Meniscal Allograft Replacement: A 1-Year to 6-Year Experience

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Purpose: Progressive degenerative arthritis leading to premature pain and functional loss in the postmeniscectomy state is a well-recognized and debilitating condition. Meniscal allograft replacement may be a suitable, early treatment alternative for this population at risk. The purpose of this study was to examine the potential benefits of meniscal allograft replacement on relieving pain and restoring function. **Type of Study:** Retrospective clinical review. **Methods:** From 1993 to 1999, 29 menisci were implanted in 28 patients. Of these, 25 patients (26 menisci) were available for review. All patients had a minimum of 12 months of follow-up, with an average of 33 months. Study participants included 17 men and 8 women with primary symptoms of pain or instability at study onset. Eighteen patients had grades I through III Outerbridge chondromalacia changes and 7 demonstrated grade IV changes in the affected compartment. Data were collected using the International Knee Documentation Committee (IKDC), Lysholm II, and Tegner scoring systems as well as a visual analogue scale (VAS) for pain measurement. **Results:** Our findings revealed that following meniscal allograft replacement, pain was significantly reduced and function was improved ($P < .001$). In addition, IKDC scores for activity were reported as normal or nearly normal in 17 subjects and abnormal in 8 participants. Outerbridge grade had a significant impact on final outcome; only 3 of 7 with grade IV changes achieved normal or nearly normal scores versus 14 of 18 in those with lesser Outerbridge changes. Isolated implants fared the same as those combined with an ACL reconstruction. Overall satisfaction reported by the subjects averaged 83%. Ten second-look procedures revealed 5 normal menisci, 3 with shrinkage, and 2 with recurrent tears. **Conclusions:** Earlier results from this population of patients indicated substantial pain relief and improved function. The durability of these early results has not met the test of time for those with exposed subchondral bone. However, statistically significant early and midterm improvements in pain, symptoms, and functional status continue to be noteworthy in the properly selected patient. **Key Words:** Meniscus—Allograft—Transplant.

Premature, progressive articular cartilage degeneration following loss of meniscal tissue is well established.[1-7] Furthermore, the risk of postmeniscectomy arthritis remains a function of the amount of tissue resected.[8,9] Over the past 20 years, considerable effort has been directed at repairing, regenerating, or replacing the damaged meniscus,[10-16] including fibrin clot, fascial sheaths, tissue "welding," and "ingrowth" scaffolding accompanied by a deluge of new instruments and implants designed to facilitate repair. Milachowski et al.[17] are credited with implanting the first meniscal allograft in 1984. Since then, thousands of allografts have been performed worldwide, with several studies attesting to the early benefits of pain relief.[18-23] This clinical review seeks answers to several questions. First, can allograft replacement effectively improve visual analogue scale (VAS), Lysholm II, Tegner, and International Knee Documentation Committee (IKDC) scores? Second, are VAS, Lysholm II, Tegner, and IKDC scores related to (1) Outerbridge grade, (2) medial versus lateral allografts, (3) concomitant anterior cruciate ligament (ACL) reconstruction, (4) gender, (5) Workers' Compensation status, and (6) interval to surgery?

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METHODS

Between 1993 and 1999, 29 menisci were implanted in 28 patients. Twenty-five (89%) patients with 26 implanted allografts were available for review. In this retrospective review, 23 patients were evaluated in the office, and 3 completed a questionnaire and responded to telephone interviews. The office evaluation consisted of an interval history, physical examination, radiographic or magnetic resonance imaging (MRI) studies when indicated, and completion of study instruments. Seventeen men and 8 women comprised the study group. One male participant underwent bilateral lateral replacements. Ages ranged from 15 years to 49 years, with the average age 34.5 (standard deviation [SD] = 8.5). The minimum follow-up was 12 months with the longest follow-up of 72 and a mean of 33 months. Sixteen lateral and 10 medial allografts were implanted, and 12 patients also underwent a concomitant ACL reconstruction. Seven of the participants were Workers' Compensation patients. Minor debridement and partial synovectomies accompanied many of the allograft transplants.

Instruments

Study instruments included the VAS (visual analogue scale with ratings of 1-10), Lysholm II survey, Tegner functional rating, the IKDC activity rating, and a subjective satisfaction scale (from 0% to 100%). Data were analyzed using the paired-samples *t* test, χ-square, and analysis of variance (ANOVA), with the Scheffe test for post hoc comparisons as indicated. Statistical significance was set at the $P < .05$.

