Cartilage Care in the Mature Female Athlete

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Department of Orthopedic Surgery
University of Colorado

Women in Sports Medicine Conference
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Disclosures

- None
Goals

- Background
  - Types of Cartilage Injury
  - Does Sports Participation Increase Our Risk?
- Prevention & Non-Operative Measures
  - BMI
  - Supplementation
  - Corticosteroid Injections
  - Biologics
- Surgical Options for Cartilage Restoration
  - Knee
  - Hip
- Conclusions
Types of Cartilage Injury

FOCAL

- Articular cartilage injuries of the knee are common with a reported incidence of up to 66% in diagnostic knee arthroscopies.

- Similar in the hip; with > 30% of patients undergoing hip arthroscopy for FAI having acetabular cartilage damage.

- Cartilage lesions often occur without discrete event or recalled injury; though labral tears in the hip and ACL tears in the knee for example carry higher risk.

- Symptoms can be vague; pain is the most common complaint.
FOCAL

- Non-operative treatment is the mainstay for patients with articular cartilage injury
  - Especially in the over 40 and female population

- Increased prevalence in certain athletes
  - Highest in elite, professional athletes
  - Higher in cutting/pivoting/twisting sports
  - BUT...
Types of Cartilage Injury

OSTEOARTHRITIS

- OA is the most commonly occurring joint disease – affecting more than 30 million adults in the US
- The knee is the most commonly affected joint
  - Followed by the hip
- Prevalence is higher among Women than Men; exponentially rising around the time of menopause
Types of Cartilage Injury

- Similar to focal injuries
  - Symptoms can be vague – **pain** most common
  - Prior ligament/meniscal injuries in knee or labral injury in hip
  - Non-operative management gold standard
  - Sports associated with significant shear stress have higher risk (soccer, basketball, field hockey)
BUT – Exercise and Fitness is Important in Prevention!!

- Articular cartilage volume and thickness increases with weight-bearing activity
- Positive linear dose-response relationship for repetitive loading activities and articular cartilage function
  - Threshold reached (Ex: over 20 km running/day)
BUT – Exercise and Fitness is Important in Prevention!!

RECOMMENDATION 1

We recommend that patients with symptomatic osteoarthritis of the knee participate in self-management programs, strengthening, low-impact aerobic exercises, and neuromuscular education; and engage in physical activity consistent with national guidelines.

Strength of Recommendation: Strong

Description: Evidence is based on two or more “High” strength studies with consistent findings for recommending for or against the intervention. A Strong recommendation means that the benefits of the recommended approach clearly exceed the potential harm and/or that the quality of the supporting evidence is high.

Implications: Practitioners should follow a Strong recommendation unless a clear and compelling rationale for an alternative approach is present.

PHYSICAL THERAPY AS A CONSERVATIVE TREATMENT

Strong evidence supports the use of physical therapy as a treatment to improve function and reduce pain for patients with osteoarthritis of the hip and mild to moderate symptoms.

Strength of Recommendation: Strong Evidence

Description: Evidence from two or more “High” strength studies with consistent findings for recommending for or against the intervention.
And What’s the Harm in Running?

Findings are Controversial and Contradictory -> 2017 Systematic Review

Figure 2. Odds ratio plot of knee surgery due to osteoarthritis in runners or orienteers. M-H, Mantel-Haenszel.
And What’s the Harm in Running?

- Retrospective cross-sectional study of men/women 45-79 years old found no increased pain, XR, or symptomatic OA dx if recreational running hx
And What’s the Harm in Running?

Another systematic review from 2017 -> elite level, long distance carries higher risk

![Bar chart showing prevalence of knee osteoarthritis by injury status and level of play among soccer athletes and controls (no history of soccer participation). Prevalence was calculated using the raw data from Figure 1 of Roos et al (1994).]
Non-Operative Cartilage Care

BMI

- Obesity accelerates the development of OA and exacerbates symptoms of OA
- It exerts its effects on both a biomechanical and via systemic inflammatory changes
4 subjects s/p THA w inserted femoral prosthesis for measurement of in vivo contact forces
  - Forces across the knee 3 x body weight while walking and up to 6 x w stair climbing

Gait analysis of 142 obese, sedentary elderly individuals
  - For every single extra pound there is a 4 pound increase in load across the knee -> 4,800 pounds per mile
A Pro-Inflammatory Producer

Koonce et al. JAAOS. 2013.
Benefits of massive weight loss on symptoms, systemic inflammation and cartilage turnover in obese patients with knee osteoarthritis

Pascal Richette,1 Christine Poitou,2-5 Patrick Gamero,6,7 Eric Vicaut,8 Jean-Luc Bouillot,9 Jean-Marc Lacorte,10 Arnaud Basdevant,2-5 Karine Clément,2-5 Thomas Bardin,1 Xavier Chevalier11

