UPDATE ON CARTILAGE RECONSTRUCTION

Bernhard Waibl, Cartilage Care; Bern
Why do we have to repair cartilage defects?
Cartilage Maturation

immature cartilage  maturing cartilage  mature cartilage

<table>
<thead>
<tr>
<th>Cell Count</th>
<th>2.55 x 10^5 cells/mm³</th>
<th>2.26 x 10^5 cells/mm³</th>
<th>1.92 x 10^5 cells/mm³</th>
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<tbody>
<tr>
<td>Mitotic Index</td>
<td>32/100,000</td>
<td>6/100,000</td>
<td>0</td>
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Cartilage Nutrition

Synovial fluid = lubricant

Synovial membrane

Articular cartilage = Porous, elastic bearing material.

Bone = rigid body

Bone
Glycosaminoglycan Content of Knee Cartilage Following Posterior Cruciate Ligament Rupture Demonstrated by Delayed Gadolinium-Enhanced Magnetic Resonance Imaging of Cartilage (dGEMRIC) A Case Report

Allan A. Young, Peter Strasewell, Ashley Williams, James A. Rohrbach, David A. Parker, Bruno Girrbach and Andrew M. Tills
INDIVIDUALITY OF CARTILAGE DEFECTS OR - WHAT CAN WE DO?

cartilage defect ICRS grade IV

osteochondral defect
TREATMENT OPTIONS

- Microfracture
- Mosaicplasty
- Cartilage-Reconstruction-Techniques
- ACI
- AMIC
Microfracturing / AMIC®

Principle of *marrow stimulating techniques*:

- **Create access** to the subchondral bone marrow
- **Inflow** of bone marrow stem cells into the prepared cartilage defect
- **Transformation** into predominantly hyaline like repair tissue
Surgical technique MFx

Steinwachs et al. (2008) INJURY, Vol.39S1; 26–31
Hypertrophy of the subchondral bone

Steinwachs et al. (2008) INJURY
Kreuz et al. (2006) Arthroscopy
Kreuz et al. (2006) OA&Cartilage
Mithoefer K et al. (2005) JBJS
Steadman JR et al. (2003) Arthroscopy
Drawbacks of Microfracturing

- 25% osteophyte formation
- 46% incomplete defect filling
- Stiffness = 1.27 N (normal approx. 3 N)
- Tissue degeneration after 48 weeks

References:
- Shapiro et al., JBJS 1993
- Peterson L, AJSM 2002
- Mithoefer K et al., JBJS 2005
WHAT IS MFx ABLE TO ACHIEVE?

**Steadman et al. Arthroscopy. 2003** (n=72; 7-17J. FU)
- Postoperatively significant rise of clinical scores ø MRI !!!

**Mithoefer et al. JBJS 2005** (n= 52)
- Good and excellent results in (67%), in only 54% sufficient filling of the defect (MRI)

**Kreuz et al. Osteoarth. & Cartilage 2006** (n=85)
- Good short term improvement of clinical scores

**Gobbi et al. KSSTA 2013** (n=155; FU 15 yrs.!
- average clinical scores, at final FU, still above baseline
- only 11% failures
What MFx won’t achieve

*Mithoefer K et al. JBJS 2005;87:1911-20 (n= 52)*
- Worsening of the clinical score after 18 months (ICRS-Score)

- significant worsening of clinical score after 18 months!
- incomplete defect filling depending on location (MRI), hypertrophic subchondral bone

*Kon et al. 2009;37(1):33-41. (n=40, FU 5 yrs.)*
- deterioration of sports activities between 2 and 5 yrs. post-OP

*Gobbi et al. KSSTA Sep 2013 (n=155; FU 15 yrs.)*
- 40% with OA after 15 yrs.
- the smaller the defect and the younger the patient > the better the outcome

*Salzmann et al. 2013; 133(3):303-10 (n=145)*
- male do better than female
- the shorter the symptom duration > the better the outcome
**Pros and Cons**

- Easy and fast to accomplish
- Strictly arthroscopic technique
- Cheap

- Inferior tissue quality
- Intralasional ossification / osteophytes
- Limited durability
INDICATION FOR MICROFRACTURE

- chondral and osteochondral defects grade III-IV
- defect sizes 0.5 to 2.5 cm²
- young, active patients < 40 years
  Kreuz P, et. al., Arthroscopy; 2006
- duration of symptoms is crucial
  Salzmann et al., AOTS; 2013
AMIC® - surgical technique
SURGICAL TECHNIQUE AMIC®
CASE PRESENTATION AMIC
EVIDENCE IN LITERATURE

Anders et al., Open Orthop J; 2013
- AMIC (sutured or glued) vs. MFx; FU 2 yrs.
- n=6 MFx / 8 sutured AMIC / 13 glued AMIC
- defect size 3.1 / 3.8 / 3.8 cm²
- Scores improving up to 2 yrs. (Cincinnati / ICRS)
- No sign. differences between techniques

Schiavone Panni et al., KSSTA 2017
- n=21, FU 7 yrs., no control group
- mean defect size 4.3 cm²
- 76% of patients satisfied with the outcome after 7 yrs.
- mean Lysholm score 73 pts.