Technique

The principal investigator performed all 26 meniscal implants. Medial meniscal allografts were implanted using separate anterior and posterior tunnels, and lateral implants consisted of the meniscus and a single bone bridge. Initially, an osteotomy of the medial epicondyle was required and subsequently altered to an intra-articular sectioning of the posterior fibers of the deep medial collateral ligament (MCL). This technique provided excellent visualization and access to the posterior compartment. Bone anchors were initially used to secure the bone blocks, but current technique simply requires sutures secured over a bone bridge. An inside-out suturing technique was employed, using accessory posteromedial and posterolateral incisions. The menisci were sutured with nonabsorbable 2-0 suture at the periphery, with absorbable suture used at the popliteal hiatus and at the joint level of the MCL in an effort to avoid entrapping tissue.

Postoperative treatment consisted of immobilization in full extension with progressive weight-bearing over 4 to 5 weeks. Range of motion from 0° to 90° was encouraged for the first month, followed by a gradual increase in flexion of 10° to 15° each week beginning in week 5. If a concomitant ACL was performed, the ACL protocol was subordinated to the meniscal allograft requirements.

TABLE 1. *Means and Standard Deviation for VAS, Lysholm, and Tegner Scores*

	Preoperative	Postoperative	t (*P* values)
VAS	6.21 (1.83)	1.98 (1.20)	12.40* (.000)
Lysholm	61.58 (10.70)	85.42 (11.13)	−14.48* (.000)
Tegner	1.69 (1.01)	4.42 (1.35)	−14.33* (.000)

NOTE. n = 26.
Abbreviation: VAS, visual analogue scale.
*$P < .05$, two-tailed.

RESULTS

Significant Findings

Preoperative Versus Postoperative Status: Results displayed in Table 1 show statistical significance ($P < .001$) in postoperative scores using VAS, Lysholm II, and Tegner functional grading systems. Pain scores decreased from an average of 6.21 to an average of 1.98, whereas Lysholm II scores rose from 62 to 85. Tegner scores reflected an average increase from 1.7 to 4.4. (A level-4 activity would include moderately heavy work such as truck driving with recreational activities such as jogging on a level surface at least twice a week, cycling, or cross country skiing.)

Effect of Outerbridge Grade on Outcome: As a measurement of arthritic change in the affected compartment, subjects were assigned an Outerbridge grade I through IV, with grade IV indicating exposed subchondral bone. No subjects were assigned grade I. Forty-two percent of the subjects (n = 11) were assigned grade II, 31% (n = 8) grade III, and 27% (n = 7) met grade IV criteria. As illustrated in Table 2, chondromalacia grade was significant for postoperative VAS and for preoperative to postoperative Lysholm scores. Further analysis using the Scheffe posthoc comparison test revealed that VAS scores were significant between grades II and IV ($P = .15$) and grades III and IV ($P = .043$). This was also evident on

TABLE 2. *Effect of Outerbridge Grade on Outcomes*

	VAS M	Preop SD	VAS M	Postop SD	Lysholm M	Preop SD	Lysholm M	Postop SD	Tegner M	Preop SD	Tegner M	Postop SD
Grade												
II (n = 11)	5.68	1.85	1.45	0.82	65.55	8.55	90.36	7.54	2.00	1.00	4.64	1.63
III (n = 8)	7.07	1.02	1.65	0.85	64.71	6.63	88.71	2.75	1.86	0.90	4.93	0.84
IV (n = 7)	6.19	2.25	3.00	1.36	53.38	12.48	75.75	14.10	1.13	1.00	3.69	1.10
(*P* value)	1.25	(.304)	5.08*	(.009)	4.31*	(.026)	6.27*	(.007)	2.01	(.156)	1.94	(.167)

Abbreviations: VAS, visual analogue scale; Preop, preoperative; Postop, postoperative; M, mean; SD, standard deviation.
*$P < .05$, two-tailed.

Lysholm II measurements between grades II and IV ($P = .13$) and grades III and IV ($P = .030$).

Workers' Compensation Versus Non-Workers' Compensation: Seven patients had sustained work-related injuries and required a meniscal replacement. As might be anticipated, collectively this small subgroup had significantly higher postoperative VAS scores (more pain), lower pretest Lysholm II scores, and corresponding lower post-test Lysholm scores (Table 3). Although not statistically significant with the Tegner functional scoring, the pretest Tegner scores tended to be low in nearly all patients, whereas post-test Tegner scores in all patients may have reflected a lack of confidence. This may have been compounded by the well-recognized "secondary gain" phenomenon commonly witnessed in patients on Workers' Compensation.