All clinical outcome scores improved significantly

Table 2  Effect of massive weight loss on knee osteoarthritis symptoms

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>6 Months</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain score (100 mm VAS)</td>
<td>50±26.6</td>
<td>24.5±21</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Patient global assessment of the severity of knee OA (100 mm VAS)</td>
<td>51.6±26.5</td>
<td>25.3±20.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>WOMAC pain score</td>
<td>187.3±124.4</td>
<td>94.1±93.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>WOMAC stiffness score</td>
<td>68.2±53.8</td>
<td>36.4±41.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>WOMAC function score</td>
<td>643.9±424.2</td>
<td>272.6±289</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

All inflammatory markers decreased significantly

Table 3  Serum levels of adipokines and inflammatory biomarkers at baseline and 6 months

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>6 Months</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leptin, ng/ml</td>
<td>63.2±24.4</td>
<td>33±16.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Adiponectin, μg/ml</td>
<td>7.9±4.6</td>
<td>9.9±7.7</td>
<td>0.03</td>
</tr>
<tr>
<td>IL-6, pg/ml</td>
<td>5.0±2.5</td>
<td>3.7±2.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>hsCRP, mg/dl</td>
<td>1.1±0.8</td>
<td>0.6±0.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Orosomucoid (g/l)</td>
<td>1.0±0.2</td>
<td>0.8±0.2</td>
<td>0.0001</td>
</tr>
<tr>
<td>Fibrinogen (g/l)</td>
<td>4.1±0.8</td>
<td>3.9±0.9</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Body Weight Changes and Corresponding Changes in Pain and Function in Persons With Symptomatic Knee Osteoarthritis: A Cohort Study

DANIEL L. RIDDLE¹ AND PAUL W. STRATFORD²

**Figure 1.** Dose-response relationship for the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) physical function scale. Point estimates and 95% confidence interval (95% CI) bars were derived from unadjusted estimates.

**Figure 2.** Dose-response relationship for the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain scale. Point estimates and 95% confidence interval (95% CI) bars were derived from unadjusted estimates.
Non-Operative Cartilage Care

ORAL SUPPLEMENTS (HA, GLUCOSAMINE CHONDROITIN)

• Protective?

<table>
<thead>
<tr>
<th>Incidence of Knee OA in subjects receiving glucosamine sulfate compared with those not receiving it during 2.5 years of observation, in the intention-to-treat population</th>
</tr>
</thead>
<tbody>
<tr>
<td>No glucosamine sulfate (± DEP) (N = 203)</td>
</tr>
<tr>
<td>Semi-automated mJSN ≥ 1.0 mm, n (%)</td>
</tr>
<tr>
<td>22 (10.8%)</td>
</tr>
<tr>
<td>Odds ratio = 0.42 (95% CI: 0.20–0.82) p = 0.03</td>
</tr>
<tr>
<td>Manual mJSN ≥ 1.0 mm, n (%)</td>
</tr>
<tr>
<td>26 (12.8%)</td>
</tr>
<tr>
<td>Odds ratio = 0.41 (95% CI: 0.20–0.85) p = 0.02</td>
</tr>
</tbody>
</table>

DEP, diet and exercise program; mJSN, minimum joint space narrowing.

• No Difference – at mean f/u time of 6.6 years
Non-Operative Cartilage Care

CORTICOSTEROID INJECTIONS

The Effect of Intra-articular Corticosteroids on Articular Cartilage

A Systematic Review

Chloe Wernecke,* BS, Hillary J. Braun,* BS, and Jason L. Dragoo,† MD
Investigation performed at Stanford University, Redwood City, California, USA

- Chondro-Protective if <2-3mg/dose and < 8-12 mg/cumulative dose
- Deleterious effects if >3mg/dose and 18-24mg/cumulative dose
Non-Operative Cartilage Care

HYALURONIC ACID

- Meta-analysis in JAMA
- Prospective Cohort 2011
Non-Operative Cartilage Care

BIOLOGICS: PLATELET RICH PLASMA (PRP)

- PRP is product of patient’s own peripheral blood after having undergone centrifugation that leads to high concentration of platelets.
- The platelets are then activated either endo- or exogenously leading to release of multiple growth factors, assisting in the healing process and reducing inflammation.
Non-Operative Cartilage Care

BIOLOGICS: PLATELET RICH PLASMA (PRP)

- 2012 prospective study of 40 patients who received series of 3 PRP injections 1 week apart

- Statistically significant reduction in WOMAC, VAS, Harris Hip Scores at 7 weeks and sustained at 6 months
Non-Operative Cartilage Care

BIOLOGICS: PLATELET RICH PLASMA (PRP)

