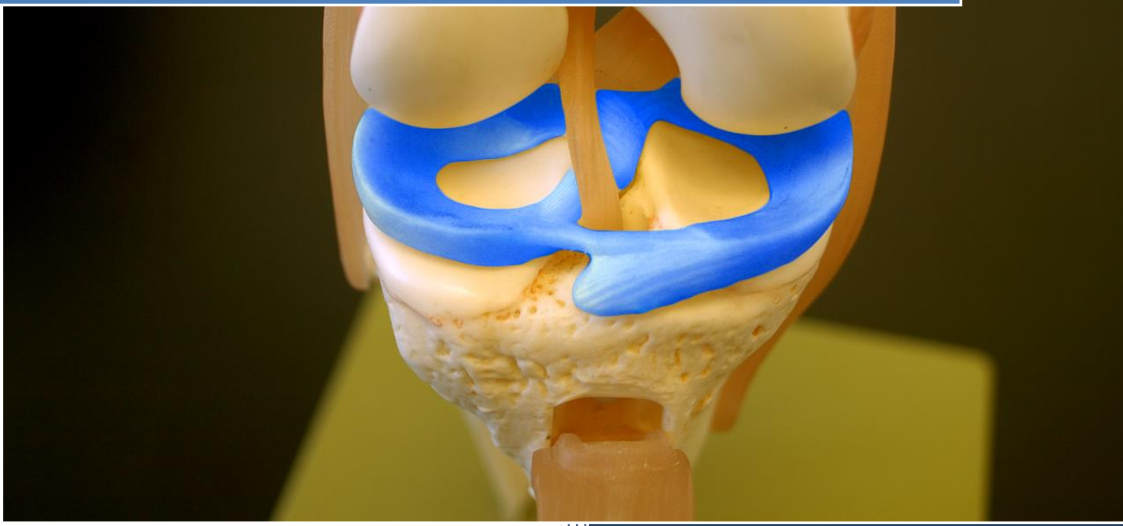
Friday March 25, 2022
1:00 PM – 3:00 PM Central Daylight Time

2022

Meniscus Transplantation Study Group Meeting



Zoom Meeting

https://us06web.zoom.us/j/86130558163?pwd=UkdwVzQ0UktBc3V5VWo1TVNNZGtDQT09

2022 Meeting Agenda

1:00 Welcome *Kevin R. Stone, MD – Chairman, MTSG*

1:05 Introduction *Moderated by Seth Sherman, MD*

Presentations *Moderated by Seth Sherman, MD*

1:10 Osteoarthritis induced by a traumatic meniscus injury is regulated by axial alignment

Henning Madry[1,2]*, *Tamás Oláh[1,2], Jan Reinhard[1], Matthias W. Laschke[3], Lars K. H. Goebel[1,2], Frédéric Walter[4], Gertrud Schmitt[1], Susanne Speicher-Mentges[1], Michael D. Menger[3], Magali Cucchiarini[1,2], Dietrich Pape[2,4]*

1:20 Can we identify the mechanically "at risk" compartment following meniscectomy? Formulating an individualized approach to meniscal deficiency and restoration.

Ian Hutchinson MD[1*], *Kalle Chastain MS[2], Suzanne Maher PhD[2] & Scott Rodeo MD[1]*

1:30 The first clinical experiences with an anatomical medial meniscus prosthesis

T van Tienen[1]*, *KC Defoort[2], PJ Emans[3], SAW van de Groes[1], PJC Heesterbeek[2], RWE Pikaart[4]*

1:40 A new technique for meniscus extrusion treatment: joint space molding

*Ri Zhou, **Wentao Zhang***, Shiyou Ren*

1:50 Biomechanical Forces of the Lateral Knee Joint Following Complete Meniscectomy and Subsequent Meniscal Transplant in Pediatric Cadavers

***Anshal Gupta MTM[1*]**, Mark Sanchez BS[1], Hunter W. Storaci MS[1], Matthew S. Rohde[1], Kevin G. Shea MD[1], Seth L. Sherman MD[1]*

