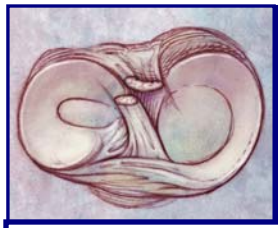

# MENISCUS TRANSPLANTATION STUDY GROUP
## 2007 MEETING BOOKLET

*Please join us at the 2007 AAOS Annual Meeting*

Thursday, February 15, 2007
San Diego Marriott Hotel & Marina
Marriott Hall 5
2:30–5:30 PM


The Meniscus Transplantation Study Group has been exploring the basic science, clinical techniques, and clinical results of meniscus cartilage transplantation since 1986.

For more information, please email research@meniscustransplantion.org

We look forward to seeing you in San Diego!

**THE 2007 MENISCUS TRANSPLANTATION STUDY GROUP MEETING**

Thursday, February 15, 2007, 2:30-5:30 PM

Marriott Hall 5

San Diego Marriott Hotel and Marina, 333 West Harbor Drive, San Diego, Ca 92101

At the 2007 American Academy of Orthopaedic Surgeons Annual Meeting, San Diego, CA

**INTRODUCTION:**

Kevin R. Stone, M.D., Chairman — ***2:30 - 2:45***

**PRESENTATIONS:**

***Cells with the Properties of Progenitor Cells are Present in Different Zones of the Mature, Normal, Canine Meniscus*** — ***2:46 - 3:01***

Presented by Cahir McDevitt, Ph.D.

***Tissue Engineering for Meniscus Regeneration in a Sheep Model*** — ***3:02 - 3:17***

Presented by Elizaveta Kon, M.D.

***Tissue Engineering Approach for Repair of Meniscal Ruptures in the Avascular Zone.*** — ***3:18 - 3:32***

Presented by Peter Angele, M.D.

***DNA Fingerprint of 39 Post-transplantation Biopsies*** — ***3:33 - 3:49***

Presented by Peter Verdonk, M.D., Ph.D.

***The Use of Collagen Meniscus Implantation (CMI) in Anterior Cruciate Ligament (ACL) Reconstruction*** — ***3:50 - 4:05***

Presented by Pier Francesco Indelli, M.D.

***Freezing Causes Changes in the Menisci Collagen Net*** — ***4:06 - 4:21***

Presented by Joan C. Monllau, M.D., Ph.D.

***Meniscal Allograft Transplantation: A New Arthroscopically Assisted Technique*** — ***4:22 - 4:37***

Presented by Philippe Boisrenoult, M.D.

***Results of the Meniscal Transplantation Series in Allografts without Bone-blocks*** — ***4:38 - 4:53***

Presented by Ramon Cugat, M.D.

***Correlation of Extent of Meniscus Loss during Meniscectomy with Clinical Symptoms*** — ***4:54 - 5:09***

Presented by William G. Rodkey, DVM

***Meniscus Transplantation in Australia*** — ***5:10 - 5:25***

Presented by Peter T Myers, FRACS

# MENISCUS ALLOGRAFT SURVIVAL IN PATIENTS WITH MODERATE TO SEVERE ARTHRITS: A 2-7 YEAR FOLLOW-UP

*Stone, KR; *Walgenbach, A; *Turek, T; *Freyer, A
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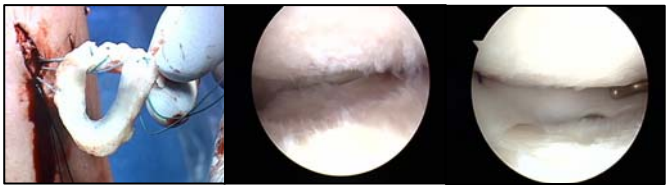
www.stoneresearch.org

## INTRODUCTION

Can meniscus allografting survive in the setting of knee arthritis? We present the findings of 45 patients (47 meniscal allografts) with significant arthrosis to determine if the meniscus can survive in the arthritic joint of older adults. We believe that replacing the meniscus in this patient population may help to delay arthroplasty and improve the results of debridement alone.



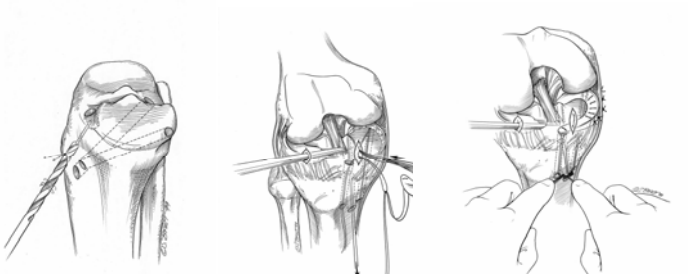
*Allograft Meniscus* | *Missing Meniscus Outerbridge GrIII Arthritis* | *Allograft Meniscus After 4 Months*

## METHODS

**Patients:** Prospective data was collected for 45 patients (31 men, 14 women, mean age 48, age range 14-69, 2 patients had bilateral grafts), with pre-operative evidence of significant arthritis. Allografts were medial in 37 (79%) and lateral in 10 (21%). Of 47 knees, 9 were Outerbridge Class III (19%) and 38 were Class IV (81%).

