The 2006 Meniscus Transplantation Study Group

Thursday, March 23, 2006
3:00 - 6:00 PM

McCormick Place Convention Center
Room E257
Chicago, IL

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THE 2006 MENISCUS TRANSPLANTATION STUDY GROUP MEETING

Thursday, March 23, 2006, 3:00-6:00 PM
McCormick Place Convention Center, Room E257
At the 2006 American Academy of Orthopaedic Surgeons Annual Meeting, Chicago, IL

INTRODUCTION:
Kevin R. Stone, M.D., Chairman — ***3:00 - 3:10***

PRESENTATIONS:

Advances in Our Understanding of the Cell and Matrix Biology of the Meniscus: the Emerging Frontier. — ***3:11 - 3:18***; *Discussion 3:18 - 3:27*
Presented by Cahir McDevitt, Ph.D.

Tissue Engineering of a Biologic Meniscus Replacement. — ***3:28 - 3:35***; *Discussion 3:35 - 3:44*
Presented by Cristin M. Ferguson, M.D.

Tissue Engineering for Meniscus Regeneration in a Sheep Model. — ***3:45 - 3:52***; *Discussion 3:52 – 4:01*
Presented by Elizaveta Kon, M.D.

PDGF and Meniscal Allograft: Experimental Results in Sheep. — ***4:02 – 4:09***; *Discussion 4:09 – 4:18*
Meniscal Allograft: Is There a Better Technique?
Presented by Otto Campbell, M.D.

Meniscal Transplantation: Surgical Technique. — ***4:19 – 4:26***; *Discussion 4:26 – 4:35*
Presented by Ramon Cugat, M.D.

Medial and Lateral Meniscal Allograft Transplantation with Bone Bridge in Slot. — ***4:36 – 4:43***; *Discussion 4:43 – 4:52*
Presented by Jack Farr, M.D.

Meniscal Allograft Transplantation Utilizing a Femoral Distractor. — ***4:53 – 4:59***; *Discussion 4:59 – 5:08*
Presented by Jon K. Sekiya, M.D.

Meniscal Transplantation: Clinical Protocol and Preliminary Results in a Multicenter Study. — ***5:09 – 5:15***; *Discussion 5:15 – 5:24*
Presented by Juan D. Ayala Mejías, M.D.

Meniscal Allograft Transplantation: Long-Term Clinical Results with Radiological and Magnetic Resonance Imaging Correlation. — ***5:25 – 5:31***; *Discussion 5:31 – 5:40*
Presented by René Verdonk M.D., Ph.D.

MRI Measurement of the Contralateral Normal Meniscus is a Better Method of Determining Meniscal Allograft Size than Measurement of the Recipient Tibial Plateau. — ***5:41 – 5:47***; *Discussion 5:48– 6:00*
Presented by Chadwick C. Prodromos, M.D.

Tissue Engineering of a Biologic Meniscus Replacement

Cristin M. Ferguson, MD
Wake Forest University School of Medicine
Department of Orthopaedic Surgery

Hypothesis: Seeding of decellularized allograft meniscus scaffolds with differentiated meniscus fibrochondrocyte or undifferentiated stem cell populations, and growth modification using oxygen tension variation will result in the production of a metabolically active meniscus tissue regenerate that more closely approximates the biologic and mechanical function of the meniscus.

A three dimensional porous meniscus allograft scaffold fashioned using decellularization and chemical etching techniques provides an optimal environment for cell attachment, penetration, and tissue maturation. Inner and outer zones of meniscus tissue exhibit regionally distinct characteristics, and represent a source of differentiated autologous cells for meniscus regeneration that can be expanded in primary culture and seeded onto decellularized meniscus scaffolds. Alternatively, bone marrow derived mesenchymal stem cells (BM-MSCs) represent a potential source of undifferentiated autologous cells for scaffold seeding. Growth conditions adapted to more closely approximate the *in vivo* decreased oxygen tension levels of the meniscus and surrounding articular cartilage can be further applied to the seeded scaffold *ex vivo* to regulate growth and production of extracellular matrix components such as collagens and proteoglycans. This approach also probes the self-selection process in that only those cells capable of surviving nutrient (i.e. oxygen) deficient levels will persist within the scaffold at low oxygen tension.

