Friday October 1, 2021
11:00 AM – 2:00 PM Pacific Standard Time

2021

Meniscus Transplantation Study Group Meeting

Zoom Meeting

https://us06web.zoom.us/j/89360157803?pwd=QXBLZlVQRkpCZTRZZzUyRHVCdzVoQT09

2021 Meeting Agenda

11:00 **Welcome** *Kevin R. Stone, MD – Chairman, MTSG*

11:05 **Introduction and Presentation** *Moderated by Alberto Gobbi, FRCS*

Presentations ***Moderated by Alberto Gobbi,** FRCS*

11:30 **10 Years of Clinical Results Using Hyaluronic Acid-Based Scaffold With Bone Marrow Aspirate Concentrate for treatment of chondral lesions of the knee**
Gobbi, FRCS*

11:45 **Long-term Outcomes of Primary Repair of the Anterior Cruciate Ligament Combined with Biologic Healing Augmentation to Treat Incomplete Tears**
***Morales*,** *FRCS*

Updates in Biological Stimulation techniques for Meniscal Lesions
Gobbi*, Morales

12:15 **Biomechanical Forces of the Lateral Knee Joint Following Complete Meniscectomy and Subsequent Meniscal Transplant in Pediatric Cadavers**
***Anshal Gupta MTM[12*],** Mark Sanchez BS[1], Hunter W. Storaci MS[1], Matthew S. Rohde BS[1], Kevin G. Shea MD[1], Seth L. Sherman MD[1]*

12:30 **OXIDIZED ALGINATE BASED HYDROGEL FOR MENISCAL TEAR: *IN VIVO* EVALUATION**
R. Resmi[a*], J. Parvathy[a], Annie John[b], and Roy Joseph[a]

12:45 **Results of Meniscal Transplant with Primary or Revision ACL Reconstruction**

***Matthew Walker*,** Nicole Bausch, Niall McGoldrick, Andrew Metcalfe, Peter Thompson*

1:00 Meniscus Transplantation Update on Stone Clinic Experience

Kevin R. Stone, MD*

1:10 Discussion

Refer to the suggested topics for group discussion

1:50 Close

Suggested Topics for Discussion

- Augmenting Meniscus Allograft Transplantation with Stem Cells and Growth Factors
- Sterilization procedures and irradiation
- Meniscus tibial ligament preservation vs Skeletonizing
- Permanent suture and anchors vs resorbable suture only
- Return to full sports
- Prevention of arthritis
- Treatment of growth plate in adolescents
- Combined medial and lateral transplantation
- Meniscal Allograft Transplantation vs Unicompartmental Joint Replacement
- Combined Meniscus allograft transplantation and
    - Articular cartilage repair
    - ACL reconstruction
    - Osteotomy

10 Years of Clinical Results Using Hyaluronic Acid-Based Scaffold With Bone Marrow Aspirate Concentrate for treatment of chondral lesions of the knee

Gobbi, FRCS*

Purpose: To investigate the long-term clinical outcomes of knee joint full-thickness cartilage repair with a hyaluronic-acid constructed scaffold embedded with bone marrow aspirate concentrate (HA-BMAC).

Methods: Patients who underwent treatment of full-thickness chondral injury in the knee with HA-BMAC were followed prospectively for a minimum of 6 years. Clinical outcomes were examined with patient-reported scoring instruments: the Tegner Activity Scale, International Knee Documentation Committee (IKDC) subjective score, visual analog scale, and Knee injury and Osteoarthritis Outcome Score (KOOS). Comparative analysis of pre-and postoperative scores was performed. The effects of patient age, body mass index, lesion size, number of treated lesions, and concurrent treatment with associated procedures were examined.

Results: Twenty-three patients (mean age, 48.5 years) were followed prospectively for a mean eight years (range, 6-10 years). Median cartilage lesion size was 6.5 cm2 (range, 2-27 cm2). At final follow-up, median Tegner, visual analog scale, and IKDC subjective scores were 4, 0.3, and 85, respectively. Final median KOOS subset scores were as follows: Pain, 94; Symptoms, 89; Activities of Daily Living, 99; Sports/Recreation, 85; and Quality of Life, 85. All scores were significantly increased at the final follow-up ($P < .001$). Comparable median outcome scores were demonstrated after categorizing patients by age, lesion size, treatment of multiple lesions, treatment of multiple knee compartments, and treatment by associated procedures. Rank correlation analysis demonstrated a negative correlation between patient age and final outcome scores of the IKDC, Tegner, and KOOS subsets of Pain, Activities of Daily Living, and Sports/Recreation. No associations were identified between body mass index or lesion size and outcome scores.