**Statistics:** Serial clinical exams, x-ray, MRI and validated questionnaires for pain, activity and function were used. No patient was lost to follow-up. Graft failure was defined as surgical removal of the allograft or increased pain as reported by the patient. Five out of 47 allografts were considered failures (10.6%). Statistical analysis included paired t-tests and Kaplan-Meier survival analysis. Power analysis with alpha of 0.05 and N=47 demonstrates a power > 0.90.

**Surgical Technique:** Surgical technique used was the "three-tunnel technique" previously described by the senior author.[1]



*Three-Tunnel Technique For Meniscus Fixation* | *Insertion of Medial Meniscus Allograft* | *Suturing of Medial Meniscus Allograft*

## RESULTS

Statistically significant mean improvement in self-reported measures of pain, activity and functioning with corresponding probabilities of p=0.001, 0.008 and 0.004 using paired t-tests, independent of age, joint space narrowing or severe mal-alignment are reported in Table I.

Twelve of 47 menisci required a second arthroscopy for either suture repair or partial meniscectomy, but were not considered failures because the transplant was a success. A Kaplan-Meier analysis revealed that the mean time to failure, adjusting for censoring, was 4.4 years. The overall failure rate was 5 of 47, or 10.6%.

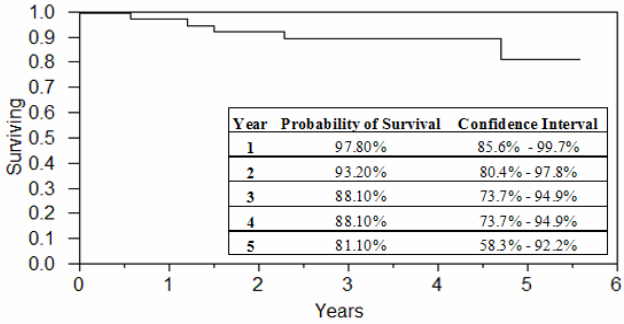
All 5 patients had chronic injuries with osteochondral lesions (classified as Grade IV Outerbridge lesions) with unremitting pain in the affected compartment, eventually leading to arthroplasty. Table II reveals the survival probabilities from one to five years.

**Table I**
**Descriptive Statistics for Self-Reported IKDC Pre-Op and Post-Op Measures**

| Variable | Pre-Op | Post-Op | Wilcoxon p-value |
|---|---|---|---|
| **Pain**[a] | | | |
| Mean | 3.02[a] | 4.06 | 0.001 |
| Standard Deviation | 0.99 | 0.86 | |
| **Activity**[b] | | | |
| Mean | 2.16 | 2.65 | 0.008 |
| Standard Deviation | 0.9 | 0.92 | |
| **Functioning**[c] | | | |
| Mean | 2.37 | 3.34 | 0.001 |
| Standard Deviation | 0.81 | 0.81 | |

[a] Based on a scale from 1-5 where 1 = the most pain and 5 = the least pain.
[b] Activity refers to sports-like activities where the most strenuous activities are basketball or soccer and the least strenuous activity is recreational walking.
[c] Functioning refers to daily activities such as heavy or light work, ascending and descending stairs, and getting in and out of a car.

**Table II**
**Product-Limit Survival Plot and Survival Probabilities**




| Year | Probability of Survival | Confidence Interval |
|---|---|---|
| 1 | 97.80% | 85.6% - 99.7% |
| 2 | 93.20% | 80.4% - 97.8% |
| 3 | 88.10% | 73.7% - 94.9% |
| 4 | 88.10% | 73.7% - 94.9% |
| 5 | 81.10% | 58.3% - 92.2% |

## DISCUSSION

Meniscus allografts survive moderately well in knees with arthritis. Most patients in this population are pleased to gain 5-10 years if it delays arthroplasty. The role that allografts play is difficult to parse from the benefit of the concomitant procedures performed during arthroscopy of arthritic knees; however, recent reports have indicated that arthroscopic debridement alone has not been satisfactory. Therefore, the addition of the shock-absorbing meniscus may be required to provide longer-term relief. These results compare favorably with previous reports of patients who were younger and with less severe degenerative disease. This study demonstrates that meniscus allograft transplantation can be used in higher-risk patients with reasonable expectations of a successful outcome.[2]

## REFERENCES

1. Stone KR, Walgenbach AW. "Meniscal Allografting: the Three-Tunnel Technique." *Arthroscopy – The Journal of Arthroscopic and Related Surgery.* 2003, 19(4):426-30.
2. Stone KR, Walgenbach AW, Turek T, Freyer A. "Meniscus Allograft Survival in Patients With Moderate to Severe Arthritis: A 2-7 Year Follow-Up." *Arthroscopy – The Journal of Arthroscopic and Related Surgery.* Vol 22, No 5 (May), 2006: pp 469-478.

# CELLS WITH THE PROPERTIES OF PROGENITOR CELLS ARE PRESENT IN DIFFERENT ZONES OF THE MATURE, NORMAL, CANINE MENISCUS.

Cahir A. McDevitt, Cory Johnson, Alison Klika, and Amitabha Chakrabarti.

