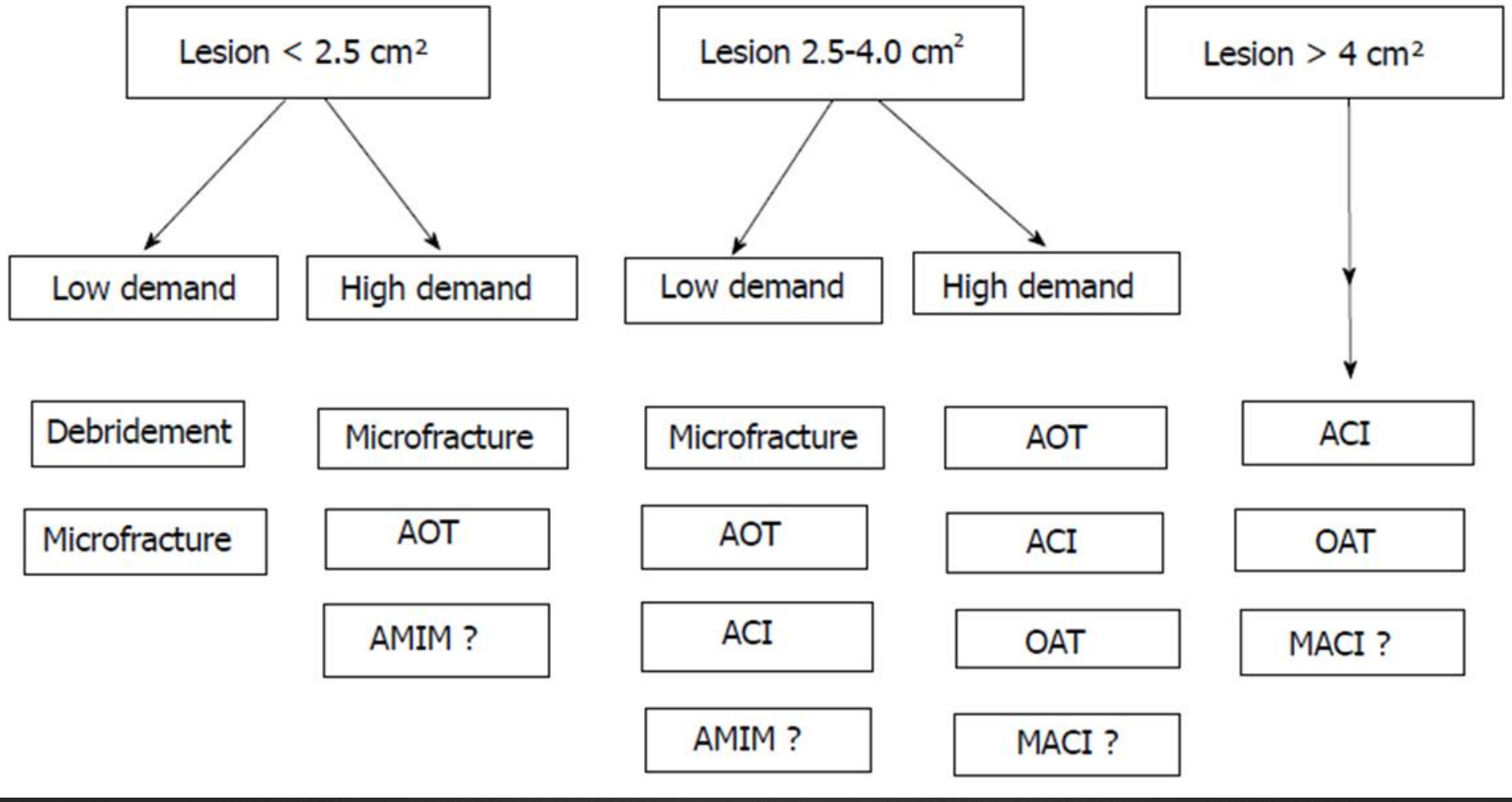
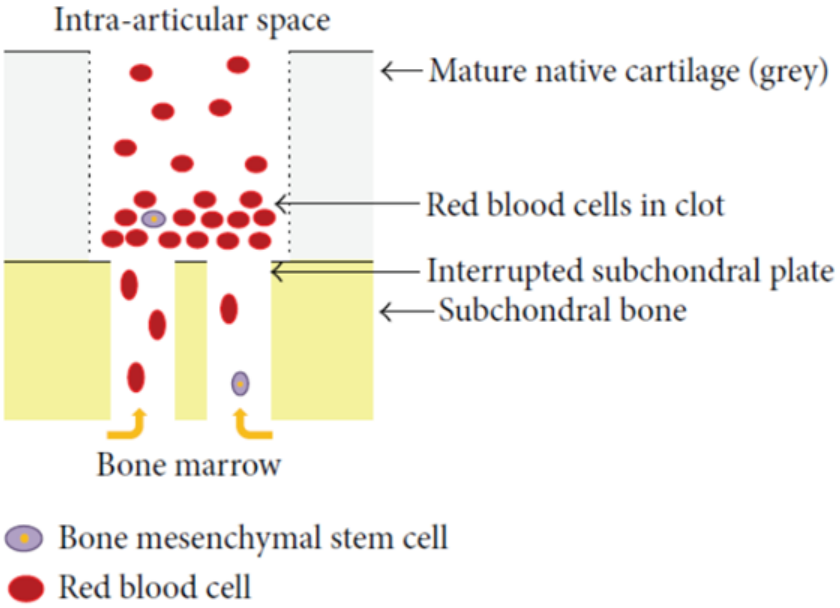
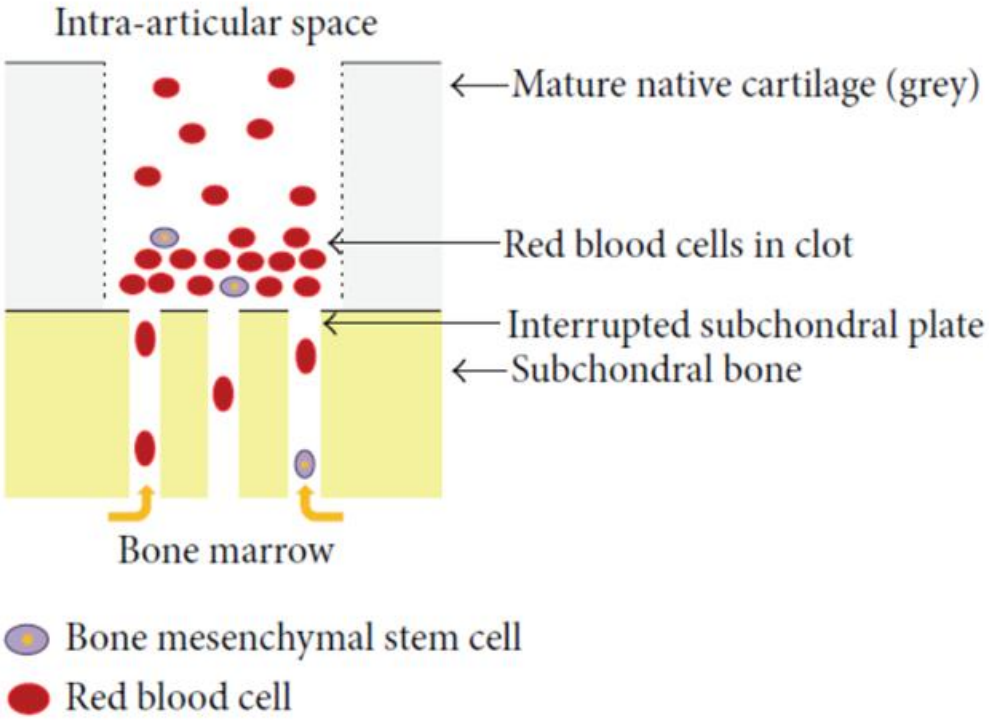


Table 1: Summary of techniques.

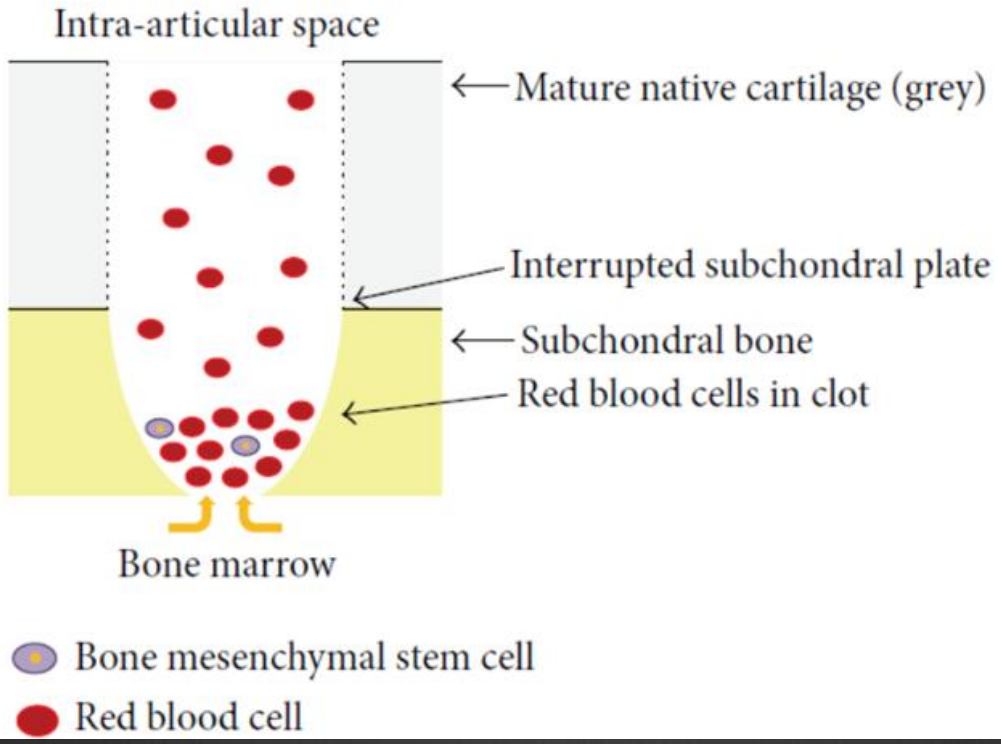
Category/technique	Schematic representation	Notes	Commercial products
Surgical bone marrow access			
Pridie drilling		*Cell source*: autologous bone marrow constituents *Scaffold*: none (i) 1 stage (ii) Open procedure (iii) 2- to 2.5-mm drill holes to access bone marrow (iv) Inconsistent results (v) Long recovery (vi) High complication rate	

Microfracture

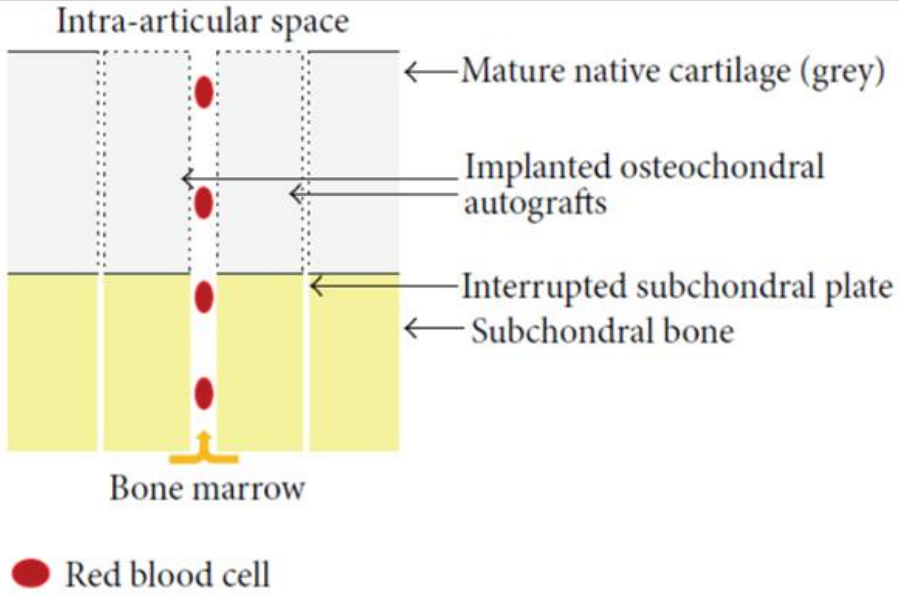


Cell source: autologous bone marrow constituents
Scaffold: none
(i) 1 stage
(ii) Arthroscopic procedure
(iii) 0.5- to 1-mm drill holes to access bone marrow
(iv) Less impact than Pridie drilling on biomechanics of underlying subchondral bone