Methods:

Creation and characterization of a three dimensional acellular collagen meniscus scaffold. Decellularization of fresh whole rabbit meniscus explants will be performed using cell lysis techniques followed by chemical etching of the extracellular matrix to create a porous scaffold optimized for cell attachment, penetration, and tissue maturation. "Chemical etching" of the extracellular matrix will be performed to modify the architecture of the acellular scaffold and allow for improved cellular penetration and in-growth. Scaffolds will be analyzed using histology, scanning electron microscopy, and DNA quantification to confirm acellularity and characterize the porous network of the scaffold. Mechanical testing will be performed.

Characterize the growth potential of two different meniscus cell types for scaffold seeding, differentiated fibrochondrocytes and undifferentiated adult mesenchymal stem cells, when exposed to variable oxygen tension levels.

Cell culture: Primary rabbit meniscus fibrochondrocyte cultures and rabbit BM-MSC cultures will be obtained through methods well described in the published literature.
Cell seeding: Matrices will be equilibrated in growth media using DMEM supplemented with 10% FBS and 0.1% penicillin/streptomycin and maintained at 37^{o}C in a humidified atmosphere with 5% CO_2. Primary rabbit meniscus fibrochondrocytes from inner or outer zone culture groups or BM-MSCs will be seeded onto the collagen meniscus matrices at a concentration of 1-4 x 10^5 cells per mm^3 of matrix and allowed to grow and attach for three days, the completion of seeding defines the 0 week time point.
Oxygen tension: Seeded matrices will be grown in (A-Control) 20% O_2 + 5% CO_2 + 75% N_2 or (B-Oxygen deprived) 10% O_2 + 5% CO_2 + 85% N_2 or (C-Oxygen deprived) 1% O_2 + 5% CO_2 + 94% N_2 environments [22].
Analysis: Seeded matrices will be harvested at 2 and 5 week culture time points for real time RT-PCR analysis, *in situ* hybridization, immunohistochemistry, proliferation assays, and biomechanical testing.

Summary: The proposed research will investigate the molecular response of meniscus fibrochondrocytes and BM-MSCs cultivated on decellularized collagen meniscus scaffolds under conditions of variable oxygen tension. The findings from these studies will characterize the proliferation, matrix production, and angiogenesis responses as well as mechanical properties of the tissue engineered meniscus replacement construct. Improved technologies to address meniscus deficiencies will allow orthopaedic physicians to limit the disabilities caused by irreparable meniscus tears.

Tissue Engineering for Meniscus Regeneration in a Sheep Model

E. Kon[1], M. Delcogliano[1], G. Filardo[1], C. Chiari-Grisar[2], S. Nehrer[2], L. Ambrosio[3], D. Salter[4], E. Tognana[5] and M. Marcacci[1]

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 GRD1-2001-40401 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: Twelve sheep (right stifle joints) were treated with total meniscus replacements. Six of those received a total meniscus replacement with the implant of the scaffold seeded whit autologous articular chondrocytes while the others six sheep were treated whit the implant of the empty scaffold. . The animals received a plaster cast for 5 days. The animals were euthanized after 4 months. 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) (Fig. 2). All of the joints were compared with the non-operated ones and evaluated with 'joint changes score' (min 48, max 0).

Results: A mild swelling, due to the thickening of joint capsule, was noted 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.

Conclusion: 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 tissue formation and its meniscus-like properties and also the role of the cell will have to be confirmed in future long-term animal studies actually ongoing.