Dept. of Biomedical Engineering, Orthopaedic Research Center, Cleveland Clinic, Cleveland, OH 44195. mcdevic@ccf.org

Mesenchymal progenitor cells have the capacity to differentiate along different cell lineages. We explored the possibility that the normal menisci from skeletally mature dogs contained progenitor cells.

Canine knee joints were obtained from animals sacrificed from other protocols that were approved by the Institutional Animal Care and Use Committee of the Cleveland Clinic. The lateral and medial menisci, femoral, tibial, and patellar articular cartilage, anterior cruciate ligament (ACL), and the digital extensor tendon (DET) were dissected from the canine knee joints. The cells from the superficial zone were isolated from dispase/collagenase digests and from testicular hyaluronidase/ trypsin/ collagenase digests of the and the inner, middle and outer zones of the lateral and medial canine menisci. Cells were tested for their ability to differentiate into osteocytes, adipocytes, and chondro/fibro-chondrocytes. The chondrogenic potential of the cells was evaluated by plating them in LabTek chambers and culture in either 2ml control (DMEM-F12 with 1% L-ascorbate-2-phosphate, 1% Insulin-transferrin-selenium, 0.05% linoleic acid) or induction medium (composed of control medium with 10ng/ml TGF□-1 and $10^{-7}$ M dexamethasone). Chondrogenesis was assessed immunochemically by staining for Types I and II collagen and by real time TaqMan PCR for gene expression of COLIAI and COL2BAI. Similarly, in adipogenic tests, cells were incubated in the presence or absence of adipogenic inducing medium and stained with Oil Red O or analyzed for gene expression of PPAR□gamma. Cells were tested for their capacity to differentiate into osteoblasts by incubation in the presence or absence of osteogenic stimulators and assessed for the presence of alkaline phosphatase enzyme activity or gene expression.

Evidence for the presence of progenitor cells that could respond to the differentiation stimuli and express an adipogenic, chondro/fibro-chondrogenic, or osteogenic phenotype was found in cells of all zones of the meniscus and in the ACL. For example, we could not detect any cells with the characteristic staining of adipocytes in the middle or inner zones of the meniscus, and only occasionally in the outer zone. When cultured in the adipogenic media, however, abundant adipocytes were found in cells isolated from all zones. The outer meniscus does not stain for Type II collagen (1) and contains little aggrecan (2). The cells isolated from this zone showed little COL2 gene expression or immunostaining for Type II collagen protein when cultured in the control media that lacked the chondrogenic stimuli. In contrast, the cells from this zone that were cultured in the chondrogenic stimulating medium formed colonies that showed abundant expression of COL2 in PCR assays Similarly, cells that were exposed to the osteogenic medium formed colonies that expressed much more alkaline phosphatase than controls. Our data show that cells with the capacity to differentiate along different mesenchymal lineages are present in all zones of the meniscus and in the ACL and DET of the mature canine knee joint.

(1). Kambic HE, McDevitt CA. (2005). Spatial organization of types I and II collagen in the canine meniscus. Journal of Orthopaedic Research; 23(1):142-149, 2005.
(2). Valiyaveettil M, Mort JS, McDevitt CA**.** (2005) The concentration, gene expression, and spatial distribution of aggrecan in canine articular cartilage, meniscus, and anterior and posterior cruciate ligaments: a new molecular distinction between hyaline cartilage and fibrocartilage in the knee joint. Connective Tissue Research; 46(2):83-91.

Supported by NIH grants R01 AG 14342 and R21 AR 46991, and the Department of Defense grant DAMD 17-02-1-0677.

# TISSUE ENGINEERING FOR MENISCUS REGENERATION IN A SHEEP MODEL

Kon E.[*], Delcogliano M.[*], Filardo G.[*], M. Fini[*], Chiari-Grisar C.[**], Nehrer S.[**], Ambrosio L.[***], Salter D.[****] and Marcacci M.[*]

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**INTRODUCTION:**
Injuries or complete loss of the meniscus cause cartilage degeneration and osteoarthritis. The healing capacity of the meniscus is limited. Artificial meniscus replacement is a possible alternative to allograft transplantation, which is associated with limited availability, logistical difficulties and the risk of disease transmission. Within the framework of the EC-Project a pivotal study in sheep was conducted to evaluate surgical technique, critical defect size, implant ingrowth and integration and postoperative mobilization using a meniscus replacement device. A new biomaterial consisting of hyaluronic acid and polycaprolactone was used as a meniscus substitute in sheep.