2:00 Meniscus Allograft Transplantation In Patients over 50 Years Old

Kevin R. Stone, MD*

2:10 Evolving All-inside MAT Technique

Volker Musah*

2:20 **Business of MAT**
JRF*

Discussion

Refer to the suggested topics for group discussion

2:50 Close

Suggested Topics for Discussion

Moderators: Kevin Stone, Seth Sherman

- Biologics for MAT
- RTP after MAT
- Imaging of MAT
- Tissue processing and preparation of MAT
- Preventing MAT extrusion
- Prophylactic MAT
- MAT + Concomitant procedures (cartilage +MAT, ligament + MAT, multiple MATs, osteotomy)

Osteoarthritis induced by a traumatic meniscus injury is regulated by axial alignment

Henning Madry*
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Articular cartilage damage instructed by a defined meniscal injury may lead to early osteoarthritis (OA). We first modeled early human OA by gathering detailed spatiotemporal data from knee OA surgically induced by partial medial meniscectomy in sheep. We identified a specific topographical pattern of osteochondral changes, showing that both cartilage and subchondral bone degeneration are initiated from the region adjacent to the damage. Alterations of the subarticular spongiosa arising locally and progressing globally disturbed the correlations of cartilage with subchondral bone seen at homeostasis and were indicative of disease progression. We validated our quantitative findings against human OA, showing a similar pattern of early OA correlating with regions of meniscal loss and an analogous late critical disturbance within the entire osteochondral unit. In patients with advanced varus knee OA, we show strong correlations of osteochondral parameters within individual topographical patterns, highlighting their fundamental and location-dependent interactions in OA. We further identify site-specific effects of varus malalignment on the lesser loaded compartment and, conversely, an unresponsive overloaded compartment. Last, we trace compensatory mechanisms to the overloaded subarticular spongiosa in patients with additional high body weight. Finally, we investigated how normal, over-, and underload affect OA development induced by a traumatic meniscus injury. In the clinical case study, we provide evidence of osteochondral recovery upon surgically unloading symptomatic isolated medial tibiofemoral knee OA associated with varus malalignment by high tibial osteotomy (HTO) in a 57-year old man with isolated medial tibiofemoral knee OA with varus malalignment and a medical history of a degenerative medial meniscal lesion. To provide scientific translational evidence for the link between OA caused by meniscal injury and malalignment, we identify spatially complex degenerative changes in cartilage after overloading by HTO in a clinically relevant ovine model by mapping response correlations at high resolution. We further report that surgically unloading diminishes OA cartilage degeneration and alterations of critical parameters of the subchondral bone plate in a similar topographic fashion. Last, therapeutic unloading shifted the articular cartilage and subchondral bone phenotype to normal and restored several physiological correlations disturbed in neutral and varus OA, suggesting a protective effect on the integrity of the entire osteochondral unit. This study enables a detailed insight into the pathological effects of normal, over-, and underload and their role in knee OA induced by a traumatic medial meniscus injury in a large animal, a highly challenging endeavor in small animals or patients. Collectively, these findings identify surgically modifiable trajectories with considerable translational potential to reduce the burden of human OA.

References:
Oláh *et al.* **Sci Transl Med**. 2019;11(508):eaax6775.
Haberkamp *et al.* **Sci Transl Med**. 2020;12(562):eaba9481.
Oláh *et al.*, **Sci Transl Med**. 2022;14(629):eabn017

Can we identify the mechanically “at risk” compartment following meniscectomy? Formulating an individualized approach to meniscal deficiency and restoration.

Ian Hutchinson MD[1*], Kalle Chastain MS[2], Suzanne Maher PhD[2] & Scott Rodeo MD[1].

Sports Medicine Institute[1] and Department of Biomechanics[2], Hospital for Special Surgery, New York, USA.

Background: Partial meniscectomy is the most commonly performed orthopaedic procedure in the USA with over 700,000 cases performed annually. However, the mid to long term clinical results of meniscectomy remain highly variable between patients ranging from symptom alleviation to progression of knee joint degeneration. Of particular interest, some patients who undergo meniscectomy experience rapid, symptomatic deterioration of their operated compartment and meniscus allograft transplantation (MAT) may be indicated. The goal of this study is to identify mechanical factors that predispose to an elevated risk of post-meniscectomy compartment degeneration.