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[1]Istituto Ortopedico Rizzoli,
Via Di Barbiano 1/10, Bologna 40136, Italy
[2]Department of Orthopaedics, Medical University of Vienna,
Waehringer Guertel 18-20, A-1090 Vienna, Austria
[3]Institute of Composite and Biomedical Materials – IMCB-CNR, and Interdisciplinary Research Centre in Biomaterials, University of Naples "Federico II", Piazzale Tecchio 80, 80125 Naples, Italy
[4]Department of Pathology, Edinburgh University Medical School,
Teviot Place, Edinburgh EH8 9AG, UK
[5] Fidia Advanced Biopolymers s.r.l.
Via Ponte della Fabbrica 3/B, 35031 Abano Terme (PD), Italy

PDGF and Meniscal allograft: Experimental Results in Sheep

Otto A. Campbell MD*, Cesar Morales Trevizo MD*, Edmundo Berumen MD*, Arturo Aguirre Madrid MD*, Ricardo Fierro Murga MD**
*Christus Muguerza del Parque
**Chihuahua Chih. México.

The aim of this study was to evaluate the effects of PDGF gel on meniscus allografts in sheep, using fresh frozen allografts. For this study we use 8 six months Peliguey sheep between 35 and 40 kilograms; We divide them in two groups of 4 sheep each.

We perform medial meniscal allograft transplantation with out bone plugs in both groups, but we add PDGF gel in group 2. The transplanted knees were evaluated macroscopic and microscopically at 2 and 4 months.

Although we find evident integration on both groups at 2 and 4 months, we noted that group 1 (without PDGF) presented more shrinking than those meniscal allografts in group 2 (with PDGF) an that this shrinking was statistically significant ($p= 0.002178$) ; while group 2 presented no statistical shrinking ($p= 0.1817$), finally the shrinking among group 1 versus group 2 presented a statistical difference ($p=0.01443$).

The articular surface of those allografts done with PDGF showed les fibrotic reaction than those in group 1, but there was more cellularity in the meniscus and with a more normal like pattern than those of group 1. Also we find that there was more neovascular formation in group 2(with PDGF).

This study demonstrates that PDGF may have an important role in the adequate meniscal allograft transplantation, leading to less meniscal shrinking and avoiding an excessive inflammatory response causing less fibrotic reaction with a better cellular repopulation in the allograft.

There is need of a bigger and longer study to determine better the results of this procedure.

Meniscal allograft: Is There a Better Technique?

Otto Campbell*, Edmundo Berumen, David Chung***, Arturo Aguirre Madrid**.**
* Fourth year Orthopaedic resident. Hospital Clinica del Parque; Chihuahua México.
* * Orthopaedic Surgeon, Hospital Clínica del Parque, Chihuahua México
*** Orthopaedic Surgeon, Guadalajara México.

Introduction: This study represents the first case series of meniscal allograft documented in México, since October 2002 to July 2005. We evaluated 42 meniscal allografts done in 40 patients using two techniques: Arthroscopically assisted with bone plugs in 14 patients and pure arthroscopic with out bone plugs in 28 patients.

Material and Methods: There was 40 patients (21 males, 19 females) with a 37.7 average age.(range 18 to 54 years), with history of a previous meniscectomy having pain in the effected side.

Results: This study presents the ISK scale and EVA scale results from the comparation of the meniscal allograft done with bone plugs (EVA diminution of 3.03, and ISK improvement of 3.8 points) and with out bone plugs (EVA diminution of 3.37, and ISK improvement of 3.22 points). Showing similar results in both groups at 3, 6, 12 and 24 months of follow up.

Also we compare the clinical results of those meniscal allografts done with Outerbridge I and II chondromalacia vs. Outerbridge III and IV chondromalacia showing that the improvement obtained in the Outerbridge III and IV (EVA diminution of 4.67, ISK diminution of 2.87) group was slightly better than in the first group(EVA diminution of 2.33, ISK diminution of 2.065) , meaning that probably the meniscal allograft it has a role in the treatment of a very damage knee, acting as a biological implant with minimal invasion to the knee and preserving it from pain until a definitive procedure is done.

We also compared the result of those knees operated from a meniscal allograft simultaneously with a realignment osteotomy (EVA disminution of 3.20 and ISK improvement of 4.41 points) vs. those with meniscal allograft done only (EVA disminution of 3.13 and ISK improvement of 3.98 points) , finding similar results in both groups.

And those knees with concomitant LCA reconstruction and meniscal allograft (EVA disminution of 3.3 and ISK improvements of 3.16) vs. meniscal allograft alone (EVA disminution of 3.47, and ISK improvement of 3.3) at 12 months.