**METHODS:**
30 skeletally mature sheep (50-64 kg) underwent total medial meniscectomy in the right stifle joint, 6 sheep were left untreated for control group. 24 sheep were subjected to meniscal implant and were divided in two groups: the SCS group (scaffold cell seeded, n=12) received total medial meniscal replacement by the implant of a scaffold seeded with aoutologous chondrocytes, and the SCF group (scaffold cell free, n=12) where the meniscus was replaced by a cell free implant. In the SCF group the left stifle joints served as non-operated joints for comparison. In the SCS group the cartilage biopsy was performed from the left stifle joint to obtain the chondrocyte culture. This joints were used as a sham controls in order to see the impact of the artrotomy in a healthy joint.
Twelve sheep, six for each group, were euthanized 4 months after surgery in general anesthesia, while the other twelve were euthanized at 12 months of follow up. 6 sheep of control group were euthanized at 12 months.
A follow-up blood analysis to detect infection or allergic reactions, and a radiographic examination to exclude fracture were performed before euthanazia. The joints were evaluated clinically for swelling, stability and limb. Under sterile conditions the right and the left joints were opened through the previous approach, a swab for microbiological analysis and a synovial aspirate were taken, and the presence of effusion or popliteal cysts was documented. The joints were resected in toto, compared with the non-operated ones and evaluated with 'joint changes score' (min 48, max 0). A macroscopic examination of the implant was performed, too. The specimens were assessed by macroscopic evaluation focusing on implant aspect and tissue quality, its integration to the capsule, fixation and location using a 'meniscus implant score' (min 9, max 27). A routine histologic processing with paraffin embedding and 3µm cuts was performed. The specimen were subjected to staining of Hematoxilin/Eosin for general morphology, Safranin O/Fast Green for glycoseaminoglycans (GAG) and Azan for collagen. A mapping system for the implant was created, dividing the implant into a peripheral (zone1), intermediate (zone 2) and central (zone 3) zone, moreover a superficial (zone s) and a core (zone c) zone were determined. The cartilage underneath the implant was assessed in the periphery (cart – p) and the center (cart – c).
Sections were viewed by an experienced osteoarticular pathologist (DMS) without information on whether the samples were from sheep which had been treated with seeded or unseeded scaffolds.

**RESULTS:**
At 4 months of follow up we noticed a mild swelling, due to the thickening of joint capsule, in all animals, there was no joint instability and no infection .The implants remained in position and showed excellent tissue ingrowth and integration to the capsule. However, we observed in some sheep some cleft of the implant and a full substance tear in three of them due to the insufficient mechanical proprieties of the graft. The average meniscus implants score was 22,33 (min 18, max 26) for the scaffold cell seeded ant 20,66 (min 17, max 25) for the cell free. The histological investigation revealed tissue formation, cellular infiltration and vascularization.
At 12 months of follow up we observe significantly better macroscopic and histological results in SCS group. The average meniscus implants score was 23 (min 17, max 27) for the scaffold cell seeded ant 18,5 (min 12, max 27) for the implant cell free. Progressive joints degeneration was observed in all operated joints. Anyway the degree of the joint damage was significantly lower in the joints where meniscus implantation was performed respect to the control group.
The average joint score at 12 months was 20 for the control cases, 10,5 for the implant cell seeded and 9,4 for the implant cell free.
At the histological analysis the residual scaffold with an associated foreign body response consisting of a mixed giant cell and mononuclear histiocyte infiltrate was present in all the implants. In addition to the foreign body reaction, all implants showed extensive vascularisation with an admixture of blood vessels including small muscular arteries. Cellular fibrous tissue was present in all of the implants to a degree which varied from area to area in the implant. Cartilaginous differentiation was significantly more commonly seen in the cell seeded constructs.

**CONCLUSIONS:**
The present study shows promising results concerning the biological qualities of this biomaterial. The mechanical properties of the implant should be improved. The promising results concerning more meniscus like tissue formation in the cell seeded implants confirms the important contribute of the tissue engineering of the implants.

# TISSUE ENGINEERING APPROACH FOR REPAIR OF MENISCAL RUPTURES IN THE AVASCULAR ZONE

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**Introduction**:
Meniscal ruptures in the avascular zone are nowadays mainly treated by partial or subtotal meniscectomy, however this predisposes the knee joint for osteoarthritis. Tissue engineering provides a promising approach for the repair of these defects. It has been recently shown that meniscal defects in the vascular and avascular zone can be successfully treated with progenitor cell-matrix composites, which were precultured in chondrogenic medium prior to implantation (1). It has also been shown, that it is possible to repair an avascular meniscal punch defects by using a progenitor cell-matrix composite. The goal of this study was to analyse the healing response of avascular meniscal ruptures on cell-matrix composites and the biomechanical evaluation of the induced repair tissue.

**Material and Methods:**
4mm long ruptures were inserted in the avascular zone of the lateral menisci of adult New Zealand White Rabbits. Treatment as follows: *Group A*: suture of the rupture; *Group B:* defect filling with a cell-free hyaluronan-collagen composite matrix (2); *Group C:* defect filling with a hyaluronan-collagen composite matrix loaded with mesenchymal progenitor cells, precultured in chondrogenic medium (3) for 2 weeks prior to implantation. All the composites were placed in the ruptures with a 5-0 suture. After 6 and 12 weeks, all menisci of *groups A-C* were analysed macroscopically for stability and filling. Histological analysis for the quality of the surface area, integration, cellularity and cell morphology was also done. Immunohistochemistry for proteoglycan and collagen type II was done to characterise the repair tissue. The repair tissue induced by the treatment with mesenchymal stem cells and the hyaluronan-collagen matrix was evaluated biomechanically by a strength-to-rupture test.