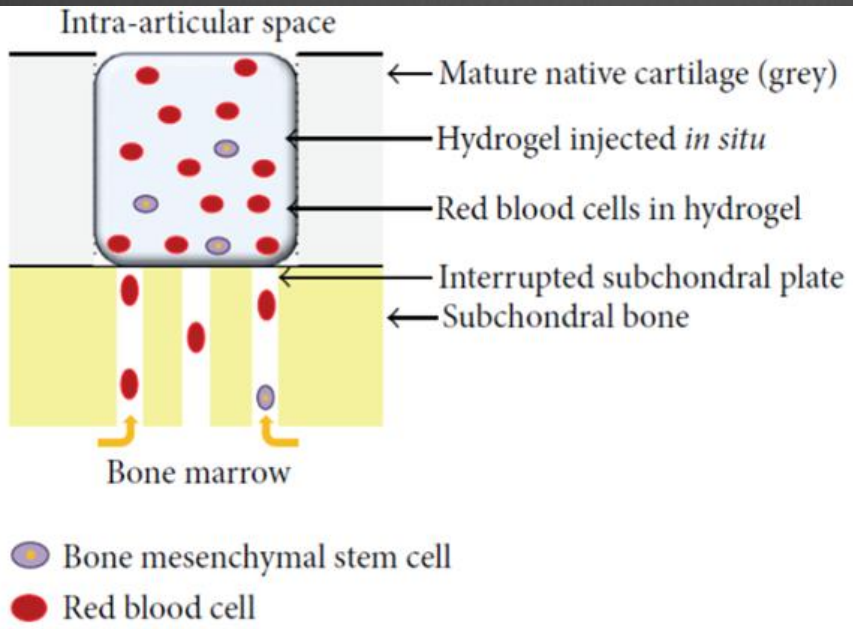
Abrasion chondroplasty



Cell source: autologous bone marrow constituents
Scaffold: none
(i) 1 stage
(ii) Arthroscopic procedure
(iii) Irreproducible, unreliable
(iv) Loss of underlying subchondral mechanical support

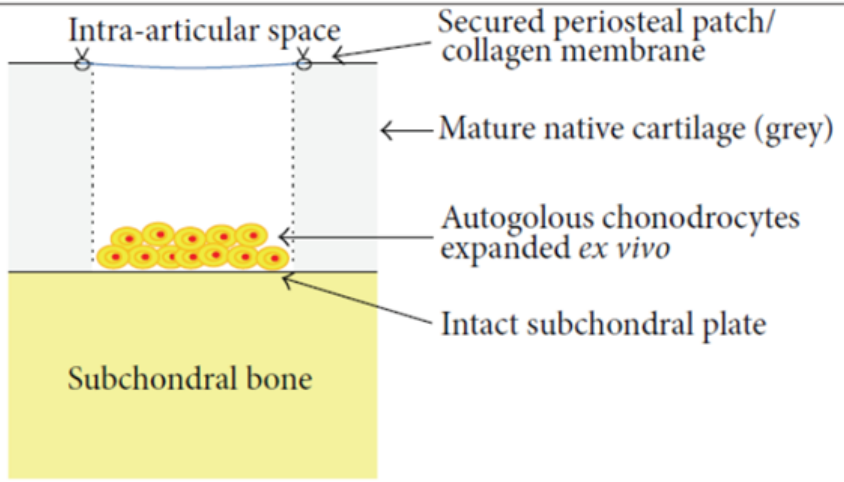
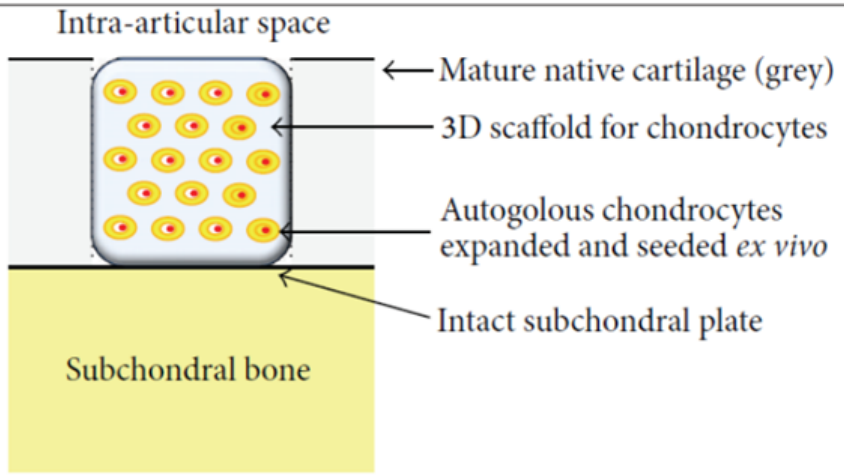
Category/technique	Schematic representation	Notes	Commercial products
Mosaicplasty		*Cell source*: osteochondral autograft and autologous bone marrow constituents *Scaffold*: N/A (i) 1 stage (ii) Morbidity at harvest site (iii) Osteochondral plugs 15–20 mm deep (iv) Blood clot in interspaces	

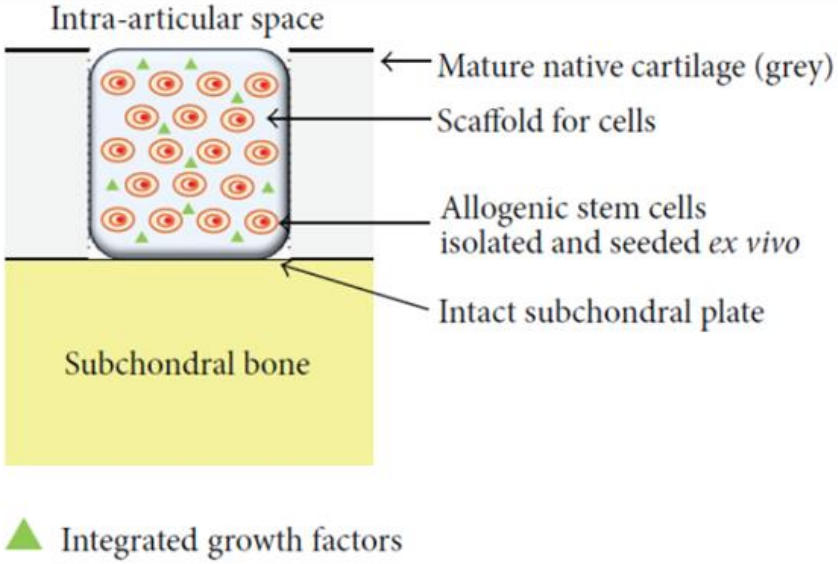
Autologous matrix-induced chondrogenesis



Cell source: autologous bone marrow constituents
Scaffold: hydrogel
(i) 1 stage
(ii) Arthroscopic procedure
(iii) 0.5- to 1-mm drill holes to access bone marrow
(iv) Less impact than Pridie drilling on biomechanics of underlying subchondral bone

ChonDux
CART-PATCH
BST-CarGel

Chondrocyte implantation			
First generation		*Cell Source*: autologous chondrocytes *Scaffold*: none (i) 2 stages (ii) Periosteal patch or collagen membrane (iii) Secured by sutures and/or fibrin glue (iv) Greatest clinical experience	Chondro-Gide Carticel
Second generation		*Cell source*: autologous chondrocytes *Scaffold*: hydrogel, fibrous scaffold, decellularized ECM, or composite (i) 1 or 2 stages (ii) ±Cells expanded and seeded in scaffold or matrix (iii) Also known as matrix-induced autologous chondrocyte implantation (MACI)	Hyalograft C BioSeed-C Histogenics NeoCart CaReS Cartilage Autograft Implantation System

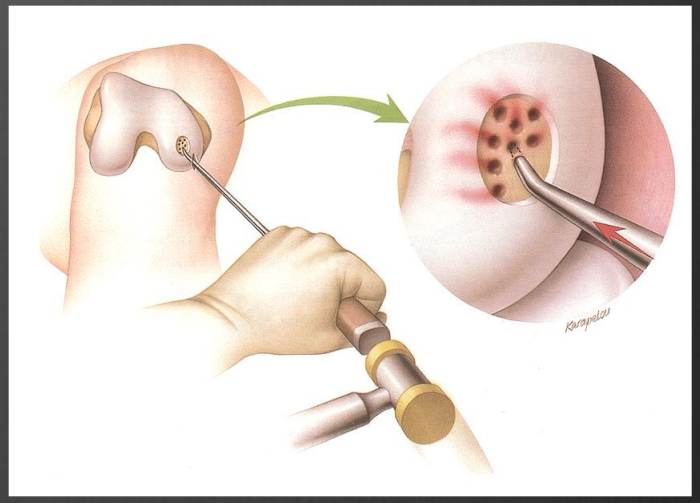
Category/technique	Schematic representation	Notes	Commercial products
Third generation		*Cell source*: allogenic stem cells, autologous stem cells *Scaffold*: hydrogel, fibrous scaffold, decellularized ECM, or composite (i) 1 stage (ii) Differentiation of pluripotent stem cells induced by environment (iii) Least clinical experience	DeNovo ET DeNovo NT

Debridement & Lavage

- Strengths:
  - Arthroscopic
  - Does not violate sub-chondral bone
  - Temporary pain relief
- Limitations:
  - Low prospects for long term result
  - Fibro-cartilage

MicroFracture

- Strengths:
  - Arthroscopic
  - Relatively simple procedure
- Limitations:
  - Creates fibro-cartilage / poor wear characteristics
  - More effective on smaller defects
  - 6-8 weeks non-weight-bearing and CPM required to optimize results