Discussion: The results from this study suggest that meniscal allograft is another option in the Orthopedic surgeon arsenal when dealing with pain in a previously menisecomized knee. It also puts in the air the question about its utility related with the chondromalacia grade of severity. And give us the opportunity of a less aggressive treatment of a knee in the young people that probably would need another surgery with time. Also rise up the question about the importance of the use or not of bone plugs with the allograft, the results are interesting.

The use of the meniscus as a biological implant could be another alternative to the use of an osteotomy for the treatment and prevention of a unicompartmental arthrosis, making the future total knee replacement easier and with less morbidity.

We do not yet know the long term results in meniscal allografts, the literature is promising with its indications, but these are changing constantly and dramatically in the way that we have more studies and experience, after all, only the time will give us the answer.

Meniscal Transplantation: Surgical Technique

Ramon Cugat, MD* **, **Xavier Cuscó MD, Montserrat García MD, Gonzalo Samitier MD, Roberto Seijas MD *, Pedro Álvarez MD, Marta Rius MD, Gilbert Steinbacher MD ****
*Clínica del Pilar. Office #18#. C. Balmes, 271. 08006-Barcelona-Spain
**Mutualidad de futbolistas. Rda. S. Pedro, 19-21. Barcelona-Spain
e-mail: ramon.cugat@sportrauma.com

The following surgical technique was developed after doing an anatomical study during the period January 2000 – April 2001, of frozen specimens in the Laboratory of the Anatomy Department of the Medical School of the University of Barcelona. The objective was to be able to carry out the least aggressive arthroscopic surgical technique possible. Frozen meniscal allograft without bone blocks in either horn, is always used.

INDICATIONS: The meniscal transplant can be carried out when all the following conditions are present:
1 previous meniscectomy
2 femoro-tibial axes are aligned
3 age lower than 50 years
4 pain

SURGICAL TECHNIQUE:
1. **Preparation of the meniscal graft** for transplant: It is important that the meniscal graft is unfrozen slowly at room temperature and in sterile conditions in order to maintain the degree of flexibility of the tissue. To do this, the process should be started about two hours before beginning the surgical procedure.

Two threads of Vycril No. 1, each of 20-25 cm in length, are attached to each one of the meniscal horns: anterior and posterior.

A perpendicular suture of reabsorbable thread is placed in the postero-medial corner of the medial meniscus or in the postero-lateral corner of the lateral meniscus.

From this side until the anterior horn along the medial and the anterior third, 4 or 5 perpendicular stitches are placed. It is important that the threads are of different colors to facilitate later identification during suturing.

2. **Arthroscopic exam** of the joint. The surgery is carried out under epidural anesthesia and tourniquet.

3. **Bleeding of the parameniscal area** which is to receive the meniscal graft.

4. **Drilling of 2 tibial tunnels** which are used to attach the anterior and posterior meniscal horns. For this, the tibial guide of the anterior cruciate ligament surgery and a cannulated drill of 4.5 mm. (Endobuton®) are used.

If the meniscus transplanted is the medial, the location of these tunnels is the following: the posterior tunnel is posterior to the medial tibial tubercle and anterior to the posterior cruciate ligament. This area receives the name of "insertion of the posterior ligament of the medial meniscus".

The anterior tunnel is anterior to the tibial insertion of the anterior cruciate ligament and posterior to the intermeniscal ligament.

The external entrance of the tibial guide is located in the lateral side of the tibia.
And if the meniscus transplanted is the lateral, the location of the tunnels is as follows: the posterior tunnel is posterior to the tibial insertion of the anterior cruciate ligament.
The anterior tunnel is anterior and lateral to the tibial insertion of the anterior cruciate ligament.
The external entrance of the tibial guide is located in the medial side of the tibia.

5. **Introduction of 2 threads** of Vycril No 1 through both tibial tunnels posterior and anterior. The posterior is made to emerge from the inside of the joint through the approach AL or AM, depending on whether the graft to be transplanted is the medial meniscus or the lateral meniscus using a grasping. Then this Vycril No 1 is tied from the thread anchored to the posterior horn and is pulled from the end which is at the antero-medial or antero-lateral side of the tibia. In this way the meniscal graft is slipped and placed inside of the knee.