**Results:**
Ruptures treated with suture alone and cell-free matrices showed no healing response (*group A, B).* The defects of *group C*, which were treated with progenitor cell-matrix composites were completely filled with a stable meniscus-like tissue and the rupture was repaired. A positive proteoglycan and collagen II expression could be detected by histology and immunohistochemical analysis.
The healing response was analysed with the help of a developed macroscopic and histological based scoring system. The results showed no significant difference between the empty defects (*group A*) and the implantation of empty matrices (*group B*). In contrast, the implantation of progenitor cell-matrix composites (*group C*) produced a repair tissue of significantly higher quality than the other groups.
The strength-to-rupture test for *group C* showed nearly as good biomechanical properties of the repair tissue as the native meniscus (Fig. 2).

**Discussion:**
Tissue engineering implants of hyaluronan-collagen composite matrices loaded with mesenchymal progenitor cells showed meniscal repair in the avascular zone by the development of a completely integrated meniscus-like repair tissue. The repair tissue in the avascular meniscal defect showed stable biomechanical properties. The results of an earlier study (1), which focused on meniscal defects in the vascular/avascular zone, indicated that tissue–engineered cartilage could be used to promote meniscal repair. The role of mesenchymal progenitor cells in the healing of avascular meniscal ruptures seems to be essential.
The use of biomaterials loaded with mesenchymal progenitor cells, which have the potential to be modulated and differentiated *in vivo*, seems to be a promising approach to repair isolated avascular meniscal ruptures.

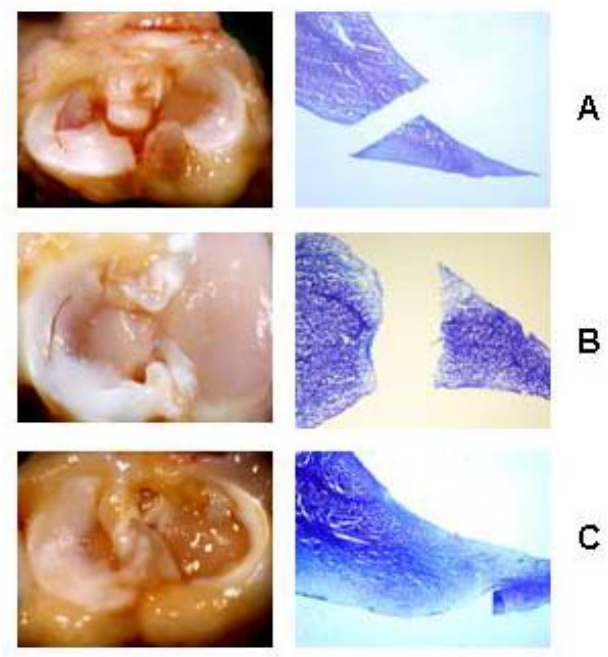


Figure 1: macroscopic and histological view of a meniscal ruptures 12 weeks after implantation treated as follows:
A: group A: suture of the rupture
B: group B: cell-free hyaluronan-collagen composite matrix
C: group C: progenitor cell-matrix composite

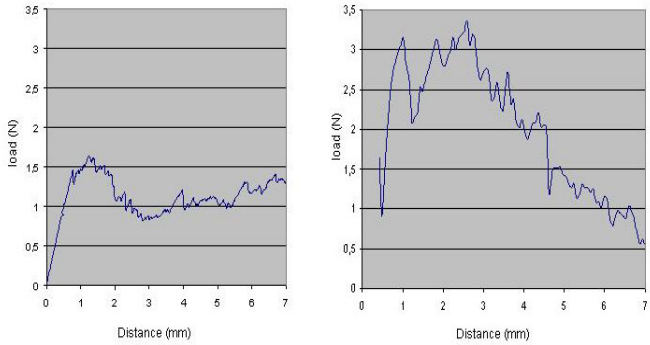


Figure 2: Results of the biomechanical analysis in a strength-to-rupture test of the repair tissue induced by a progenitor cell-matrix composite (*group C*) on the left in comparison to native meniscus on the right

Literature:
(1) Angele P. et al. Trans Orthop. Res. Soc. 605 (2000)
(2) Angele P. et al. Tissue Eng. 5: 545 (1999)
(3) Johnstone B. et al. Exp Cell Res. 238: 265-272 (1998)

# DNA FINGERPRINT ANALYSIS OF 39 POST-TRANSPLANTATION BIOPSIES

PCM Verdonk, H Van der Bracht, KF Almqvist, R Verdonk

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**Introduction:**
Cellular repopulation of the graft has been described in both human and animal post- transplantation biopsies. Animal data suggest a rapid and complete repopulation with acceptor DNA found in all biopsies taken 1 month after transplantation. To the contrary, human data obtained from deep frozen grafts show superficial and incomplete repopulation. We have investigated the DNA fingerprint profile of 39 viable meniscus allograft biopsies.

**Materials and methods:**
39 biopsies taken between 6 months and 12 years after transplantation of a viable meniscal allograft were analyzed using DNA fingerprint technology. A blood sample from the acceptor was taken as sample for acceptor DNA. The DNA fingerprint profiles of the biopsies were divided into 5 categories (complete donor DNA (1), more donor than acceptor DNA (2), as much donor as acceptor DNA (3), more acceptor than donor DNA (4), complete acceptor DNA (5)).