Methods: Five human cadaveric knees were subjected to simulated gait and axial loading at 50% body weight using a multi-axis testing apparatus (AMTI, Watertown, MA). The normal contact stresses were captured using a thin electronic sensor containing piezoelectric pressure sensing elements (Tekscan Inc. Boston, MA). Reflective markers were attached to anatomic landmarks and motion capture of knee kinematics was achieved using a motion analysis system (Motion Analysis Inc. CA). Specimens were tested in the i) intact condition and ii) partial medial meniscectomy condition. The cartilage-cartilage contact zone and area under the meniscus on the tibial plateau were identified and considered separately; specifically, a cartilage-meniscus force ratio analysis was used.

Results: Meniscal loading was successfully captured and compared between knees and testing conditions. In each case, loading of the meniscus was decreased following meniscectomy with corresponding increases in the cartilage-cartilage contact area. Interestingly, there was some variation in the extent of meniscal loading between the intact conditions of different specimens. In addition, the relative change in meniscal loading was variable despite similar meniscal resections.

Conclusion: While meniscal loading predictably decreased following meniscectomy in each case, variations in intact and post-meniscectomy meniscal loading patterns were detected between cadaveric specimens. Magnetic Resonance Imaging (MRI) and Finite Element (FE) analysis for each cadaveric knee will be applied to interpolate the specific mechanical factors that contribute to variations in meniscal loading in the intact and meniscectomy conditions. Ultimately, prediction of pathological cartilage loading following meniscectomy may guide individualized patient surveillance and support earlier meniscal restoration in “at risk” patients.

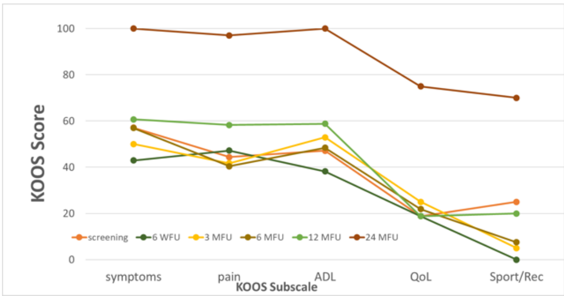
The first clinical experiences with an anatomical medial meniscus prosthesis

T van Tienen[1]*, KC Defoort[2], PJ Emans[3], SAW van de Groes[1], PJC Heesterbeek[2], RWE Pikaart[4]
1 Radboud University Medical Center, The Netherlands
2 Sint Maartenskliniek Nijmegen, The Netherlands 3 Maastricht University Medical Center, The Netherlands

Purpose
There is a strong unmet need for a solution that will relieve post-meniscectomy pain. Meniscus allograft is de golden standard in these patients. An off-the- shelf meniscus prosthesis would be a valuable alternative. Purpose of this first-in-man study was to evaluate the safety and clinical performance of this first anatomical medial meniscus prosthesis.

Methods
A first-in-man, prospective, multi-centre, single arm clinical investigation was intended to be performed on 18 post-medial meniscectomy syndrome patients with limited underlying cartilage damage (Kellgren Lawrence scale 0-3) in the medial compartment and having a normal lateral compartment. Five patients received a polycarbonate urethane medial meniscus prosthesis which was clicked onto two titanium screws fixated at the native horn attachments on the tibia. KOOS was collected at baseline and at 6 weeks, 3, 6, 12 and 24 months and MRI scans at 12
and 24 months.

Results
The surgical technique to select the appropriately sized implant and correct positioning of the fixation screws and meniscus prosthesis onto the tibia was demonstrated feasible and reproducable. The surgeries showed that in particular the positioning of the posterior screw is crucial for correct positioning of the prosthesis. Inclusion stopped after 5 patients. All patients reached the 6 months evaluationon which all patients reported knee joint stiffness and slight effusion. In case of symptomatic patients an evaluation of the device position and integrity was performed by MRI. In three patients the implants were removed because of implant failure and in one patient the implant was removed because of persistent pain and extension deficit. In all patients the KOOS score did not improve in the first 6 months after surgery till the implants were removed. The explantations of the implants demonstrated no articular cartilage damage and the fixation screws were securely anchored. One patient still has the implant in situ. In this patient all PROMs started to improve 1 year after surgery and this improvement continued onto 2 years follow up. His knee functions nearly optimal.