6. **Fixation of the postero-medial or postero-lateral corners.** The knee should be at 30º flexion and in valgus angle. Two spinal needles are introduced through the postero-medial or postero-lateral corner, depending whether it is the medial or lateral meniscus transplanted. One of them is placed in the lower side of the meniscus or the tibial plateau and the other is in the upper meniscal side. Through these are introduced two threads of PDS No.1 which will exit through the PA portal and will be sutured with the threads placed at the corners (see point 1).

7. **Adaptation of the meniscal graft over the tibial plateau** is started from the posterior joint area to the anterior, in order to make firm the graft to the joint capsule and can be carried out when:
- The threads of the posterior tunnel and posterior horn are tied together and
- The PDS of the capsule postero-medial or postero-lateral corner are sutured to both PDS of the postero-medial or postero-lateral corner of the meniscal graft.

Both threads, the posterior and the corner, should be tensed at the same time in order to place the graft in the correct place and avoid that it twists.

8. Before starting the suturing, the correct placement of the graft is checked.

9. **Suturing.** All the stitches are carried out in the same way: location from the outside of the capsular site which coincides with a meniscal suture. This is carried out using the Arthropierce® forceps in order to withdraw the thread of the meniscal suture. The lower thread is always removed first and then the upper. When all the threads are outside the knee they can be sutured to the capsule.

The meniscal area of the posterior horn which has not received any stitches is attached to the posterior capsule with 2 or 3 Fast-Fix® in-in sutures.

Once the meniscus is sutured it is important to check if another stitch is necessary. If this is the case, this stitch must be out-in.

10. **Horns Anchored**. Finally, the Vycril No 1 thread from the anterior tibial tunnel is tied to the Vycril No 1 of the anterior horn and is pulled from the medial-anterior side of the tibia. In this area both threads of Vycril No 1 are sutured to each other, leaving both meniscal horns anchored.

11. **PRGF Infiltration** is carried out inside the knee before performing the skin suture.

12. **Skin Suture**.

13. Compressive bandage with knee in extension.

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Medial and Lateral Meniscal Allograft Transplantation With Bone Bridge in Slot

Jack Farr, MD
OrthoIndy
Orthopaedic Research Foundation, Inc.
5255 East Stop 11 Road, Suite 300
Indianapolis, Indiana 46237

INTRODUCTION: Since reported in 1989 by Milachowski, various techniques have been devised for meniscal allograft transplantation (MAT). The goal of MAT is to recreate the function of the original meniscus both biologically and biomechanically. From a biomechanical standpoint, Howell and associates have demonstrated in vitro the importance of bony attachment to the horn sites in the correct anatomic position. To accomplish this biomechanical goal, several techniques have evolved with a bone bridge recommended only for the lateral compartment. One technique uses a bone bridge in a slot inserted with an arthroscopically assisted approach reproducing horn position and bridge slope. Unlike in prior series, the current series uses the bone bridge for both medial and lateral transplants.

METHODS: We report on a subset of 108 MAT performed between 1999 and 2005 at our institution using the bridge in slot technique. Fifty-nine males and 23 female patients with 82 meniscal transplants have more than one year follow up. The average age is 34.7 +/- 10.2 with the average number of surgeries prior to the transplant 3.1 ranging from 1 to 9. There were 57 medial, 22 lateral and 3 bicompartmental meniscal transplants. Concomitant surgeries were performed in over 50% of the patients including articular cartilage restoration, unloading osteotomy, and anterior cruciate ligament reconstruction. We compare pre and post operative scores for 70 of the 82 patients with Lysholm, visual analog pain scales of rest pain and maximal pain and modified Cincinnati scores. The comparisons pre to post op are: Lysholm 59 to 83, rest pain 2.8 to 1.1, maximal pain 7.4 to 4.2 and patient Modified Cincinnati score 4.1 to 6.6.

RESULTS: There were no statistical differences in outcomes of medial compared to lateral meniscal transplants.