**Results:**
27 biopsies (69%) had complete acceptor DNA (5); 7 biopsies (18%) more acceptor than donor DNA (4), 2 biopsies (5%) had as much donor as acceptor DNA (3), 1 biopsy (3%) had more donor than acceptor DNA (2) and 2 biopsies (5%) had only donor DNA.

**Discussion:**
Our data show that donor cells are able to survive in a human viable transplanted meniscus for a long period. The authors hypothesize that the cellular repopulation process by acceptor cells is more incomplete and slower in the human model in contrast to the animal model where repopulation is forthwith.

# THE USE OF COLLAGEN MENISCUS IMPLANTATION (CMI) IN ANTERIOR CRUCIATE LIGAMENT (ACL) RECONSTRUCTION.

Pier Francesco Indelli MD, Pier Paolo Summa, Riccardo Minola.

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**Objective:**
A partial or total meniscectomy could have devastating effects on long term knee cartilage viability, especially in an ACL deficient knee. The purpose of this study was to evaluate the clinical applicability, in terms of restoring a normal knee stability, of a meniscal saving procedure, as the collagen meniscus implantation, combined with an ACL reconstruction.

**Methods:**
Eleven consecutive patients with an ACL deficient knee, a previous partial medial meniscectomy, and a neutral mechanical axis received an ACL reconstruction combined with a CMI procedure. The study group included 7 males and 6 females. Average age was 24 years (range, 22 to 29). ACL reconstruction was done with bone-patellar tendon-bone in 5 cases and quadruple-semitendinosus and gracilis in 6 cases. All patients were prospectively reviewed at 3, 6, 12, 18, and 24 months from surgery, following the IKDC and Lysholm evaluation forms. An MRI evaluation was performed in each patient at 6, 12, and 24 months from surgery. Two patients had a second look arthroscopy at 1 year from the index procedure.

**Results:**
The average Lysholm score of the eleven patients improved from a preoperative average of 55 to 85 at 2 years minimum follow-up. Seven patients were preoperatively included in IKDC group C, while 4 in group D. At follow-up 3 patients were in group A, 7 in group B, and 1 in group C. One patient had a failure of the procedure at 18 months from surgery, showing an osteolysis around the ACL tibial fixation screw and extrusion of the CMI because of size mismatching. KT-1000 evaluation at 134 Newton at follow-up, showed an average side to side difference of 1.8 mm (range, 1.5 to 2.3 mm) in 10 of 11 patients. MRI evaluation during the prospective study showed a good biological incorporation of the CMI in 10 of the 11 patients.

**Conclusions:**
This technique offers an alternative approach to classical knee stabilization procedures when a partially excised meniscus and a torn ACL co-exist in the same knee. The biomechanical characteristics of the meniscus include load distribution, shock absorption, and the improvement of joint stability. In this consecutive series, the meniscal-saving procedure appeared to be beneficial in terms of knee stability when accompanied by ACL reconstruction.

# FREEZING CAUSES CHANGES IN THE MENISCI COLLAGEN NET. A New Ultrastructural Menisci Disarray Scale.

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Alterations in meniscal permeability leading to nutritional deficit have been suggested as a cause of shrinkage in meniscal transplantation. The purpose of this study was to ascertain how freezing, one of the most common procedures used to preserve allografts, alters the collagen's architecture. Twenty-six fresh human external menisci were analyzed with transmission electron microscopy. Thirteen of them were previously frozen at -80$^{o}$ C while the rest were used as controls. A new scale of the collagen meniscal architecture was proposed according to the collagen's periodicity and degree of disruption, loss of banding, degree of collagen packing, fibril size variability and its intrafibrilar oedema. Each meniscus was scored from 0 to 7. Subsequently they were classified in grades ranging from a normal state (grade I; 0 to 2 points) to severe disarray (grade III; 5 to 7 points). The fibril collagen diameters of those menisci which had been previously frozen showed an average size in the longitudinal section of 14.26 ± 2.59 nm, whereas it was 17.28 ± 3.46 nm in the menisci used as controls ($p=0.019$). In the transverse section, the frozen menisci averaged 13.14 ± 2.99 nm and 16.93 ± 2.9 nm in the controls ($p=0.003$).

Samples of the 13 previously frozen menisci were classified as grade III in 61.54 % of the cases. In the control group, all the menisci were classified either as grade I or II. The frozen menisci averaged 4.85 points, whereas the control group did so at 2.46 ($p<0.001$). The fibril diameters in frozen menisci showed a thinner diameter and had a higher degree of disarray. Therefore, the results suggest that the freezing process alters the menisci's collagen net. This could partially explain the pathological changes found in shrunken menisci.