Discussion
This is the first clinical study with an anatomical meniscus prosthesis. One out of five patients showed good clinical results after two years. The other four implants needed to be removed due to failure or discomfort of the patient: the implant seemed too stiff and carried all the load in the medial compartment of the knee. There was no load-sharing with the tibial cartilage. Furthermore, the fixation with screws seemed too rigid which restricted the motion of the posterior horn. Therefor, we changed the design and fixation of the newly developed meniscus prosthesis and started with a new study-in- men in 2022.

A new technique for meniscus extrusion treatment: joint space molding

Ri Zhou, Wentao Zhang*, Shiyou Ren

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Purpose: the gap between the femoral condyle and tibial plateau is normally filled by the meniscus. Due to discoid meniscal or meniscal injuries, the femoral condyle or tibia plateau morphology is abnormal, the normal joint space disappears, and the meniscus loses its living space. Joint space molding technology reconstructs the joint space for the transplanted or injured meniscus, reducing the degree of extrusion of the transplanted or injured meniscus.

Methods: We divide the joint space loss into two types, the grinding-disc type and the pestle type. The grinding-disc type performs femoral condyle molding, and the pestle mold performs tibia platform molding.

Results: joint space molding technique reducing the degree of meniscus extrusion.

Conclusion: joint space molding is an effective technique to reduce the degree of extrusion of the transplanted or injured meniscus.

Biomechanical Forces of the Lateral Knee Joint Following Complete Meniscectomy and Subsequent Meniscal Transplant in Pediatric Cadavers

Anshal Gupta MTM[1*], Mark Sanchez BS[1], Hunter W. Storaci MS[1], Matthew S. Rohde[1], Kevin G. Shea MD[1], Seth L. Sherman MD[1]

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Abstract

Background: Meniscus transplant successfully treats symptomatic meniscal deficiency in children. While clinical outcomes are well characterized, biomechanical lateral joint forces in the meniscus-deficient and transplant states are unknown.

Hypothesis/Purpose: We hypothesize that meniscectomy will decrease contact area (CA) and increase contact pressures (CP). Transplant will partially, but not fully, restore biomechanics towards intact meniscus state.

Study Design: Descriptive laboratory study

Methods: Pressure mapping sensors were inserted underneath the lateral meniscus of eight cadavers (ages 8-12). CA and CP on the lateral tibial plateau were obtained using a six-degrees-of-freedom robot that applied cadaver appropriate pressure load equivalent at 0, 30, 60 degrees of knee flexion. Three meniscus states were characterized: intact, meniscectomy, transplant. Meniscus transplant was anchored with transosseous suture fixation and sutured to the joint capsule with horizontal mattresses.

Results: Contact area (CA): All CA trends were consistent with our hypotheses. At 0°, no differences between groups reached significance. Partial restoration of CA was observed at 30° and 60°. At 30°, the meniscectomy state was greater than the intact state (P=0.04). The transplant state was not significantly different than the meniscectomy or intact states. At 60°, CA of the intact state was greater than the transplant state (P=0.03), which was greater than the meniscectomy state (P=0.01). These results suggest partial restoration of CA at 30° and 60°.

Contact Pressure (CP): All trends for average CP were consistent with our hypothesis. At 0°, meniscectomy state CP was significantly greater than the intact state (P=0.004) and the transplant state (P=0.003). Comparable means between transplant and intact states at 0° suggests full restoration of CP with transplant. At 30° and 60°, the meniscectomy state was significantly greater than the intact state (P=0.002 and P<0.001, respectively). However, the transplant state was comparable to both the meniscectomy state and the intact state. This suggests partial restoration of CP with transplant.

Conclusion: Meniscus transplantation following meniscectomy optimally improves contact area and pressure at low degrees (<30°) of flexion. Meniscus transplant outcomes may improve with research that fully restores contact biomechanics.

Clinical Relevance: Pediatric meniscus transplant partially but not fully restores CA and CP toward the normal, intact meniscus state. Meniscus transplant outcome may improve with surgical methods that fully restores contact biomechanics.

Key Terms:

Meniscectomy, Transplant, Lateral Meniscus, Biomechanical Testing