Courtesy of Brian Cole, MD

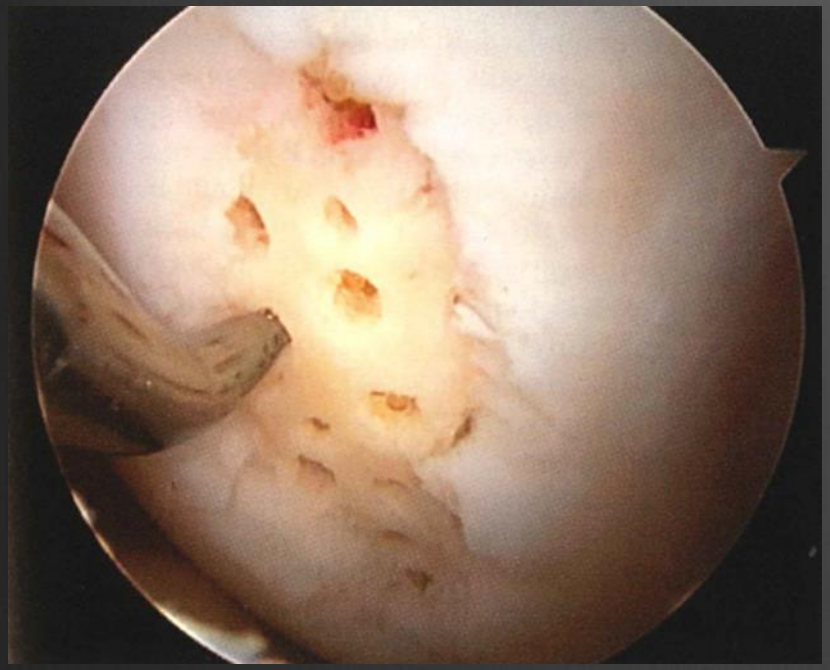


Table 1. Key Rehabilitation Points

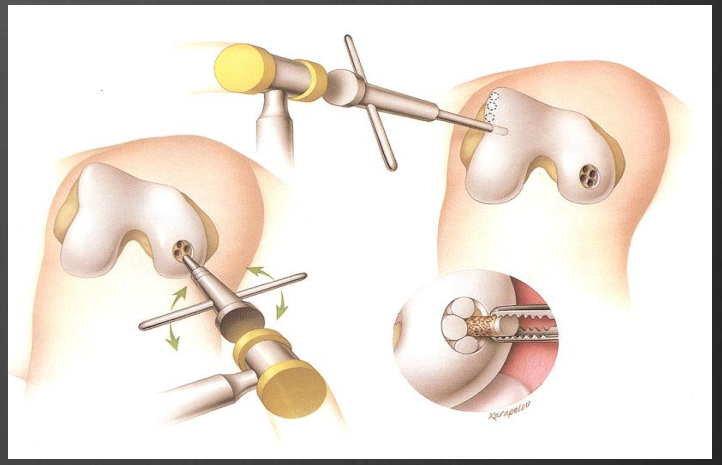
Lesions of the femoral condyle or tibial plateau
Immediate continuous passive motion, 8 hours daily for 8 weeks; 1 cycle per minute at 30° to 70°
No brace
Touch-down (20%-30%) crutch walking for 8 weeks
Cycling (light resistance): start 2 weeks postoperatively
Deep water exercise: start 2 weeks postoperatively
After 8 weeks, full weightbearing and active range of motion
No cutting, turning, or jumping for at least 4 to 9 months depending on the patient
May be longer for competitive or larger patients
Patellofemoral lesions
Immediate continuous passive motion, 8 hours daily for 8 weeks at 0° to 50°
Brace locked at 0°; full weightbearing at 2 weeks
Stationary bike (light resistance): start 2 weeks postoperatively
Water program (no impact): start 2 weeks postoperatively
After 8 weeks, begin walking with a brace
Treadmill at 7° incline starting at 12 weeks postoperatively
Biking and water program: increase intensity at 8 to 12 weeks
Elastic resistance program with 0° to 30° knee bends starting at 12 weeks

MICROFRACTURE

- PERFORATE SUBCHONDRAL BONE
- PROMOTES MIGRATION OF MESENCHYMAL STEM CELLS
- HYALINE LIKE CARTILAGE EARLY THEN FIBROCARTILAGE - DETERIORATES AFTER 3 YEARS

OsteoChondral Autografting

- Strengths:
  - May be performed arthroscopically
  - Fills defect with native cartilage
- Limitations:
  - Limited to smaller defects
  - Donor site morbidity
  - No lateral integration
  - Congruity of joint difficult to re-produce with multiple plugs



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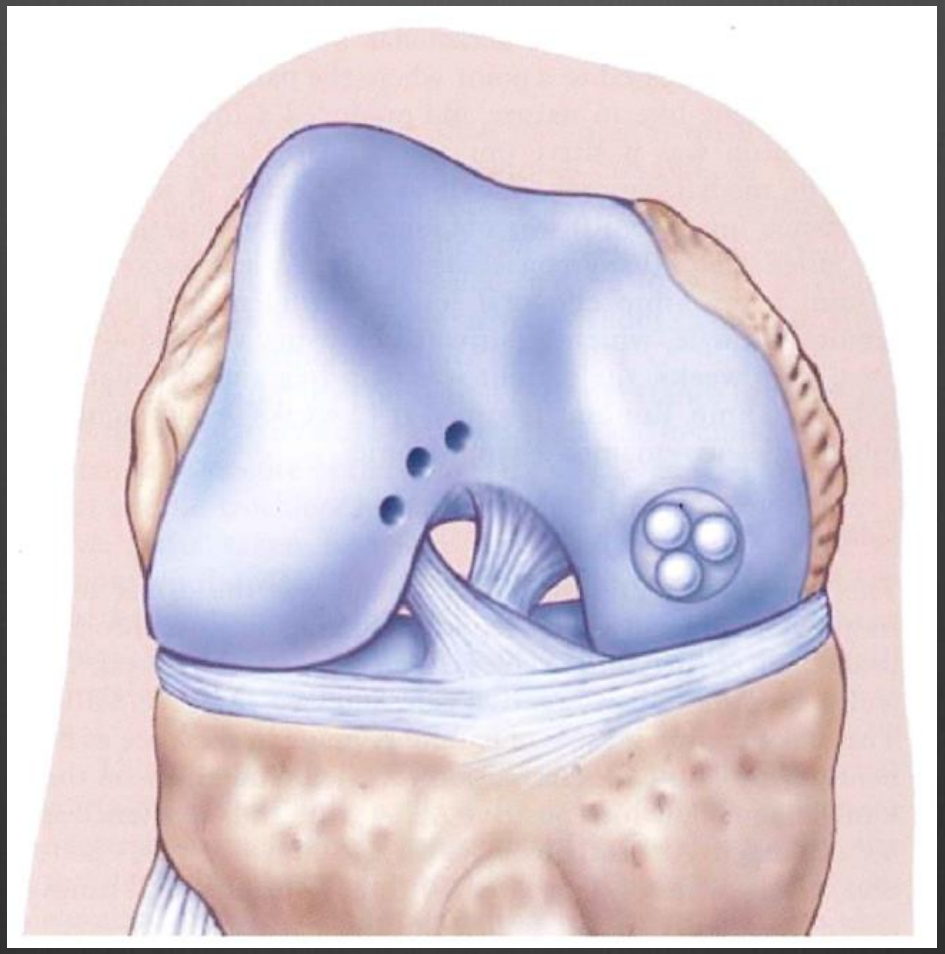
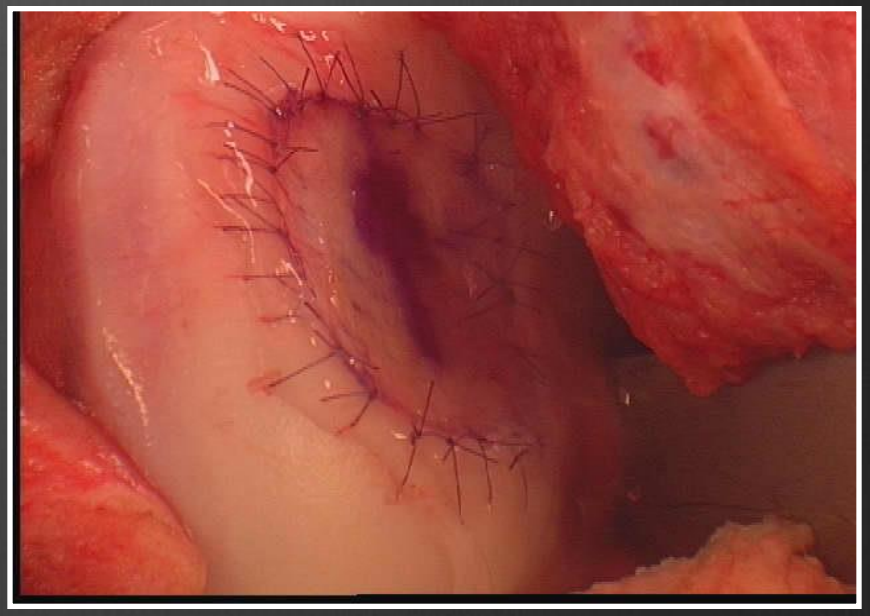