- 2015 RCT, 160 patients, 83% women, age 40-70

<table>
<thead>
<tr>
<th>STUDY GROUPS AND TIME POINTS</th>
<th>WOMAC INDEX SCORES, MEAN (SD)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PAIN</td>
<td>STIFFNESS</td>
<td>PHYSICAL FUNCTION</td>
<td>TOTAL</td>
</tr>
<tr>
<td>PRP group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>8.46 (4.17)</td>
<td>2.2 (1.76)</td>
<td>28.91 (12.63)</td>
<td>39.5  (17.06)</td>
</tr>
<tr>
<td>Week 52</td>
<td>4.03 (3.36)</td>
<td>1.19 (1.4)</td>
<td>13.19 (10.39)</td>
<td>18.44 (14.35)</td>
</tr>
<tr>
<td>Change baseline vs week 52</td>
<td>4.39 (3.57)</td>
<td>1.05 (1.76)</td>
<td>15.77 (10.80)</td>
<td>21.11 (14.18)</td>
</tr>
<tr>
<td>P value</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Hyalgan group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>6.91 (3.82)</td>
<td>1.88 (1.72)</td>
<td>19.88 (12.32)</td>
<td>28.69 (16.69)</td>
</tr>
<tr>
<td>Week 52</td>
<td>5.08 (3.71)</td>
<td>2.14 (1.66)</td>
<td>19.51 (11.9)</td>
<td>27.48 (16.36)</td>
</tr>
<tr>
<td>Change baseline vs week 52</td>
<td>1.11 (3.89)</td>
<td>0.25 (2.11)</td>
<td>0.3 (13.69)</td>
<td>1.22 (18.65)</td>
</tr>
<tr>
<td>P value</td>
<td>0.029</td>
<td>0.16</td>
<td>0.819</td>
<td>0.78</td>
</tr>
<tr>
<td>Between group (P value)</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

- Both groups improved at 12 months
  -> More so in PRP over HA
Non-Operative Cartilage Care

BIOLOGICS: BMAC AND STEM CELLS

- Bone marrow aspiration concentrate (BMAC): source of mesenchymal stem cells and a rich source of growth factors
- Stem Cells: can be adult or embryonic in origin, can be derived from bone marrow or adipose for example
Concentrated Bone Marrow Aspirate for the Treatment of Chondral Injuries and Osteoarthritis of the Knee

A Systematic Review of Outcomes

Jorge Chahla, MD, Chase S. Dean, MD, Gilbert Moatshe, MD, Cecilia Pascual-Garrido, MD, Raphael Serra Cruz, MD, and Robert F. LaPrade, MD, PhD

Investigation performed at Steadman Philippon Research Institute, Vail, Colorado, USA

Results: Eleven studies were considered. Of these, 5 were prospective studies, 1 was a retrospective study, 2 were case series, and 3 were case reports. Three comparative studies (2 with level 2 evidence, 1 with level 3 evidence) were found in our search; none of them were randomized. Three studies investigated the clinical efficacy of BMAC in the treatment of osteoarthritis, and 8 studies evaluated the efficacy of BMAC on focal cartilage injuries. All 3 studies regarding osteoarthritis and all 8 studies regarding focal chondral defects reported good to excellent overall outcomes with the use of BMAC.

Conclusion: Although a growing interest for biological alternatives of treating knee pathology has been observed in the past few years, there still remains a paucity of high-quality studies. The studies included in this systematic review reported varying degrees of beneficial results with the use of BMAC with and without an additional procedure for the treatment of chondral defects and early stages of osteoarthritis. Most articles present the use of BMAC as a safe procedure and report good results.
Most of cartilage reparative and restorative techniques have been widely developed and used in the knee.

Many of these techniques have been transferred and applied to the hip.
Outcomes of Microfracture for Traumatic Chondral Defects of the Knee: Average 11-Year Follow-up


- 72 pt case series; only predictor of worse outcome on multivariate analysis was older age
- Not to say NOT positive - but less than younger
Analysis of the Current Indications for Microfracture of Chondral Lesions in the Hip Joint

Darrin J. Trask,*, MD, and James S. Keene,*† MD
Investigation performed at the University of Wisconsin at Madison, Madison, Wisconsin, USA

- Case series AJSM 2016
- No significant difference in outcomes between lesion size, sex, and age (<50 vs >50) in the hip
- Potentially dissimilar indications to the knee...