Conclusion: Repair of full-thickness cartilage injury in the knee with an HA-BMAC provides good to excellent clinical outcomes at long-term follow-up in the treatment of small to large lesions. Cartilage repair with HA-BMAC leads to comparatively successful long-term outcomes in treating small or large lesions, single or multiple lesions, and lesions in 1 or 2 compartments and in cases of associated lesion treatment. While good outcomes can be expected among treated patients >45 years of age, outcomes may be comparatively more successful in younger patients.

Long-term Outcomes of Primary Repair of the Anterior Cruciate Ligament Combined with Biologic Healing Augmentation to Treat Incomplete Tears

Background: Surgical treatment to repair partial anterior cruciate ligament (ACL) injury without reconstruction has demonstrated inconsistent clinical success.

Purpose: To examine the long-term clinical outcomes of primary anterior cruciate ligament repair combined with biologic healing augmentation in cases of symptomatic partial ACL tears.

Methods: 50 patients (mean age 29.5 years) diagnosed with a partial ACL tear, suffering from symptomatic knee instability, were treated with primary ligament repair in conjunction with marrow stimulation and followed prospectively for a mean duration of 10.2 years (range5.3 – 14.3 years). Comparative analysis of preinjury, preoperative, and postoperative scores using patient-reported assessment instruments was performed to examine clinical outcomes. In addition, correlation of final outcome scores with patient age**,** type of ACL tear, the side-to-side difference in ligamentous laxity**,** and body mass index (BMI) was performed using Spearman's rank analysis.

Results: 44 patients were available for assessment at final follow-up. The median Tegner Activity Scale score of 7 at final follow-up was the same as the pre-injury median score of 7 ($p = 0.128$). The mean Marx Activity Scale, International Knee Documentation Committee (IKDC) Subjective, and Lysholm Knee Questionnaire scores were 10.8, 90.4, and 96.2, respectively, at final follow-up. Mean final 47 Knee Injury and Osteoarthritis Outcome Score (KOOS) subset assessments of Pain, Symptoms, Activities of Daily Living (ADL), Sports, and Quality of Life (QOL) were 98.6, 97.5, 99.7, 94.3, and 95.6, respectively. Secondary ACL insufficiency occurred in 27% of cases. Clinical outcome scores were similar for all scoring instruments between patients treated for an associated diagnosis of meniscal or articular cartilage injury. There was a negative correlation of patient age and pre-injury Tegner score ($rs = -0.333$, $p = 0.022$) and at final follow-up ($rs = -0.376$, $p = 0.013$). The mean side-to-side difference in ligamentous laxity at short-term follow-up in those who developed secondary ACL insufficiency was significantly greater of 3.4 mm than the mean of 0.9 mm in those who did not ($p = 0.010$).

Conclusions: Primary ACL repair combined with biologic-healing augmentation to treat selected cases of knee instability secondary to incomplete ACL rupture has demonstrated good to excellent long term outcomes in the cohort of patients who did not suffer secondary ACL insufficiency with high rates of restoration of knee stability and return to pre-injury athletic activities. The rate of secondary treatment for recurrent ACL insufficiency throughout long-term follow-up was greater than expected for primary ACL reconstruction. Greater side-to-side differences in objective findings of ligamentous laxity were identified at shorter-term follow-up in those who later went on to suffer symptomatic secondary ACL insufficiency, compared to those who maintained stability long-term.

Updates in Biological Stimulation techniques for Meniscal Lesions:

A biological solution for a biological problem

Partial meniscectomy is still the procedure of choice for most patients with meniscal injuries. Unfortunately, the rate of early-onset osteoarthritis after meniscectomy remains high. For this reason, meniscal repair is considered the gold-standard treatment not only in young-active patients but also in those aged 40 and older, with optimal healing rates and patient-reported outcome measures (PROMs). Literature accounts for meniscal healing rates of about 52% to 93%, with this being a multifactorial subject with many factors influencing like: tear type, time from injury, chronic vs. acute injury, knee weight-bearing, or medial vs. lateral meniscus injury. Despite these good healing rates, there is a subgroup of patients in which failed meniscal repair still remain high, leading to a progression of the meniscal lesion, with early osteoarthritis. These reasons have arisen the number of bio orthopedic techniques as enhancers of meniscal tear treatment such as fibrin clot, platelet-rich plasma, mesenchymal stem cell, and even hyaluronic acid or $CaCl_2$. Even though a limited number of clinical trials have provided enough evidence for the use of biological augmentation, the use of healing stimulation techniques for meniscal regeneration appears to be a promising approach to obtain the maximum possible healing potential. This reason is why the matter of this topic is crucial in order to extend our knowledge of current methods fostering meniscus healing as well as developing newer ones along with technology advances.