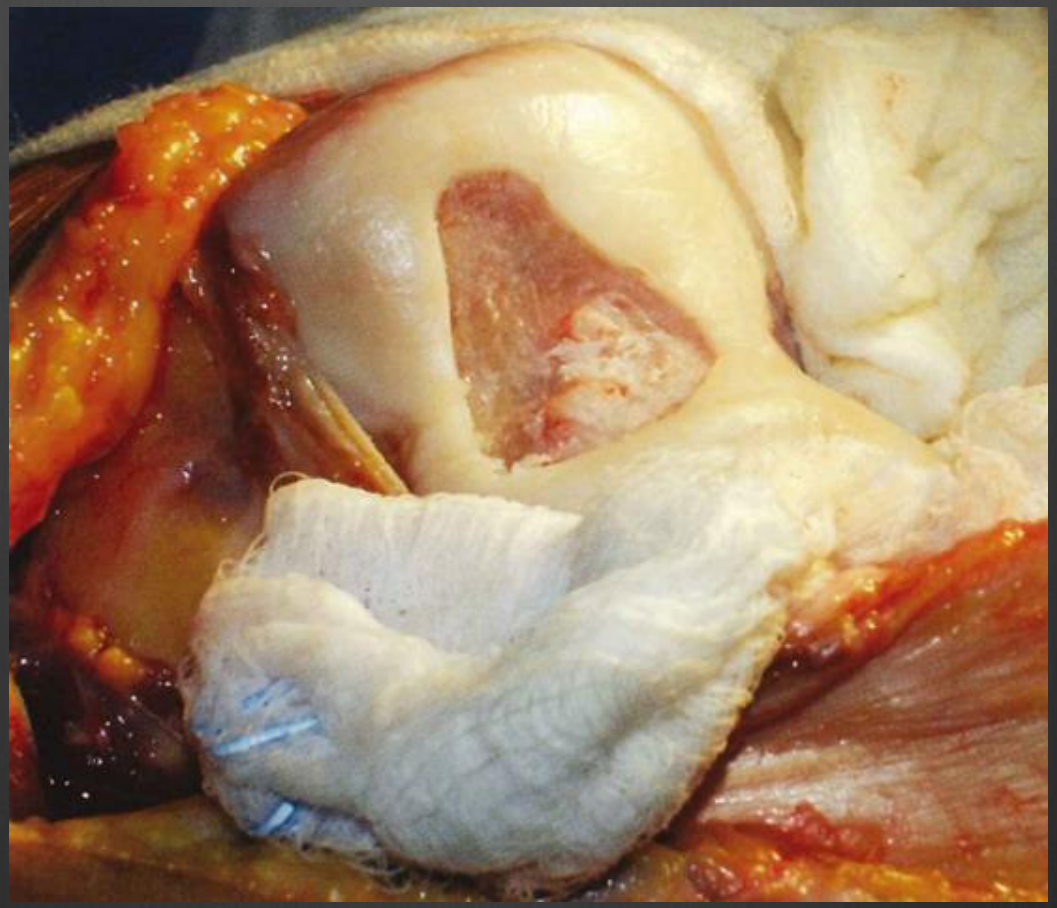
OSTEOCHONDRAL ALLOGRAFT

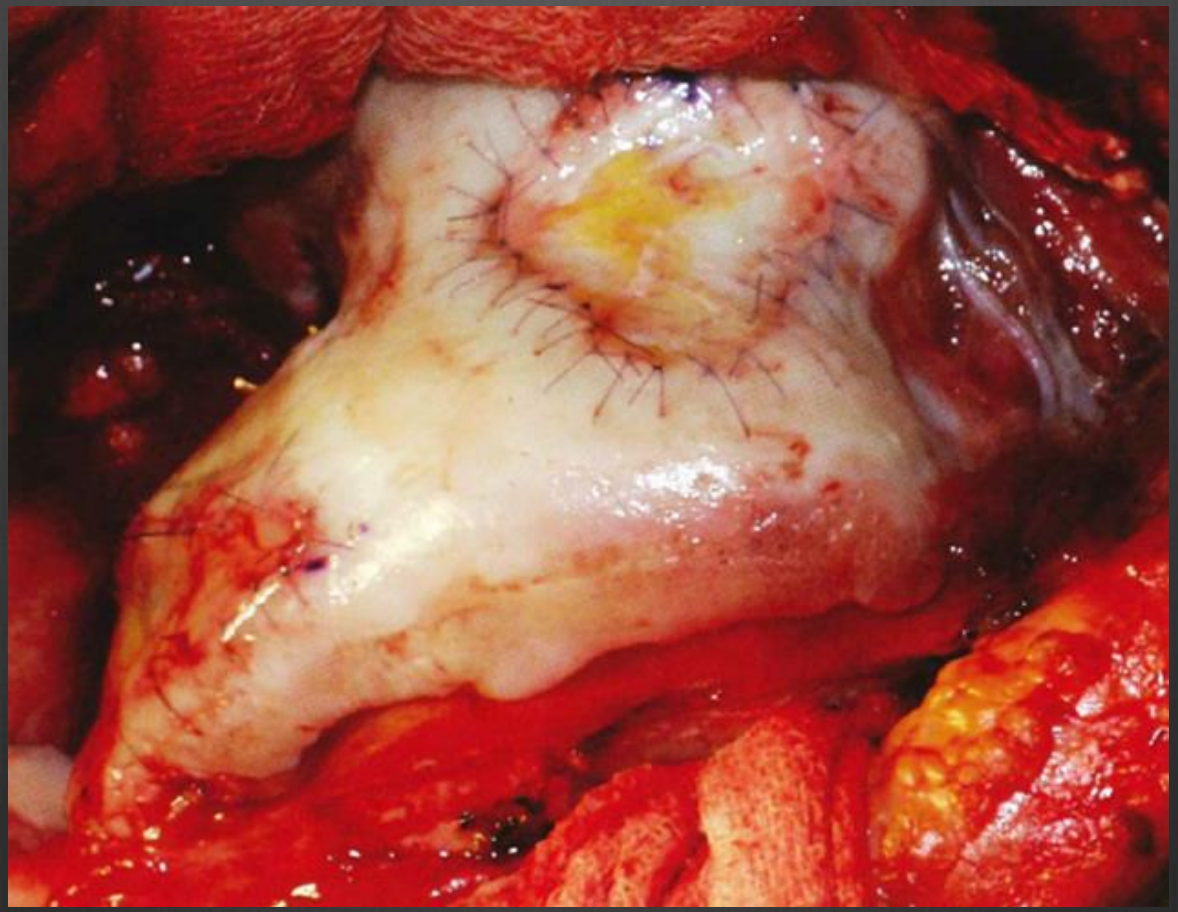
- USED WITH LARGE LESIONS FOR SALVAGE PROCEDURES
- MUST RADIATE TO DECREASE IMMUNOGENICITY WHICH KILLS CHONROCYTES
- NEWER METHODS (CRYOPRESERVED, FRESH, FRESH FROZEN) HAVE IMPROVED RESULTS
- DIFFICULT TO OBTAIN

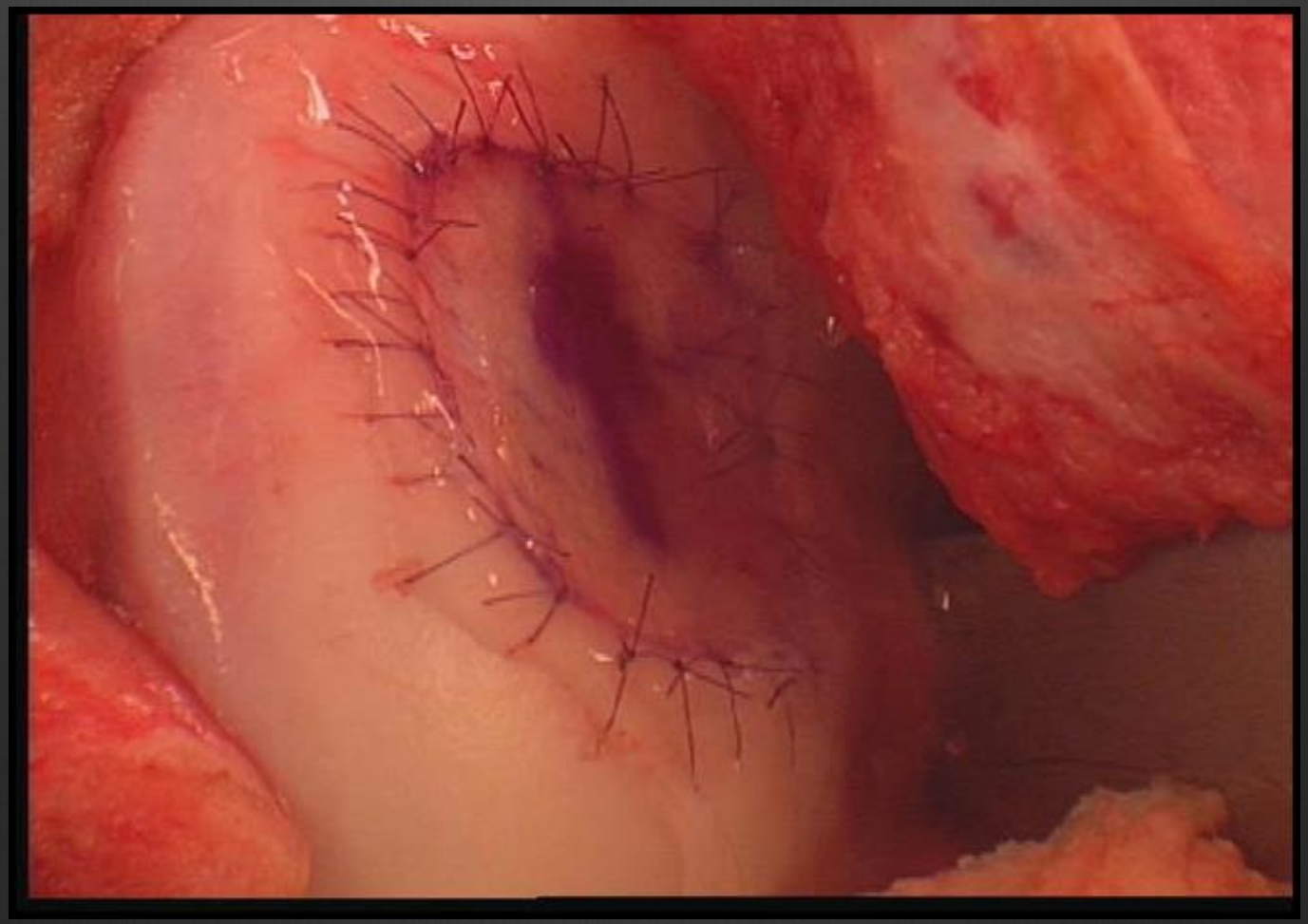
Autologous Chondrocyte Implantation / Carticel®

- Strengths:
  - Can produce hyaline-like cartilage
  - No correlation with defect size and clinical results
  - Can reduce symptoms and improve function in patients with large defects that are significantly disabled
- Limitations:
  - Invasive
  - Surgical time / Complexity of delivery
  - Expense
  - Subsequent surgical procedures
  - Longer recovery – return to sports









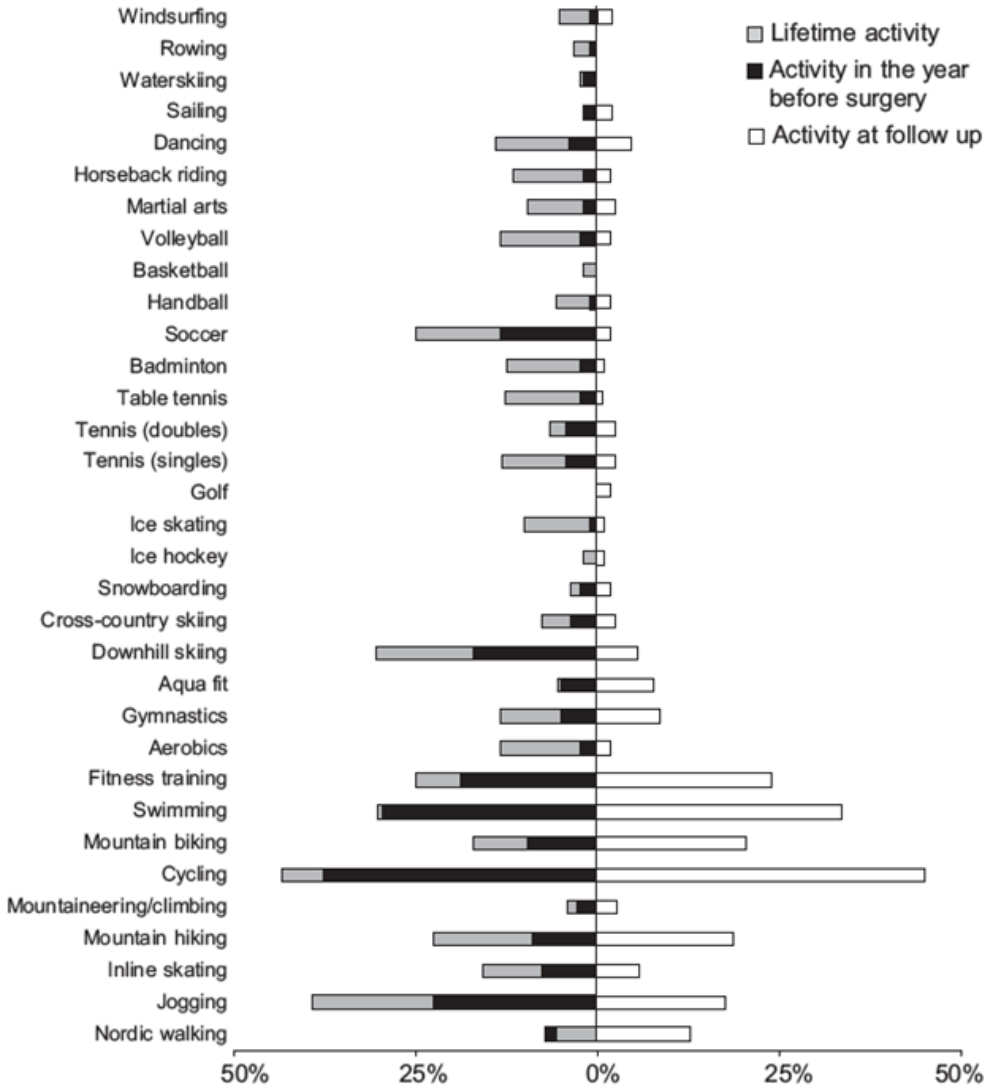


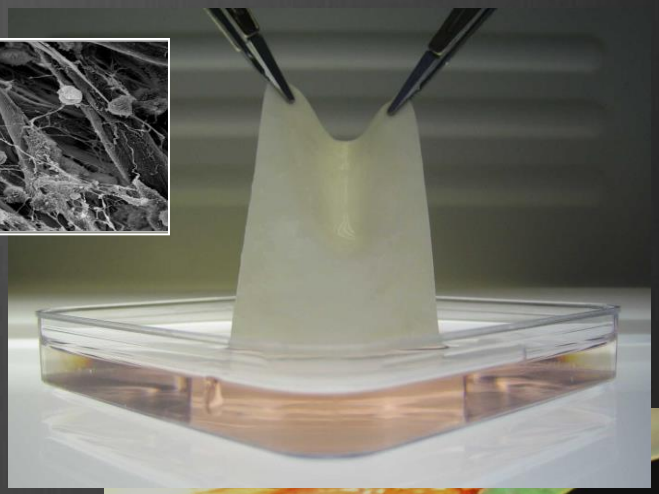
Figure 1. Percentage of study patients participating in sports activities throughout lifetime, 1 year before autologous chondrocyte implantation (ACI), and at the time of the follow-up survey.