![Image](https://via.placeholder.com/150)

TABLE 2
Comparison of 2-Year Outcomes of the 70 Microfracture Patients Based on Their Sex and Age and the Shape and Size of Their Osteochondral Defects

<table>
<thead>
<tr>
<th>Variable</th>
<th>mHHS Outcome, No. of Patients</th>
<th>P Value (χ² Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defect size, mm²</td>
<td></td>
<td>.61</td>
</tr>
<tr>
<td>&gt;400</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>200-400</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>&lt;200</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td>.33</td>
</tr>
<tr>
<td>Male</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td>.91</td>
</tr>
<tr>
<td>≥50</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Defect shape⁶</td>
<td></td>
<td>.25</td>
</tr>
<tr>
<td>Narrow (rectangular)</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Round (circular)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Irregular</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>FAI surgery</td>
<td></td>
<td>.83</td>
</tr>
<tr>
<td>No osteoplasties</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Osteoplasties performed</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>No FAI surgery</td>
<td></td>
<td>.14</td>
</tr>
<tr>
<td>Radiographic FAI</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>No radiographic FAI</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>
Results at 10 to 14 years after osteochondral autografting (mosaicplasty) in articular cartilage defects in the knee

Eirik Solheim a, b, c, *, Janne Hegna b, Jannike Øyen d, e, Thomas Harlem a, Torbjørn Strand a

Results: Both the mean Lysholm score and mean VAS pain score improved significantly from baseline, 49 (SD 17) and 58 (SD 23), respectively, to both the mid-term follow-up, 72 (SD 18, p<0.001) and 27 (SD 20, p<0.001), respectively, and the long-term follow-up, 72 (SD 21, p<0.001) and 33 (SD 23, p<0.001), respectively. A poor outcome at the long-term follow-up – defined as a Lysholm score of 64 or less or having had a knee replacement – was found in 40%. A poor outcome was more frequent in patients 40 years or older (59%), in women (61%) and in defects with an area of 3 cm² or more (57%). Conversely, in a subgroup of male individuals younger than 40 years with defect size less than 3 cm² the failure rate was 12.5% and the mean Lysholm score was 82 (SD 16).
Study above and others show age greater than 25 – 30 years old have higher failure rates.

Gender does not come up consistently or in any significance.

Similarly this technique is relatively contraindicated in the hip.
Autologus Chondrocyte Implantation

- 2 stage surgery: biopsy and then implantation
- Indicated for larger defects

Second-Generation Autologous Chondrocyte Implantation

Results in Patients Older Than 40 Years

Elizaveta Kon,*1 MD, Giuseppe Filardo,1 MD, Vincenzo Condello,1 MD, Marco Collarile,1 MD, Alessandro Di Martino,1 MD, Claudio Zorzi,1 MD, and Maurilio Marcacci,1 MD, Prof.
Investigation performed at the III Clinic, Biomechanics Laboratory, Rizzoli Orthopaedic Institute, Bologna, Italy, and the Orthopaedic Department, Sacro Cuore–Don Calabria Hospital, Negar Verona, Italy

Figure 2. International Knee Documentation Committee (IKDC) subjective score: improvement from the preoperative level to 12 months, 24 months, and final follow-up ($P < .0005$). The improvement achieved at 12 months is further increased at the 24-month evaluation ($P = .008$), whereas results are stable from 2 years to the final midterm evaluation.
Bone Grafting Hip

- In hip dysplasia and FAI subchondral acetabular cysts are frequently encountered.
- Technique developed for those cysts 1-3 cm³.
MUST FIX Underlying Mechanism

- **KNEE**
  - Limb Malalignment
  - Meniscal Injury
  - Ligamentous Injury
The effect of patient, provider and surgical factors on survivorship of high tibial osteotomy to total knee arthroplasty: a population-based study

Amir Khoshbin¹ · Ujash Sheth² · Darrell Ogilvie-Harris³ · Nizar Mahomed³,⁵ · Richard Jenkinson⁴ · Rajiv Gandhi³ · David Wasserstein⁴

- Retrospective Canadian cohort study – looked at all patients underwent HTO over 15 years
- Primary outcome of Time to TKA

Table 3  Results of a Cox proportional hazards model evaluating the effect of patient, provider and surgical factors on subsequent TKA

<table>
<thead>
<tr>
<th>Risk of subsequent TKA</th>
<th>HR</th>
<th>95 % lower CI HR</th>
<th>95 % upper CI HR</th>
<th>p value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.05</td>
<td>1.04</td>
<td>1.06</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Female versus males (reference)</td>
<td>1.35</td>
<td>1.17</td>
<td>1.55</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Must Fix Underlying Mechanism

HIP

- Femoroacetabular Impingement (FAI)
- Borderline to Frank Hip Dysplasia

- Again age over 40-45 and female sex are factors to take into consideration
Conclusions

- Exercise is overall chondro-protective; except for at extremes
- There are LOTs of non-operative treatment options for focal and diffuse cartilage injuries in the lower extremities in the mature female population
- Surgical options are numerous
  - Benefits seen in this specific population; but overall less in the over 45, female population
- Surgically MUST treat any underlying problems too!!