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

Anshal Gupta MTM[12], Mark Sanchez BS[1], Hunter W. Storaci MS[1], Matthew S. Rohde BS[1], Kevin G. Shea MD[1], Seth L. Sherman MD[1]

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Background: Meniscus transplantation 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 substantially increase contact pressures and decrease contact area. Transplant will partially restore contact biomechanics of contact pressure and contact area towards normal intact state.

Study Design: This descriptive laboratory study characterizes contact area and pressures on lateral tibial plateau during the intact meniscal state, meniscectomy, and meniscal transplant. Cadaver size appropriate pressure load equivalents were applied by a robot at degrees of flexion: 0, 30, 60.

Methods: Eight cadaver knees (ages 8-12) underwent contact pressure testing of the lateral meniscus at robot-controlled degrees of flexion: 0, 30, 60. Tekscan pressure mapping sensors were inserted underneath the lateral meniscus. Meniscus transplant was anchored with transosseous suture fixation and sutured to the joint capsule with horizontal mattresses. Multiple comparisons analysis was performed and Tukey-adjusted p-values are reported.

Results: Contact area of the intact state was significantly greater than meniscectomy state at 0 degrees ($p<0.001$) and 60 degrees ($p=0.059$). At 0 degrees, contact area of the intact state was greater than the transplant state ($p=0.002$) and the transplant state was greater than the meniscectomy state ($p=0.026$). Compared to the meniscectomy state, the transplant state at both 30 and 60 degrees improved contact area towards normal, but were non-significant.

Mean and peak pressures of the intact state were significantly less than meniscectomy state at every degree of flexion. Transplant improved mean contact pressures with full restoration of native pressures at 0 degrees and partial restoration at 30 degrees. While transplant did partially improve peak contact pressures at 0 degrees, there were no observed improvements at 30 or 60 degrees. Peak pressures of the transplant state were significantly greater than intact state at 30 degrees ($p=0.054$) and 60 degrees ($p=0.006$).

Conclusion: Meniscus transplantation following meniscectomy partially improves contact biomechanics towards normal. Most optimally, contact pressures are improved at acute degrees of flexion. Peak and mean pressures both improve at 0 degrees, whereas mean pressure also improves at 30 degrees. Contact area improves at 0 and 60 degrees.

Clinical Relevance: This study provides biomechanical support for meniscus transplantation in pediatric meniscus-deficient patients. Characterizing contact biomechanics helps surgeons identify optimized meniscal transplantation approaches.

Key Terms: Meniscectomy, Transplant, Lateral Meniscus, Biomechanical Testing

Figure 1: Femorotibial Contact Pressures in the Intact State, Meniscectomy State, and Transplant State with advancing degrees of flexion.

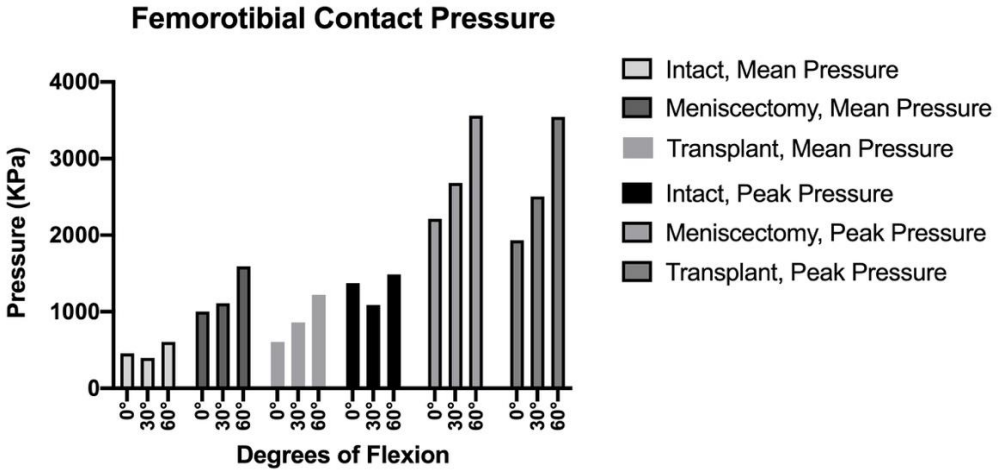

Figure 2: Femorotibial Contact Area in the Intact State, Meniscectomy State, and Transplant State with advancing degrees of flexion.