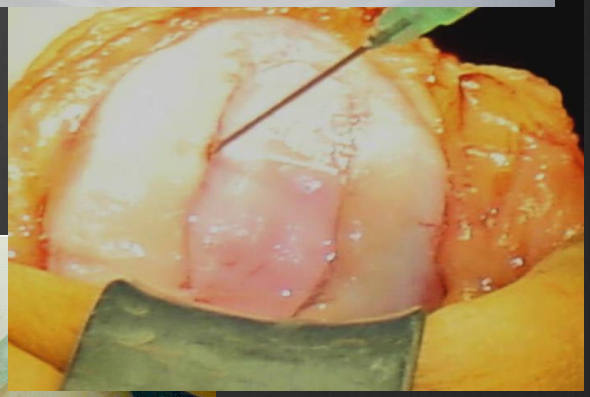
MACI

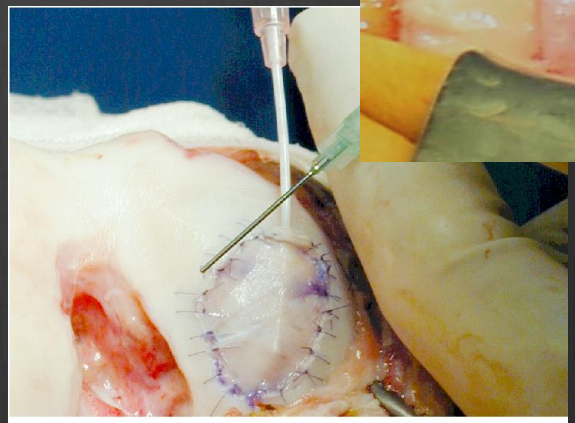
- " ON DECEMBER 14,2016, THE FDA HAS APPROVED MACI – AUTOLOGOUS CULTURED CHONDROCYTES ON PORCINE COLLAGEN MEMBRANE – FOR REPAIR OF SINGLE OR MULTIPLE FULL THICKNESS CARTILAGE DEFECTS

Matrix-Induced Autologous Chondrocyte Implantation MACI®

- Addresses Carticel adoption barriers:
  - Less morbid delivery
    - Arthroscopic in some cases
    - Eliminates periosteum and suture fixation
  - Reduces operative time
- Similar clinical results
  - Less post-operative complications
- Limitations:
  - 2-stage procedure
  - Custom product
  - Expense

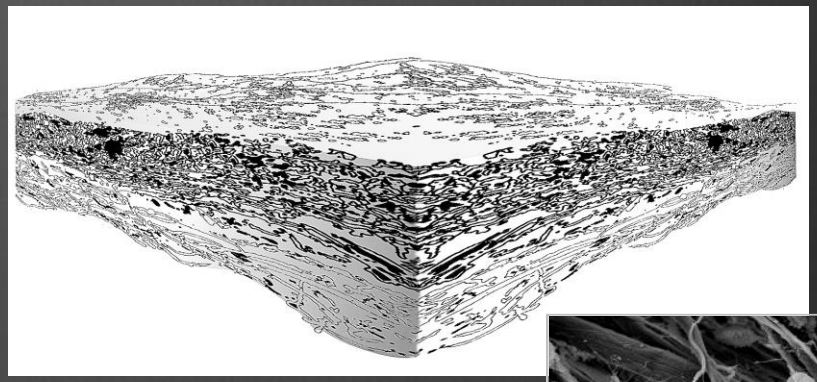




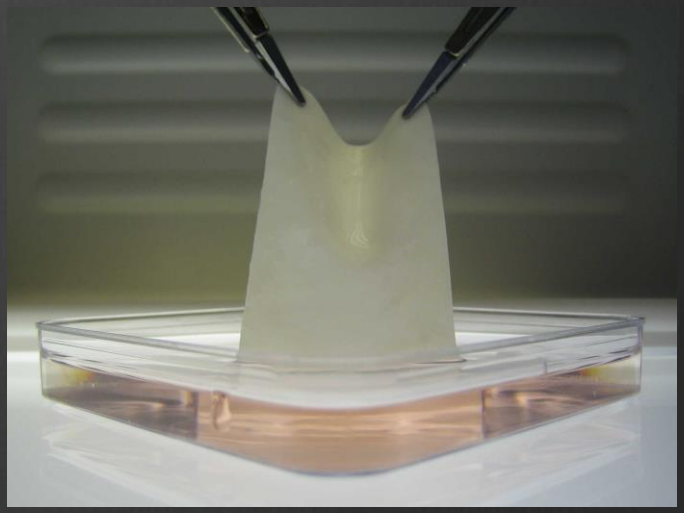


MACI®

(Matrix-induced Autologous Chondrocyte Implantation)



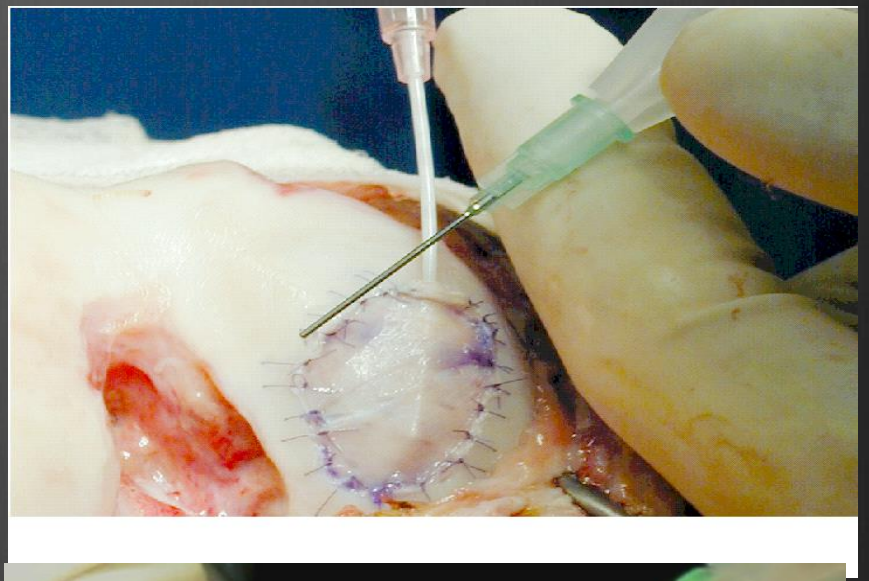
- Autologous cultured chondrocytes (manufactured similar to Carticel)
- Seeded on a proprietary, single-ply, Type I & III collagen membrane
- The *ACI-MAIX*™ membrane, is manufactured by Matricel GmbH of Herzogenrath, Germany