CONCLUSIONS: This data suggests use of bone bridge for the medical meniscus transplantation may warrant further investigation.

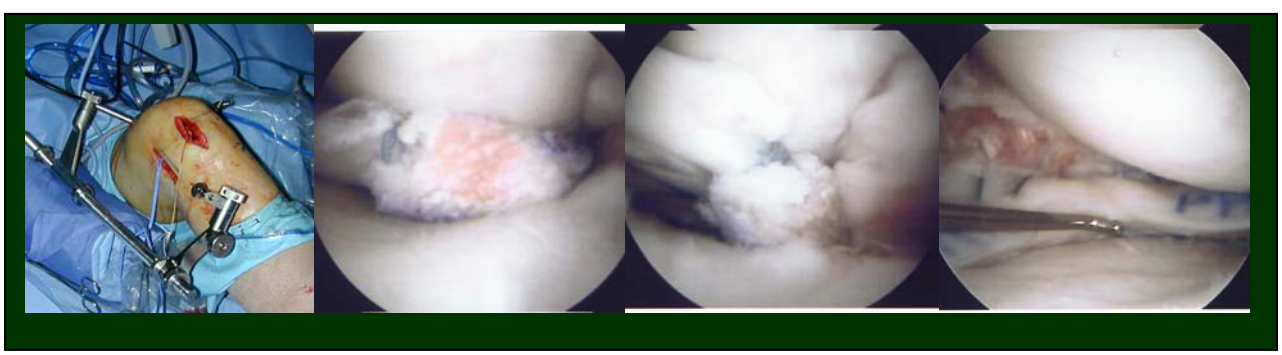
Meniscal Allograft Transplantation Utilizing a Femoral Distractor

Christopher A. Kurtz MD, Kevin F. Bonner MD, Jon K. Sekiya MD

INTRODUCTION: Meniscal allograft transplantation is a technically difficult surgical procedure to perform. Of particular difficulty is allograft graft passage and fixation, particular using a posterior bone plug for medial transplants. In addition, circumferential superior and inferior surface vertical mattress sutures for peripheral fixation is essential for graft healing and restoration of function. We developed a technique utilizing a femoral distractor placed proximal and distal to our surgical site which has significantly improved our involved compartment visualization and opening, allowing for ease of graft passage including the posterior bone plug as well as circumferential meniscal allograft repair using inside-out placed sutures.

SURGICAL TECHNIQUE: The patient is placed supine on the operating room table with a bump at the end of the table to hold the knee in 90 degrees of flexion and a lateral post placed at the level of the tourniquet. Arthroscopy is performed to verify meniscal deficiency and prepare the native compartment to receive the allograft. A medial or lateral parapatellar arthrotomy, depending on the side of transplantation, is performed and the femoral distractor is placed on the involved side. An accessory posterolateral or posteromedial incision is made to assist with suture passage. A corresponding lateral bone trough hugging the ACL medially (lateral transplant) or 2 bone tunnels placed at the anatomic attachments of the medial meniscus (medial transplant) are prepared and the meniscal allograft is passed into the respective compartment with the femoral distractor utilized to open up the involved joint. Sutures affixed to the lateral bone bridge or medial bone plugs are passed into their respective trough or tunnels and fixed, securing the allograft to the anatomic insertion sites of the native meniscus. Combined open sutures are placed through the parapatellar arthrotomy and arthroscopically placed inside-out sutures are placed for secure peripheral fixation. A standard closure and post-operative protocol is followed.

DISCUSSION: In summary, meniscus allograft transplantation can be a demanding operation with clinical outcome intimately tied to the technical accuracy of the operating surgeon. The authors have performed 21 meniscus transplantations with the aid of the femoral distractor. Of these, 12 have been medial and 9 have been lateral. Four have been performed in conjunction with ACL reconstructions. Two have been performed in conjunction with fresh osteochondral allograft transplantation. One was performed with a concomitant high tibial osteotomy. In all cases, joint visualization and access posed no difficulty. In summary, the femoral distractor is a simple yet markedly effective tool that can simplify some of the more daunting aspects of the procedure including tunnel placement, graft passage, and peripheral suture fixation.