# MENISCAL ALLOGRAFT TRANSPLANTATION : A NEW ARTHROSCOPICALLY ASSISTED TECHNIQUE.

N. Belot, L. Panarella, P. Boisrenoult, N. Graveleau, Ch. Bussières, D. Dejour, O. Charrois, Ph. Beaufils, Ph. Neyret and the French Meniscal Transplantion Group

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Department of Orthopaedic Surgery , Livet Center, Caluire, Lyon, France

**Introduction:**
Several techniques have been described to perform an arthroscopically assisted meniscal transplantation. In most of them, bone plugs or bone blocks are used but with an accessory posteromedial or posterolateral open approach. Some techniques used an all arthroscopic approach but no bone plugs. We describe a new all arthroscopic technique with bone plugs fixation for lateral meniscus transplantation.

**Technique:**
A fresh frozen allograft is prepared with a bone plug on each meniscal horn. Anteromedial and anterolateral portals are used to prepare tibial osseous tunnels. Using a retrocutter, a blind tunnel (about 10 mm) is made respectively on posterior and anterior meniscal insertion. A suture loop is placed juste beneath popliteus tendon. Graft is inserted by anterolateral portal: posterior horn first, then meniscal rim and last anterior horn . Bone block are secured in osseous tunnels. Meniscal repair is performed using all-inside repair on medium and posterior meniscal segments. Outside-in repair is performed on anterior meniscal segment.

**Results:**
This technique has been initially performed on twelves unembalmed knees. Mean surgery time was 2 hours. Open dissection was performed to assessed position and quality of transplantation. In all but one, meniscal allograft was correctly placed in anatomical position. There was no extrusion. Peripherical meniscal suture was always considered to be correct. This technique has been chose for a clinical prospect study. One case has been performed at this day, with no operative complications and good preliminary results.

**Discussion:**
At our knowledge, our meniscal transplantation technique is the only one which associated bone plugs fixation with an all inside arthroscopic approach. New anatomical works are currently performed to describe a similar approach for medial meniscus allograft. Clinical prospective evaluation is performed too by French Meniscal Allograft Group.

# RESULTS OF THE MENISCAL TRANSPLANTATION SERIES IN ALLOGRAFTS WITHOUT BONE-BLOCKS

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## MATERIALS & METHODS

This study was carried out between May 2001 and December 2006, and the total number of Meniscal Transplants was 71.

Of this series, a study was carried out between 2001 – 2005 on a group made up of 35 Patients and 37 Meniscal Grafts, with a follow-up of between 12 and 65 months (average 38,62 months).

The studied group (35 Pats. - 37 M. Graft) had an average age of 27,26 years (range: 19-54). Regarding the sports activity, it was divided between 14 soccer players – 21 non-athletes.

Of the total number of 37 Meniscal transplants, 24 were Medial Menisci (11 Right Knees and 13 Left); and 13 were Lateral Menisci (7 Right Knees and 6 Left).

## PREOP EVALUATION

The results obtained in the preoperative evaluation were as follows:

| Lysholm Test | IKDC | VAS Scale |
|---|---|---|
| 52.25 | 44.87 | 68.71 |

## SURGICAL TECHNIQUE

The arthroscopic surgical technique performed consisted of implanting the graft, anchoring both horns, anterior and posterior, through two tunnels, one for each; and fixing the periphery of the graft to the interior part of the articular capsule by sutures applied in the anterior and the medial thirds and Fast-Fix* in the posterior third.

In the Studied Group, all the patients were operated on using a frozen allograft, the same technique was carried out in each case and the same surgeon performed the surgeries.

## POSTOP TREATMENT

The average period of immobilization with cast was 21,40 days (range: 7-40 days); the average period of partial weight bearing was 3 months (range: 1 to 6 months). The average range of movement was between 0 and 127º, and the average time away from sporting activity was of 9 months.

## RESULTS

The Postop Evaluation was as follows:

| Lysholm Test | IKDC | VAS Scale |
|---|---|---|
| 86.62 | 78.90 | 22.14 |

…while the Preop Evaluation was:

| | | |
|---|---|---|
| 52.25 | 44.87 | 68.71 |

All the patients improved their pain levels except 2, who experienced the same subjective feeling. In the functional evaluation scales similar results were obtained with improvement in 92% of cases.

## COMPLICATIONS

There were 3 failed cases from 71 surgeries performed. Of these, 2 grafts were removed, and there was 1 which suffered a Rupture of the Posterior Horn of the Medial Meniscus, requiring a resection.

## DISCUSSION

All patients improved their VAS level, except 2 who stayed the same.
All patients improved their Lysholm level except 2 who worsened slightly and 2 who remained at the same values.
Three patients worsened slightly their subjective IKDC.
None of the patients worsened in the 3 parameters evaluated.
PRGF Injections were carried out in all surgeries.

## CONCLUSIONS

The Arthroscopic Technique using Frozen Meniscal Allograft without Bone Block is a technique which reduces the morbidity associated with other procedures.

It allows results to be obtained similar to the published series, with a 75% rate of good – excellent results (Lysholm).

The most important variations between the variables were obtained when the degree of the chondral lesion was matched to the postoperatory result according to the different scales, with no significant differences with regard to age, type of activity and meniscus transplanted (medial-lateral).

The degree of the chondral lesion is the principal prognostic factor of the functional result of the transplant. With degrees III-IV the good-excellent results were reduced to 50%, while in those cases involving degree I-II they rose to 92%.