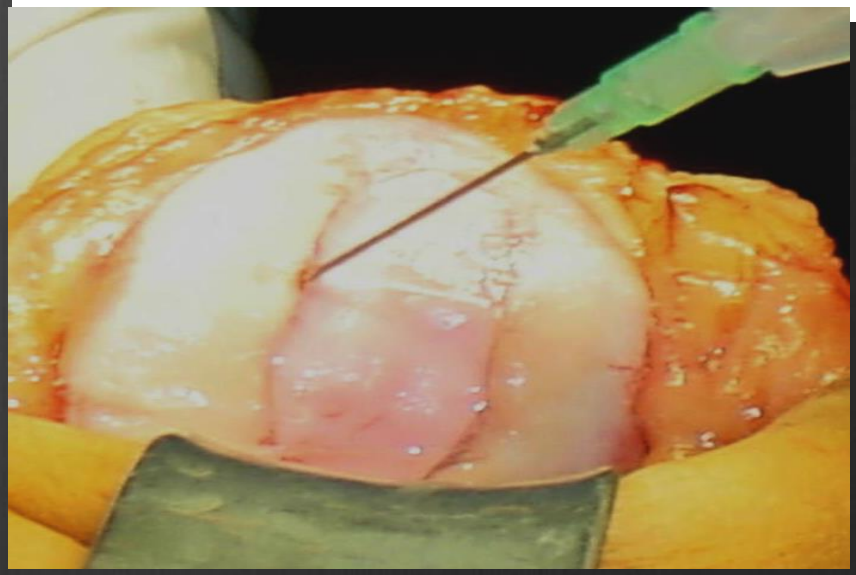


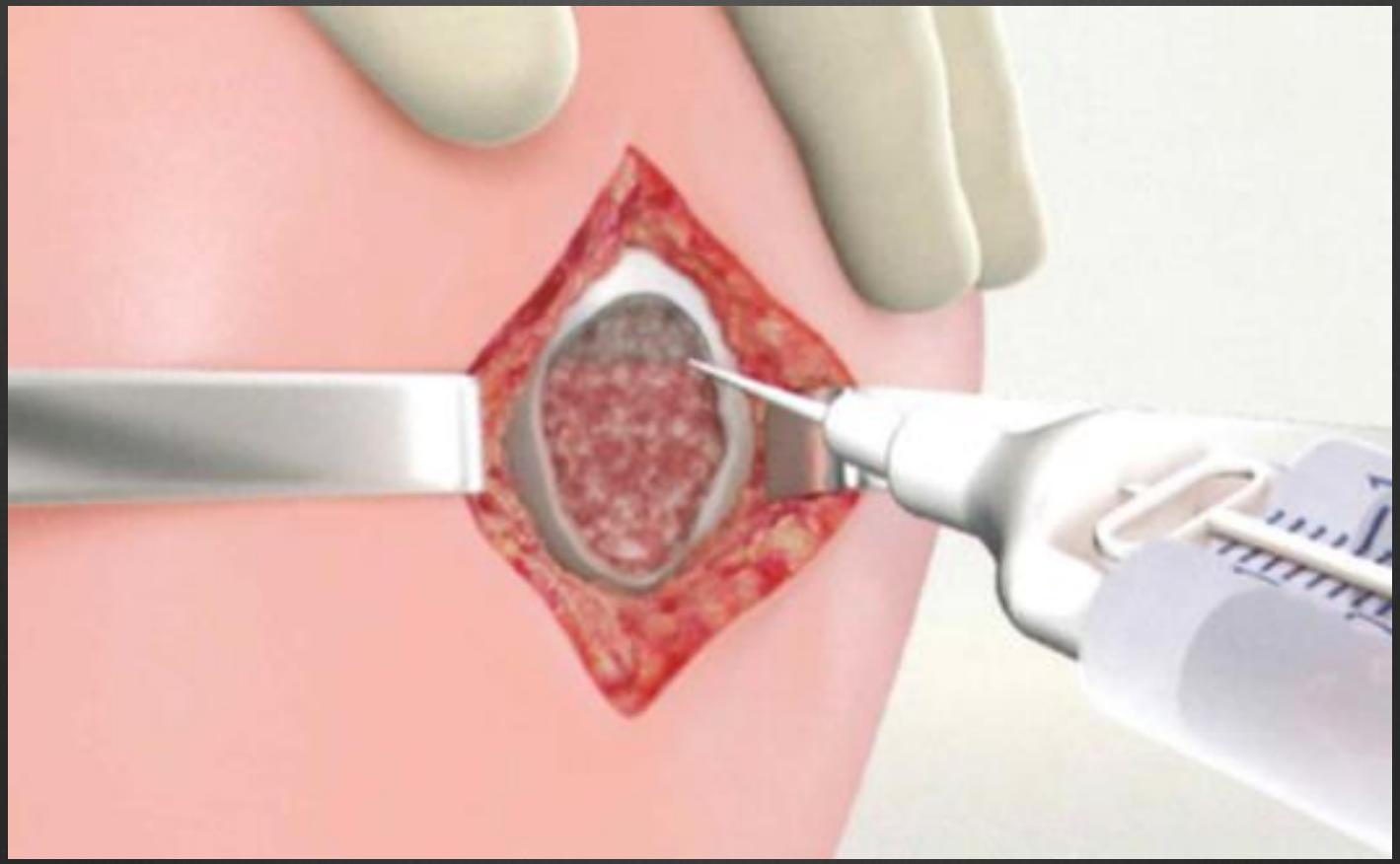
MACI®

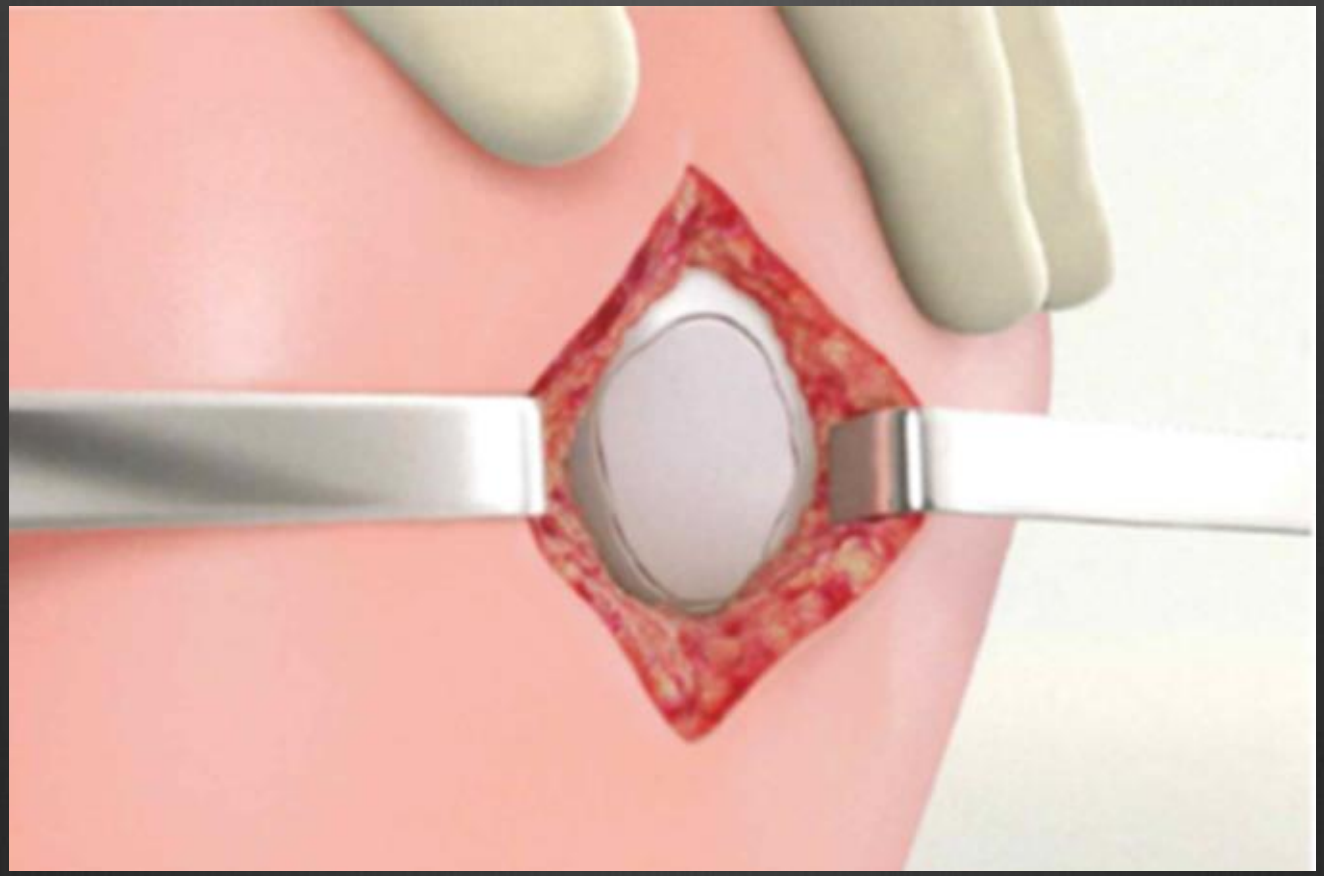
(Matrix-induced Autologous Chondrocyte Implantation)

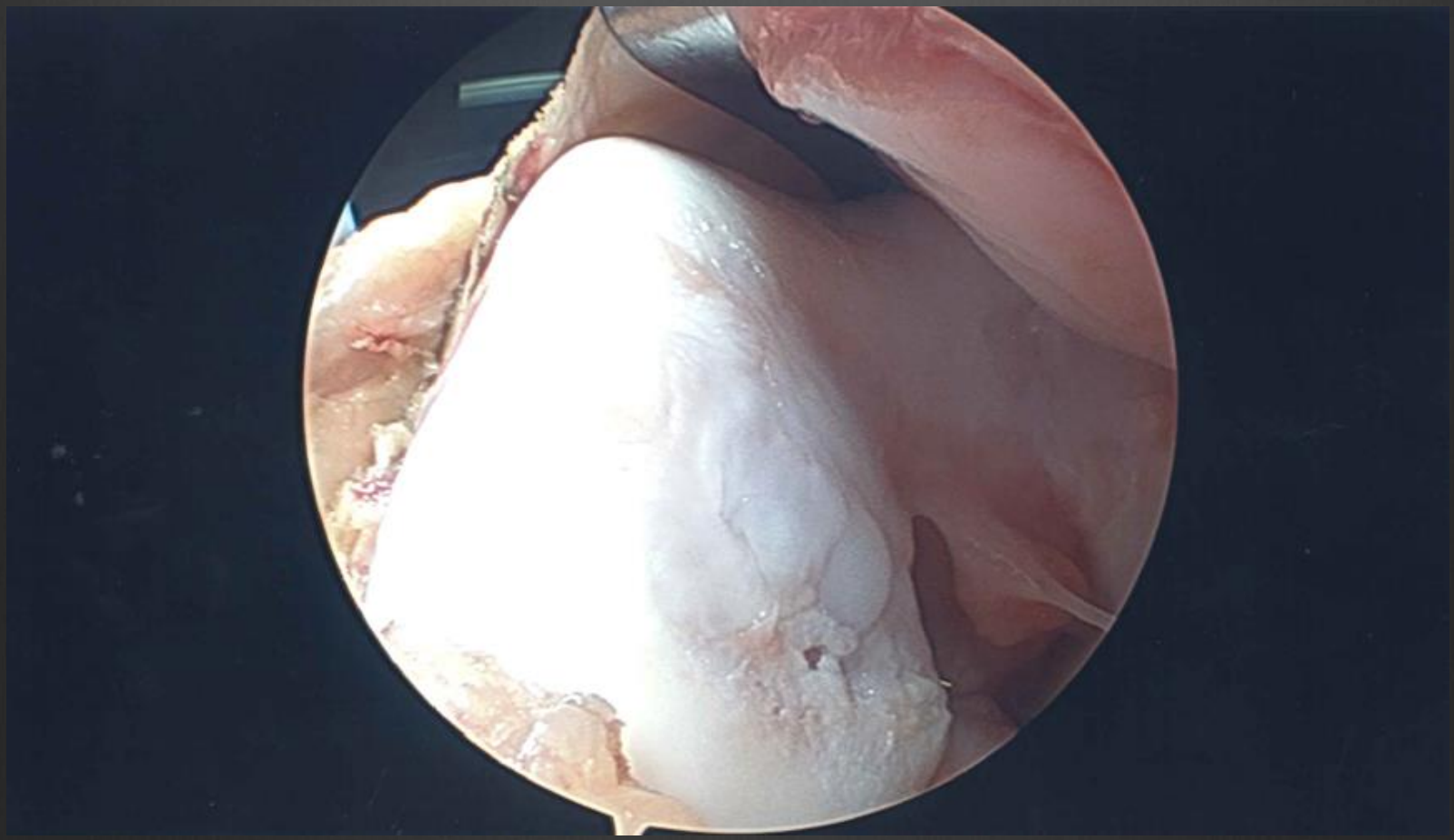
- 2nd generation ACI addresses the many of the limitations / delivery complexities of Carticel:
  - No periosteum harvest
  - No suturing
  - Significantly reduced OR time
- Smaller incision → less patient morbidity
  - Likely to have fewer surgical complications, e.g. tissue hypertrophy, adhesions
- Over 4,000 patients treated since 2001 in Europe & Australia