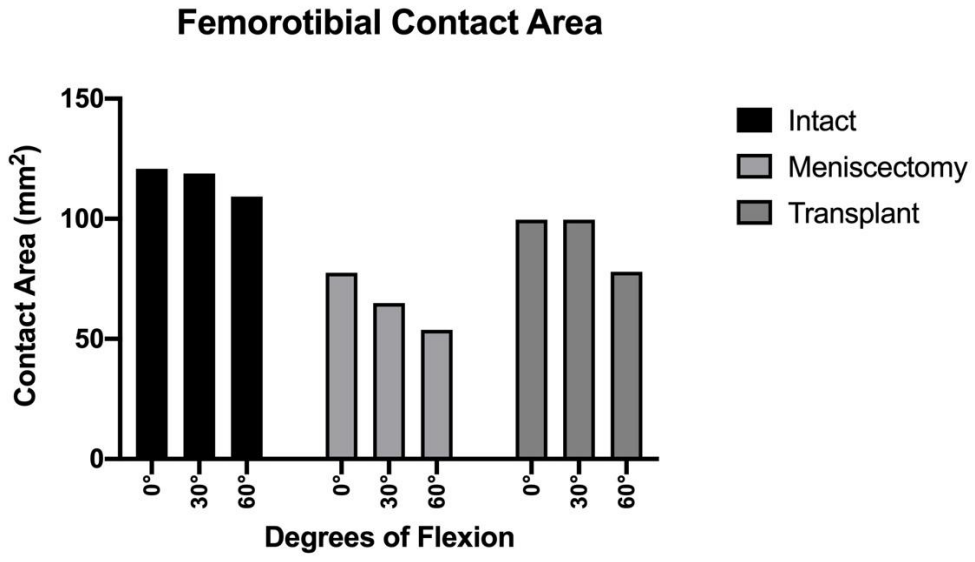

Table 1: Trends in Contact Area and Contact Pressures of the Intact, Meniscectomy, and Transplant State with advancing degrees of flexion

	Contact Area							
	I vs M	Significance	M vs T	Significance	I vs T	Significance	Trend as hypothesized (Yes / No)	Restoration of Contact Biomechanics
0 Degrees	↘	P=0.059	↗	NS	↘	NS	Yes	Partial
30 Degrees	↘	NS	↗	NS	↘	NS	Yes	-
60 Degrees	↘	P<0.001	↗	P=0.026	↘	P=0.002	Yes	Partial
	Peak Pressure							
	I vs M	Significance	M vs T	Significance	I vs T	Significance	Trend as hypothesized (Yes / No)	Restoration of Contact Biomechanics
0 Degrees	↗	P=0.058	↘	NS	↗	NS	Yes	Partial
30 Degrees	↗	P=0.015	→	NS	↗	P=0.054	No	No
60 Degrees	↗	P=0.002	→	NS	↗	P=0.006	No	No
	Mean Pressure							
	I vs M	Significance	M vs T	Significance	I vs T	Significance	Trend as hypothesized (Yes / No)	Restoration of Contact Biomechanics
0 Degrees	↗	P=0.004	↘	P=0.003	↗	NS	Yes	Full
30 Degrees	↗	P=0.002	↘	NS	↗	NS	Yes	Partial
60 Degrees	↗	P<0.001	↘	NS	↗	P=0.079	Yes	No