In the patients who had a lateral meniscus transplanted, a greater degree of chondral lesion was found during surgery than those having the medial meniscus transplanted.

Factors such as meniscus extrusion and the patient's profile (age-physical activity), have been observed not to have a major effect on whether the results are good or bad; the most influential factor has been the degree of the chondral lesion. Other variables must likewise be taken into account, and above all better-controlled studies be carried out with larger samples and over a longer time-span.

# CORRELATION OF EXTENT OF MENISCUS LOSS DURING MENISCECTOMY WITH CLINICAL SYMPTOMS, FUNCTION, AND ACTIVITY LEVELS

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## INTRODUCTION:

Loss of meniscus tissue leads to decreased clinical function and activity levels. However, no report has quantified the amount of meniscus tissue removed at meniscectomy and correlated meniscus tissue loss with clinical symptoms, function, and activity. We determined, prospectively, the amount of tissue loss at time of partial medial meniscectomy and then correlate extent of meniscus loss with clinical symptoms, function, and activity levels 2 years following the index meniscectomy.

## METHODS:

In a randomized controlled investigational device clinical trial (Level of Evidence I), 149 patients 18 to 60 years old underwent partial medial meniscectomy and served as controls. There were 81 acute (no prior meniscus surgery) and 68 chronic (1 to 3 prior partial meniscectomies on the involved meniscus) patients. At index surgery, size of the meniscus defect was measured using specially designed instruments, and percent of meniscus loss was calculated based on actual measurements. Patients were followed clinically for a minimum of 2 years after meniscectomy. At each follow-up, every patient completed questionnaires including Lysholm and Tegner scores to assess function and activity. Amount of meniscus tissue at index surgery was correlated with the individual domains of the Lysholm scale. Tegner index was calculated to determine the amount of lost activity regained 2 years after surgical intervention.

## RESULTS:

Two-year data were available for 127 patients (85% follow-up). There was a significant correlation between the amount of meniscus tissue remaining following the index meniscectomy and 2-year Lysholm domains of squatting ($r=0.281$, $p=0.001$), stair-climbing ($r=0.251$, $p=0.004$), and swelling ($r=0.261$, $p=0.003$). In particular, it is noteworthy that patients who had >50% of their meniscus remaining had significantly better function than patients who had <50% meniscus remaining. Patients who had worse or no improvement in pain symptoms at 2 years averaged 42% meniscus remaining, while patients who had improved pain scores had on average 51% meniscus remaining. Tegner index for patients with <50% meniscus remaining averaged 24%, and for patients with >50% meniscus remaining averaged 52% ($p=0.017$); hence, a greater amount of meniscus tissue remaining allowed patients to regain significantly more of their lost activity.

## CONCLUSIONS:

There is a significant correlation between the amount of meniscus tissue removed at meniscectomy and clinical symptoms, function, and activity 2 years after surgery. This study confirms the importance of preserving as much meniscus tissue as possible at the time of meniscus repair or meniscectomy as well as the potential positive benefits of regrowing or replacing lost meniscus tissue in order to minimize clinical symptoms that may be suggestive of early degenerative changes.

# MENISCUS TRANSPLANTATION IN AUSTRALIA

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## Introduction

The Laws governing the retrieval, processing and distribution of human tissue including blood are different in Australia to the USA such that the entities involved are to be non-profit organizations. Each State has a Bone Bank which is largely Government funded. Mortuary tissue retrieval is clean but is not sterile and all specimens must be irradiated. There is no private industry involved and therefore no industry pressure towards allograft usage or research funding.

Our regulatory authority does not approve fresh frozen dead cell grafts and special exemptions must be obtained for each meniscus transplant case. Therefore all menisci are retrieved from multi-organ live donors in a sterile fashion in an operating theatre. This is done either by my Fellow or myself because the technicians have usually changed between retrieval cases. We have a paucity of donors and thus availability of menisci. I currently have 14 menisci in the Queensland Bone Bank and some 25 cases on my waiting list for transplantation. In the last 12 months there has only been 2 retrievals in southeast Queensland. Any advice on the sterilization of mortuary-harvested menisci would be helpful.

To date I have done some 24 transplants in 23 patients over 6 years. There have been minor changes in technique in that time. Outcome has been generally good with only 1 graft failure and 2 partial tears treated by partial menisectomy.

If meniscus transplantation is to become an accepted procedure in Australia then a national standardized approach is required for issues such as harvesting, sterilization and storage, sizing, cataloguing, and availability. Maybe there needs to be standardization of these and other issues internationally and this Meniscus Transplant Study Group would be the appropriate body to make recommendations in an international forum.

## Case Presentation

A 25-year-old male presented with pain and insecurity of his right knee. Eight years previously (at age 16) he had injured his knee and had undergone ACL reconstruction. Both menisci had been torn and removed. He reinjured his knee some 7 years later and developed pain and insecurity. A revision ACL reconstruction was undertaken using a hamstring graft. Medial and lateral meniscal transplantations were performed through medial and lateral anterior and posterior arthrotomies. He continues to do well now 20 months post-operatively.