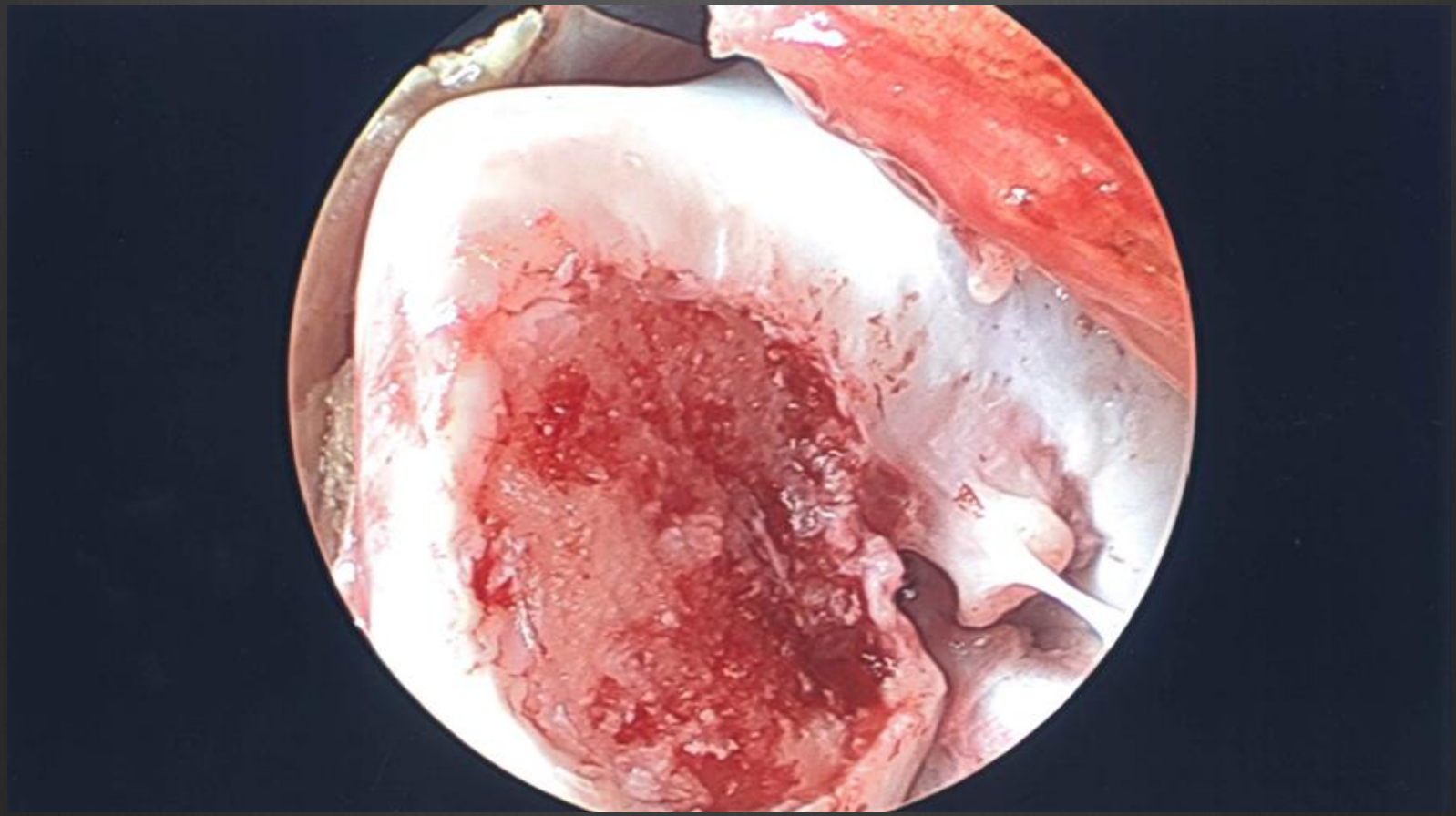


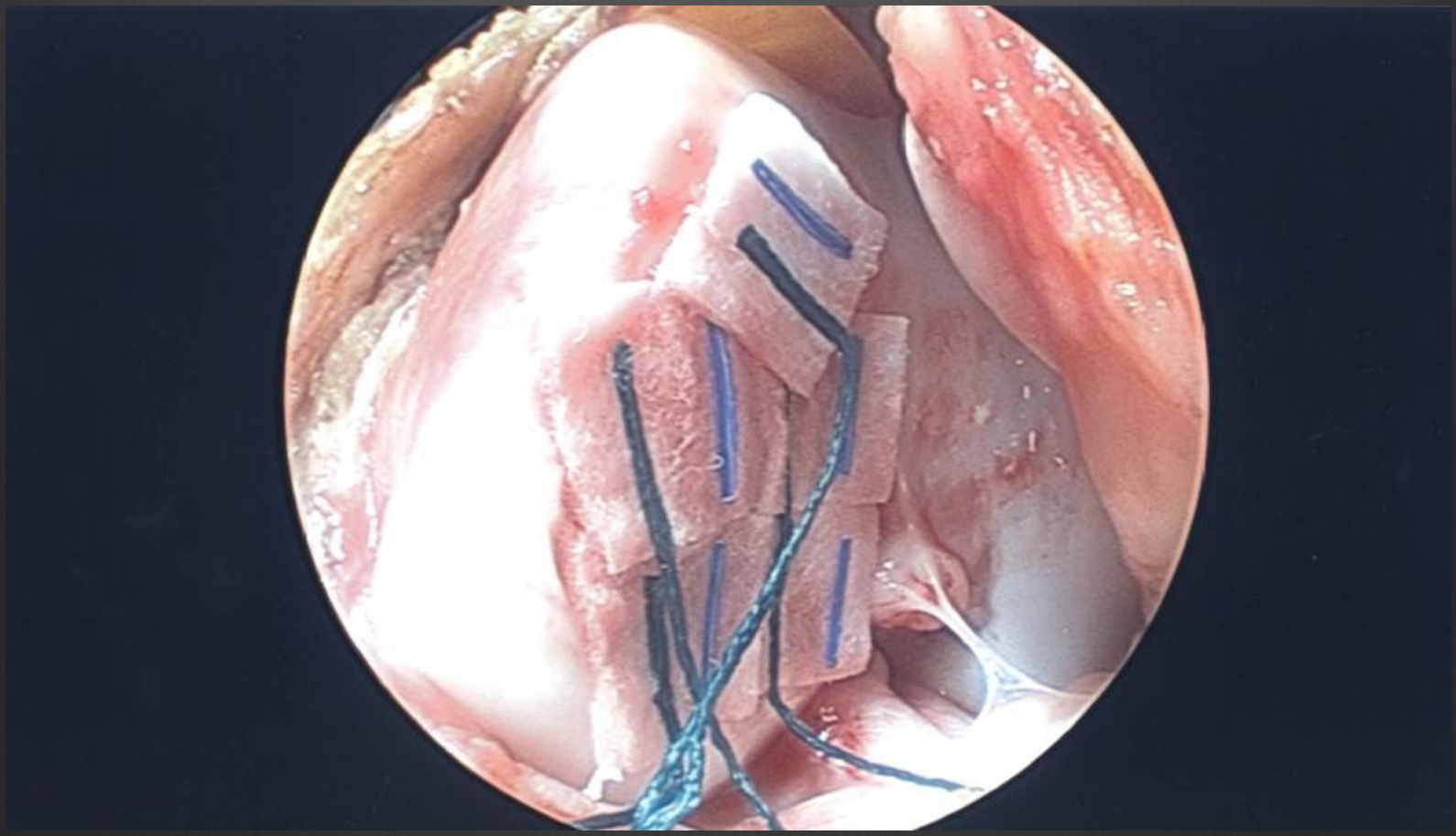


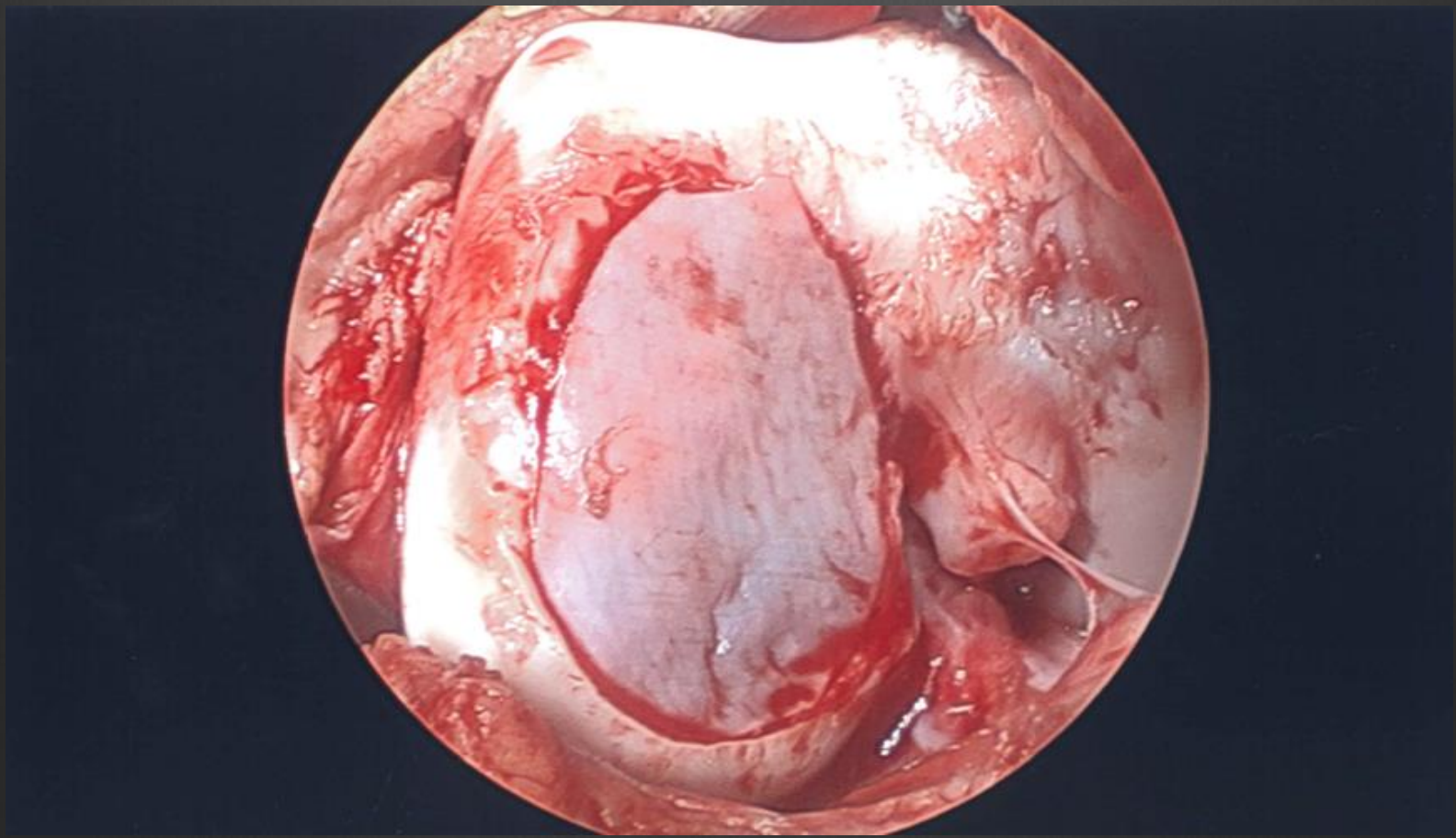


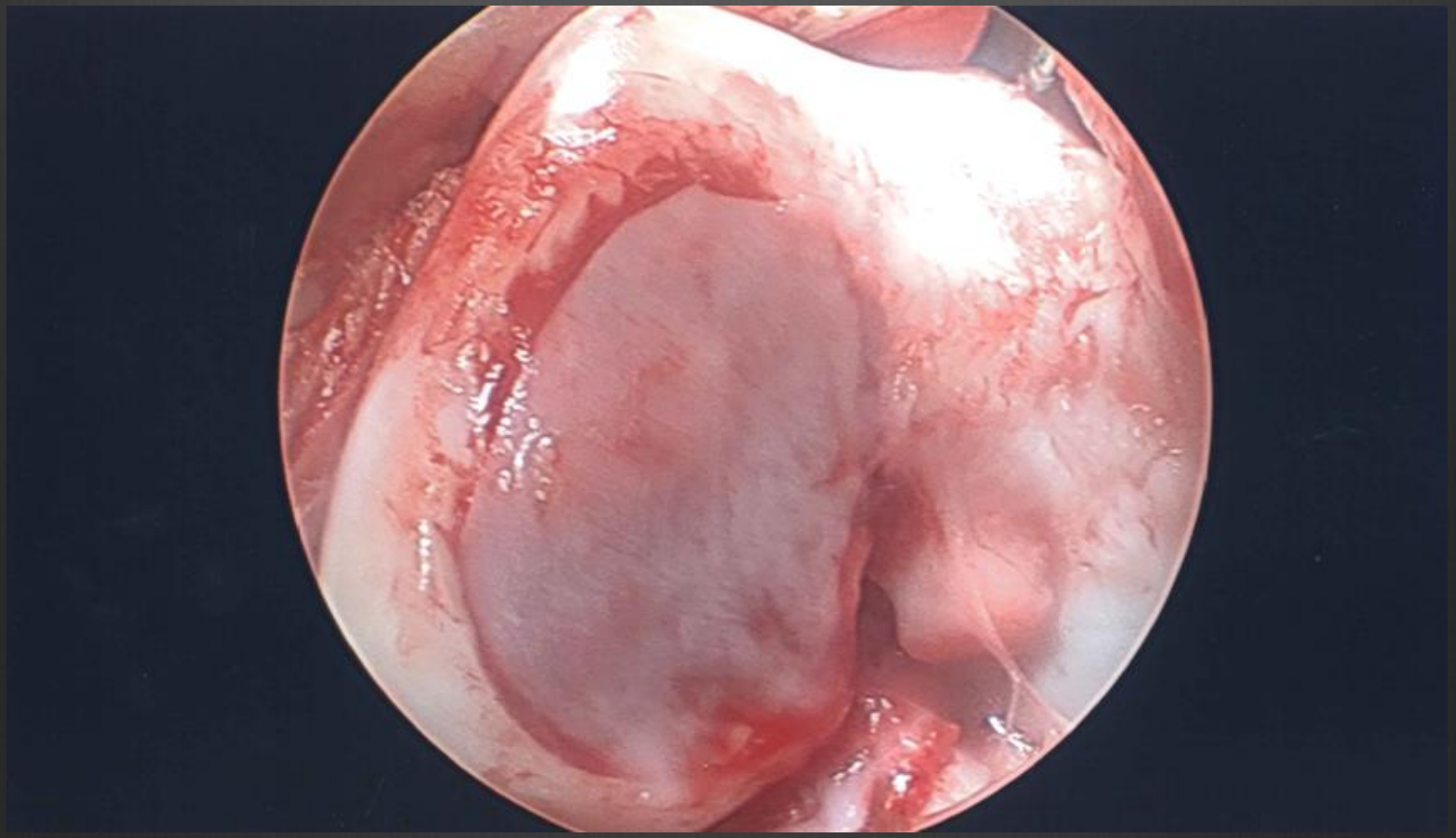






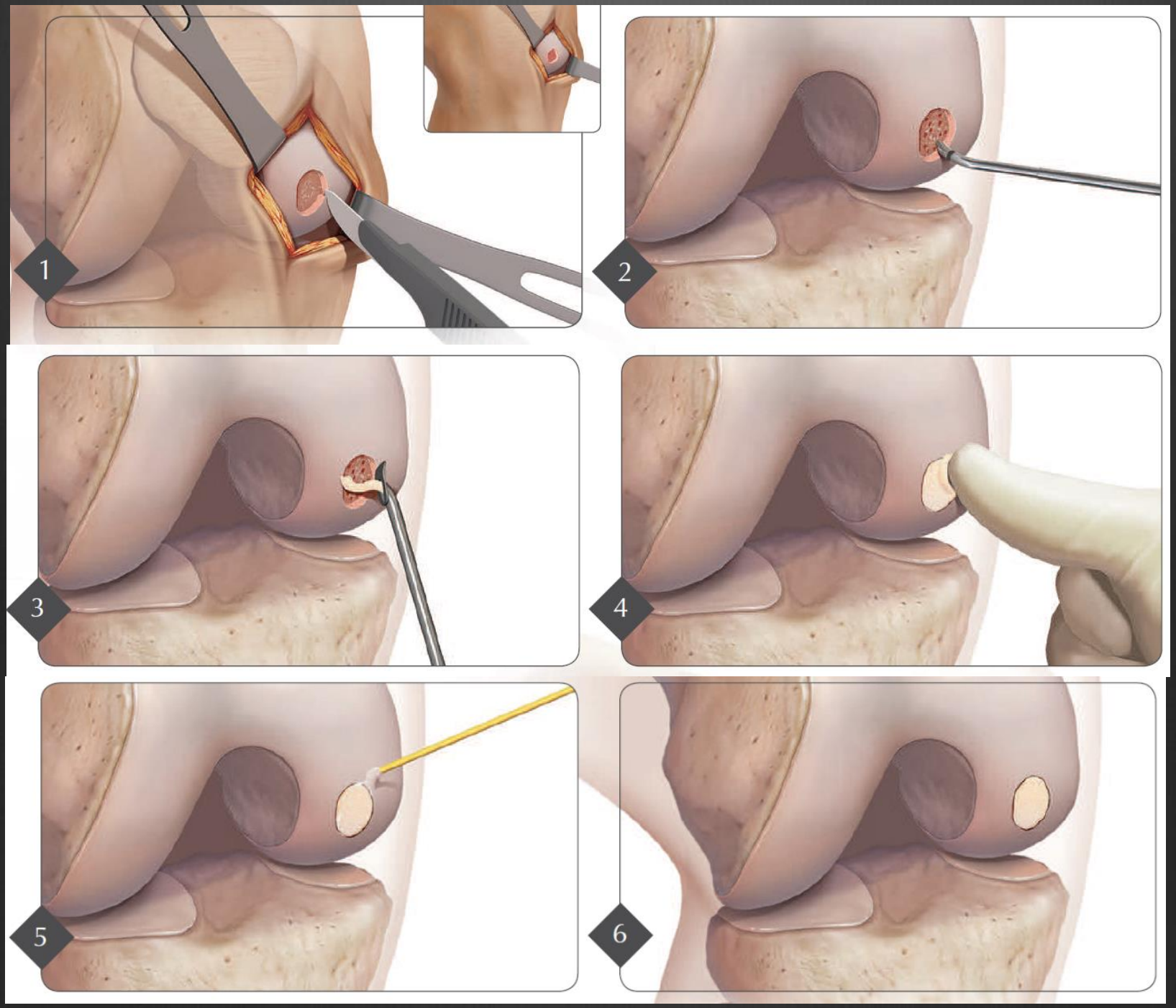






ACELLULAR MATRIX INDUCED MICROFRACTURE

- SCAFFOLD WITH MICROFRACTURE
- SINGLE STAGE
- KEEPS MESENCHYMAL STEM CELLS IN PLACE
- PROMISING RESULTS
- LITTLE EXPENSE
- ONE STAGE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RESULTS

OATS VS MICROFRACTURE

- GUDAS ET AL –
  - AFTER 37 MONTHS – 96% GOOD TO EXCELLENT RESULTS WITH OATS AND 53% GOOD TO EXCELLENT RESULTS WITH MICROFRACTURE