OXIDIZED ALGINATE BASED HYDROGEL FOR MENISCAL TEAR: *IN VIVO* EVALUATION

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Background: Meniscal tears are the most common knee injuries found among the athletes and people who are involved in labor-intensive occupations. The medial meniscal tear occurs more frequently than the lateral meniscal tear. Meniscectomy is considered as an appropriate therapy but ended up in cartilage degradation. Alternate approaches are becoming imperative for this unmet clinical need. In this work a hydrogel, prepared by crosslinking alginate dialdehyde (ADA) with gelatin (G), or ADAG hydrogel, scaffold has been proposed as a substitute for assisting the repair of the injured meniscus under trauma conditions. **Methods:** ADA was prepared by oxidation of sodium alginate with periodate. An injectable formulation of ADAG hydrogel having a working time of 4 minutes was prepared by reacting 15% aqueous solution of ADA and 20% aqueous solution of G (15ADA20G) in the presence of borax as a catalyst. The hydrogel was characterized by Raman spectroscopy, Scanning Electron Microscopy (SEM), and micro-Computed Tomography (Micro-CT). Host tissue integration was observed by SEM. Cytocompatibility of fibrochondrocyte cell-seeded hydrogel was evaluated by qualitative and quantitative methods. *In vivo* evaluation was done by surgically introducing meniscal tear in rabbit model. **Results:** Infrared spectrum of hydrogel exhibited absorption bands at 1658 cm^{-1} due to ν(C=N) suggesting the formation of Schiff's base during the crosslinking process. The hydrogel was self-healing, injectable and had acceptable water absorption (85 %), porosity (36-60 µm) and mechanical properties (270 kPa). SEM images of hydrogel showed that it integrates well with host meniscal tissue in ex-vivo conditions. Phase-contrast images, SEM micrographs, actin staining, glycosaminoglycan content and DNA and collagen estimation depicted profuse proliferation of fibrochondrocytes on ADAG hydrogel indicating that the hydrogel was cytocompatible. *In vivo* implantation of hydrogel into the meniscal tear showed better regeneration within 3 months compared to control. Histology analysis showed that the regenerated meniscal tissue formed after filling the tear with hydrogel was similar to native tissue.

Keywords: meniscal regeneration, repair, hydrogel, cytocompatible.

Results of Meniscal Transplant with Primary or Revision ACL Reconstruction

Authors: Tim Spalding, Matthew Walker**,** Nicole Bausch, Niall McGoldrick, Andrew Metcalfe, Peter Thompson

Institution: University Hospital Coventry and Warwickshire NHS Trust, Coventry, UK

ABSTRACT

Introduction

Meniscal integrity is important for joint stability contributing to reducing risk of failure of ACL reconstruction, and ligament stability is essential for meniscal reconstruction. Meniscal allograft transplantation is advocated in primary and revision ACL reconstruction where compartmental pain is dominant, and to act as secondary restraint in revision ACL reconstruction. We report on the results of MAT in combination with primary and revision ACL reconstruction.

Methods

420 patients undergoing MAT were prospectively analysed using the UHCW MAT Database. 54 underwent ACL reconstruction and 48 have minimum 1 year follow up - analysed in 2 groups. 17 underwent simultaneous primary ACL reconstruction and MAT (Group 1) and 31 underwent revision ACL reconstruction and MAT (Group 2). The data were analysed using descriptive statistics.

Outcome scores (KOOS, Tegner, IKDC, and Lysholm) were collected preop and at 1,2,3,5,7 and 10 years following surgery. Medical records were reviewed to see whether patients had undergone further surgery, and whether either the ACL graft or MAT graft had failed. Failure was defined for the ACL graft as the need for revision ACL reconstruction/MRI evidence of graft rupture and for MAT was defined as the need for removal of the graft/subsequent conversion to arthroplasty.

Results

The median age of the patients in the two groups was similar (29 in group 1 and 27.5 in group 2). Both groups had a higher proportion of males (82% in group 1 and 68% in group 2).

The patients were followed up for a median of 7 years (1-11 year range). During this time there were 5 MAT failures (10%), 3 were in group 1 (18%) and 2 (7%) were in group 2. All of the MAT failures occurred during the second year. There were four re-ruptures of the ACL graft (8%) with all of these failures occurring in group 1 (24%). 26 patients of the cohort have had further surgery (54%) with 12 (71%) and 14 (45%) in groups 1 and 2 respectively.

In both groups Lysholm, Tegner and IKDC scores improved up to 3 years and plateaued following this. Pre-operatively PROM scores were higher in the primary ACL group with Lysholm Tegner and IKDC scores of 66, 3 and 46 respectively compared to 52, 2 and 41 in the revision group. At 3 years post op scores were significantly improved in both groups with no differences seen between them. Lysholm, Tegner and IKDC scores were 89, 4 and 69 respectively in group 1 and 81, 5 and 69 in group 2.

Conclusion

Combination ACL and MAT has shown good results and patients can expect both symptomatic and functional improvement. This is regardless of whether this is a primary or revision ACL Reconstruction. However, patients should be aware of the relatively high risk of requiring further surgery following this.