Volz et al. Int Orthop; 2017
- AMIC vs. MFx; n(total)=47, FU 5 years; defect size 3.6cm²
- functional score degradation in MFx group but not AMIC between 2 to 5 yrs. of FU
INDICATIONS FOR AMIC®

- chondral and osteo-chondral defects grade III & IV
- defect size 2.5 to 6 cm²
- reconstruction of osteo-chondral defects in a one-step procedure (with spongiosaplasty)
PROS AND CONS AMIC®

- suitable for larger defects (> 2.5cm²)
- relatively cheap (biomaterial < CHF 1000.-)
- salvage procedure
- long-term outcome likely better than with MFx

- inferior tissue quality
- intralesional ossification / osteophytes
- time-consuming (arthrotomy)
Autologous Chondrocyte Implantation ACI
cartilage biopsy

standardized biopsy instruments

standardized biopsy localization

standardized biopsy volume

standardized transport vial
**Cartilage Cultivation**

- Cartilage biopsy (0.05 x 10 million cells)

- Mechanical and enzymatic digestion (≤ 16 h)

- Ex vivo expansion of chondrocytes (~ 21 days)

- Transplantation of min. 10^6 cells/cm^2 cartilage defect (3-10 x 10^6 cells)
ACI SURGICAL TECHNIQUE
18 months post ACI
comparison cartilage regenerate

**MFx vs. ACI**

- **Microfracture**
- **ACI**

**Best Score**

**Worst Score**

SARIS, AJSM; 2008
EVIDENCE IN LITERATURE

Minas et al. CORR 2013: n=210!, FU mean 12 yrs.;
- "survivorship of 71% at 10 years and improved function in 75% of patients

Niemeyer et al. AJSM 2013: FU 11 yrs., n=70;
- VAS 7.2>2.1, Lysholm 42 > 71, 77% „satisfied“ or „very satisfied“

Moradi et al. Arthroscopy; 2012: n=23, mean FU 10 yrs.;
- ACI resulted in a substantial improvement in all clinical outcome parameters, even as much as 14 years after implantation"

Peterson et al. AJSM; 2010:
- "12.8 years after the implantation, 74% of the patients reported their status as better or the same as the previous years

Bentley et al, JBJS Br; 2012: n=100;
- „number of patients whose repair had failed at ten years was ten of 58 (17%) in the ACI group and 23 of 42 (55%) in the mosaicplasty group (p < 0.001).“
INDICATION FOR ACI

- Chondral and osteochondral lesions grade III-IV
- Defect size 3 to 10 cm²
PROS AND CONS ACI

- superior quality of regenerate tissue
- Solid long-term outcome available
- two interventions needed
- arthroscopy requested
- demanding surgical technique and logistics
- cost intensive
- increasingly restrictive health system

ACI difficult to establish
OATS / MOSAICPLASTY
osteochondral transplantation
surgical technique
23 YRS. ♀ WITH FOCAL OD
MRI 6 MONTHS AFTER OATS
SINGLE PLUG TECHNIQUE

diamond coated hollow mill 12-18mm
Evidence in Literature

Emre et al., AOTS, 2013: (n=152, FU 18 months)
- Lysholm 55>88 pts., good / excellent 96%

Robb et al., Acta Orthop Belg; 2012: (n=55, FU 9 yrs.)
- survival 87.5% (at mean 8 yrs.), failures associated with varus alignment

Gudas et al. Arthroscopy; 2013:
- MF vs. OATS in ACL-reconstructions; n=102, FU 3 yrs.; OATS sign. better than MF in subj. knee scores

Krych et al., JBJS Am. 2012: (n=69, FU 5 yrs.) MF vs. OATS
- sign. higher athletic activity after OATS

Solheim et al., Knee. 2013 (n=73, FU=10-14 yrs.)
- poor long-term outcome in 40%, depending on age (>40 yrs.) and defect size (> 3cm²)
- young patients (<40) with small defect (<3cm²) success in 88%
INDICATION FOR OATS

- particularly osteochondral defects
  - Osteochondritis Dissicans
  - traumatic lesions involving the subchondral bone
- defect size 1 to 3 cm$^2$
PROS AND CONS OATS

- cheap
- good /predictable cartilage and bone quality
- potentially minimally invasive technique
- fastest return to sports (5 to 9 months)

- surface congruency?
- horizontal integration?
- donor-site morbidity
- different zonal architecture (condyle / talus)
PERSPECTIVES FOR THE FUTURE

insufficient regenerate tissue after AMIC
PRP-MSC AUGMENTED AMIC
5 year results with convincing repair quality and quantity compared to MFx, but equal clinical outcome. Shive et al., Cartilage, 2015.
Future of Cartilage Reconstruction

- try to avoid injuring the subchondral bone
- obtain bone marrow stem cells separately and concentrate them
- learn how to control hMSC!
- basics: understand growth factors
CONCLUSION

- recent cartilage repair techniques associated with *reasonable durability*
- *sufficient long term data* are existing especially for MFx and ACI
- *early* treatment (before onset of OA) is *crucial* for success
- *respect / restoration of biomechanics* (stability, meniscus, limb axis) *essential*
THANK YOU