  - BIOPSY AT 12 MONTHS SHOWED GOOD REPAIR TISSUE IN OATS IN 84% AND GOOD REPAIR TISSUE IN MICROFRACTURE IN 57%

OATS VS MICROFRACTURE

- RETURN TO FOOTBALL
  - OATS 91%
  - MICROFRACTURE 68%
- BOTH HAVE DIMINISHING RESULTS AT 3-10 YEARS
- POOR PROGNOSIS IN NBA PLAYERS- MICROFRACTURE

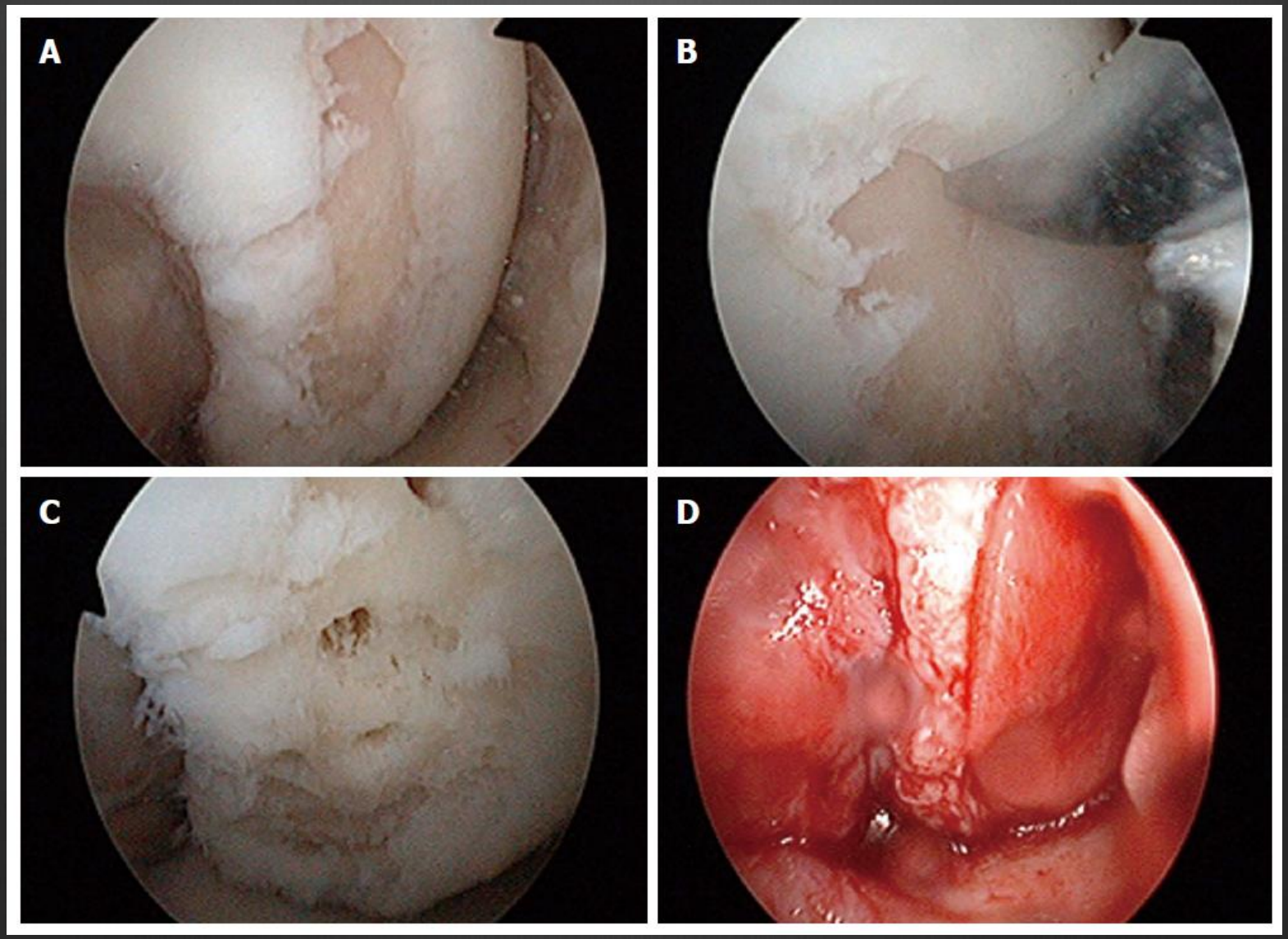
RETURN TO SPORT

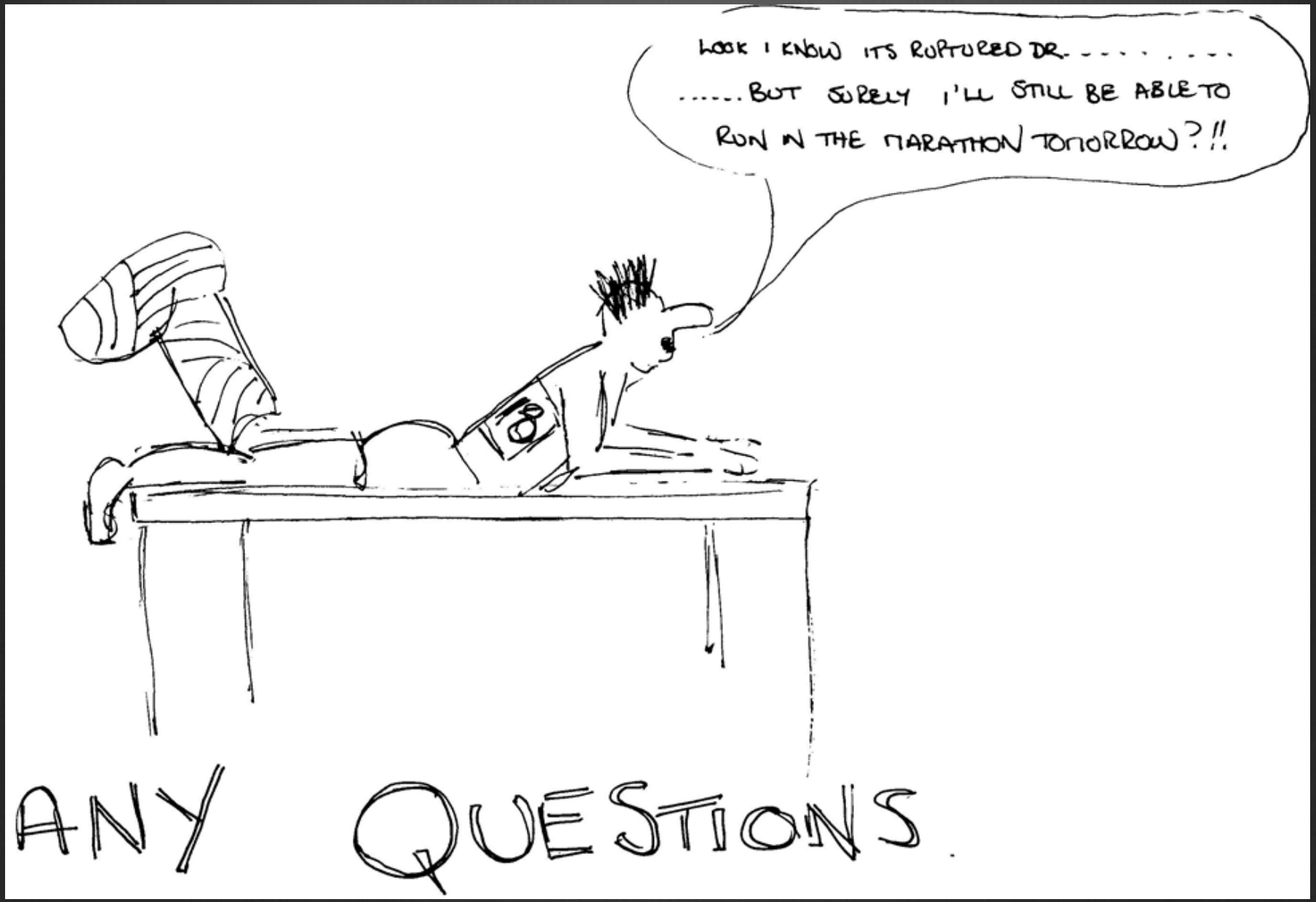
PERCENT

- OVERALL – 76%
- MFX – 58%
- OATS- 93%
- ACI- 83%
- OCA – 88%

TIME

- OVERALL – 9 MONTHS
- MFX – 9.1 MONTHS
- OATS – 5.2 MONTHS
- ACI – 11 MONTHS
- OCA – 9.6 MONTHS


A
B
C
D


LOOK I KNOW ITS RUPTURED DR.....
.....BUT SURELY I'LL STILL BE ABLE TO RUN IN THE MARATHON TOMORROW?!!
ANY QUESTIONS.

THE END