Meniscal Transplantation: Clinic Protocol and Preliminary Results in a Multicenter Study

J.D. Ayala Mejías[1], L. Alcocer[1], A. Estévez[2], R. Canosa[3], C. Gavín[3], C. Vidal [4]
[1]Hospital ASEPEYO. Coslada. Madrid
[2]Clínica Nuestra Sra. De América. Madrid
[3]Hospital Fundación Alcorcón. Madrid
[4]Hospital 12 de Octubre. Madrid

INTRODUCTION: Meniscal allograft transplantation surgery is significantly increasing because is becoming a good alternative for previously excised meniscus, the so-called "postmeniscectomy syndrome". We here endeavour to unify the criteria of indications, surgical technique, preoperatory and postoperatory management protocol. We also present our preliminary clinical results.

INDICATIONS: Total meniscectomy, body and posterior horn; age: < 55 y-o.; sports and physical activities; local untreatable pain; no instability (?); normal axial limb alignment (?); Outerbridge I and II grade (III, IV?)

MATERIAL AND METHODS:
15 cases (4 rejected < 12 m f/u)
OR Nov. 2001 – Nov. 2004
Mean F/U (months) = 13.6; r(8,22)
Activity level: Strenuous 42%; moderate 29%; sedentary 29%
Sports level: moderate 43%; none 29%; competition 14%; unknown 14%
Male 81%; Female 19%
Months post-meniscectomy: 35 (2 – 90)
Nº of previous arthroscopies: 2.3 (1-5)
Tibial plateau measurements (mean): donor 35 mm x 49 mm; patient 32 mm x 46 mm
Associated procedures: ACL 2; PCL 1; HTO 1
Outerbridge: femoral condoyle grade 0 (27%); I (19%); II (39%); III (15%); tibial plateau grade 0 (37%); I (23%); II (30%); III (10%)

RESULTS: IKDC: subjective assessment: symptoms and sports pre-op (38.27); post-op (48.72). Lysholm pre-op/post-op (45/65.75); Tegner pre-op/post-op (4.5/3.5)
2 revision arthroscopy: 1 arthrofibrosis (4th month) and 1 infection vs. immunologic response (11th month).
Revision MRI: Revision MRI (12 cases): 12 peripherally healed; 6 body and/or anterior horn extruded; 10 intrasubstance degeneration

CONCLUSIONS: Even though there have been a large number of publications on this subject over the last few years, there are rather few ones aiming at unification of the various diverging trends, at least in our country. Although our preliminary results are good, larger follow up results are needed.

Meniscal Allograft Transplantation: Long-Term Clinical Results with Radiological and Magnetic Resonance Imaging Correlations

Verdonk PCM, Almqvist KF, Veys EM*, Verbruggen G*, Verdonk R
*Department of Orthopaedic Surgery, Ghent University Hospital, Belgium
Department of Rheumatology, Ghent University Hospital, Belgium

INTRODUCTION: Long term data on the clinical outcome and the fate of the meniscus allograft after transplantation are scarce. In this study we present the clinical, radiological and MRI outcome of the meniscus graft and the articular cartilage after forty-two meniscus allograft transplantations in 41 patients with a minimum follow-up of 10 years.

METHODS: A total of 27 medial and 15 lateral meniscal allografts were transplanted. Eleven of the medial allograft procedures were associated with a high tibial osteotomy. The patients were evaluated clinically at the time of transplantation and at the final follow-up using the modified HSS scoring system. The KOOS score was used as an evaluation tool for patient-related outcome at the final follow-up. Joint space width narrowing and Fairbank changes were radiological outcome parameters, which were available for 32 patients. Femoral and tibial cartilage degeneration, graft extrusion and signal intensity were scored on MRI scans obtained in 17 patients approximately one year after transplantation and at the final follow-up (>10 years). For statistical analysis the patients were divided into 3 groups: lateral meniscal allograft (LMT), medial meniscal allograft transplantation with a high tibial osteotomy (MMT+HTO) and without (MMT).

RESULTS: The modified HSS score revealed a significant improvement in pain and function at the final follow-up for all groups. Further analysis also revealed that an MMT+HTO procedure resulted in a greater improvement at the final follow-up when compared to MMT. Nonetheless, the KOOS scores obtained at the final follow-up revealed the presence of substantial disability and symptoms, in addition to a reduced quality of life. Radiographical analysis revealed no further joint space narrowing in 13/32 knees (41%). Fairbank changes remained stable in 9/32 knees (28%). MRI analysis showed no progression of cartilage degeneration in 6/17 knees (35%). An increased signal intensity of the allograft was present, as was partial graft extrusion in the majority of patients at the final follow-up. Seven cases had to be converted to a total knee arthroplasty during the follow-up; the overall failure rate was 18%.

CONCLUSION: Long-term results after viable meniscus allograft transplantation are encouraging in terms of pain relief and improvement of function. Despite this significant improvement, substantial disability and symptoms were present in all investigated subgroups. Progression of further cartilage degeneration or joint space narrowing was absent in an unexpected number of cases, indicating a potential chondroprotective effect.

MRI Measurement of the Contralateral Normal Meniscus is a Better Method of Determining Meniscal Allograft Size than Measurement of the Recipient Tibial Plateau

Chadwick C. Prodromos MD, Brian T. Joyce BA, Brett L. Keller BS, BA Brian J. Murphy MD

INTRODUCTION: Currently menisci for transplantation are sized using plain radiographic measurements of the proximal tibia. We have found this method to be often grossly inaccurate with low inter-observer reliability. We have further found that this method can dramatically overestimate the size of the needed meniscus. In particular the measurements of the sagittal radiographs from which the anterior-posterior meniscal dimensions are estimated is subject to great inter-observer variability. This is because there are no clear landmarks on the proximal tibia from which to measure, and because small rotational differences can significantly effect measurements. While some have reported good results with Meniscal Allograft Transplantation (MAT) in arthritic knees, others have reported that in such knees the meniscus tends to fail and extrude out of the knee: as would be the case if the meniscus were oversized. MRI measurement of the patient's contralateral intact meniscus offers a potentially more accurate method to determine ipsilateral meniscal size. This has not been adopted as a sizing method because it has been widely stated, without evidence, that menisci are not bilaterally symmetric and the one study using MRI to size menisci reported poor accuracy. We hypothesized that 1) menisci are indeed bilaterally symmetric, 2) extrapolations from tibial plateau x-ray measurements do not accurately predict meniscal size; 3) MRI can accurately measure meniscal size; and 4) MRI measurement of a contralateral intact meniscus is a significantly more accurate method of meniscal allograft sizing than extrapolating meniscal size from radiographic measurements of the recipient tibial plateau.

METHODS: Part I: Symmetry: We obtained meniscal size data for 500 left/right pairs of cadaveric knees from Allosource Tissue Bank in Denver and calculated the size difference between menisci for each pair.
Part II: Sizing: We then obtained 10 cadaveric knees with intact menisci. We measured the maximum frontal and sagittal dimension of each meniscus directly and by MRI. We also used radiographs of the tibial plateau to predict meniscal size indirectly as is universally done in clinical practice. We then compared radiographic, MRI and actual meniscal dimensions.

RESULTS: Part I: Symmetry: We found that 97% of the menisci had sagittal and frontal dimensions that were within 3mm of the contralateral meniscus.
Part II: Sizing: For the 10 cadaveric knees we found MRI's to have an average error rate of 5%, versus 14.5% ($p=0.019$) for the radiographic method in measuring actual meniscal size.

CONCLUSIONS: Contrary to what has been promulgated, human knee menisci are indeed bilaterally symmetric. Also MRI is capable of measuring meniscal dimensions with a high degree of accuracy. MRI of the contralateral intact meniscus is a significantly more accurate method of assessing meniscal size than extrapolating meniscal size indirectly from plain radiographic measurements of the recipient tibial plateau. The currently used sizing system may be partly responsible for the increased failure rate from extruded, and perhaps oversized, menisci in arthritic knees. While MAT has had generally high success rates, we believe that the more accurate sizing method described above may help improve clinical results.