International Knee Documentation Committee Activity Rating: Using the IKDC activity rating system, 17 of 25 subjects (68%) rated their activity level as normal or nearly normal. The Outerbridge chondromalacia grade demonstrated a significant impact on the final activity rating. Only 3 of 7 (43%) patients with grade IV changes were rated normal or nearly normal, compared with 14 of 18 (78%) subjects with grade II or III chondromalacia wear.

Nonsignificant Results

Isolated Implant Versus Combined ACL Reconstruction: Patients with combined instability and

TABLE 3. *VAS, Lysholm, and Tegner ANOVA Results by Isolated Versus ACL, Medial Versus Lateral, Gender, and Workers' Compensation Status*

	VAS M	Preop SD	VAS M	Postop SD	Lysholm M	Preop SD	Lysholm M	Postop SD	Tegner M	Preop SD	Tegner M	Postop SD
Isolated *v* ACL												
Isolated (n = 12)	6.41	1.44	2.08	1.56	59.08	8.43	85.83	10.28	1.58	1.24	4.67	1.35
ACL (n = 14)	6.04	2.15	1.89	0.84	63.71	12.23	85.07	12.19	1.79	0.80	4.21	1.37
F (*P* value)	0.27	(.608)	0.16	(.696)	1.22	(.280)	0.30	(.866)	0.25	(.621)	0.71	(.407)
Medial *v* Lateral												
Medial (n = 10)	6.55	1.21	2.05	1.36	58.40	10.14	84.30	15.01	1.80	1.03	4.50	1.35
Lateral (n = 16)	6.00	2.14	1.94	1.13	63.56	10.87	86.12	8.36	1.63	1.02	4.37	1.40
F (*P* value)	0.54	(.468)	0.05	(.822)	1.46	(.239)	0.16	(.693)	0.18	(.676)	0.50	(.824)
Gender												
Male (n = 18)	5.75	1.92	1.92	1.30	64.44	9.18	87.06	8.29	1.83	1.04	4.53	1.38
Female (n = 8)	7.25	1.10	2.12	1.02	55.13	11.65	81.75	15.93	1.38	0.92	4.19	1.36
F (*P* value)	4.18	(.052)	0.16	(.692)	4.84*	(.038)	1.27	(.271)	1.15	(.295)	0.34	(.565)
Workers' Compensation												
Yes (n = 7)	7.36	0.69	3.07	1.37	53.86	10.64	76.29	14.50	1.00	1.00	3.64	1.10
No (n = 19)	5.79	1.95	1.58	0.87	64.42	9.47	88.79	7.59	1.94	0.91	4.71	1.37
F (*P* value)	4.22	(.051)	11.01*	(.003)	5.97*	(.022)	8.35*	(.008)	5.26*	(.031)	3.50	(.074)

Abbreviations: VAS, visual analogue scale; ANOVA, analysis of variance; ACL, anterior cruciate ligament; Preop, preoperative; Postop, postoperative; M, mean; SD, standard deviation.
*$P < .05$, two-tailed.

pain did not fare better than those requiring an isolated implant. The pretest and post-test Tegner score comparisons revealed a P value of .182, and pretest and post-test Lysholm II comparisons yielded a P value of .886 (Table 3).

Medial Versus Lateral, Gender, and Interval to Surgery: Whether the medial or lateral meniscus was replaced had no effect on the final result. Likewise, gender was not statistically significant. Because details of the index and preceding operations were difficult to pinpoint with precision, the interval from the index surgery to the meniscal allograft replacement was arbitrarily ranked as either meniscal transplant within 10 years of the original surgery or meniscal transplant more than 10 years after the initial meniscectomy. The actual interval failed to demonstrate significance.

Radiographic Findings

Comprehensive radiographic analysis was challenging because differing techniques were used and some preoperative films were not available for comparison. If the clear space loss was categorized into three groups: minimal or less than 1 mm, greater than 1 but less than 3 mm, and greater than 3 mm of narrowing, the following was observed: Of patients with a minimum of 2 years' follow-up, 8 had radiographic studies that could be compared. Of these 8, 5 had essentially no change, 2 had greater than 1 but less than 2 mm of loss, and 1 patient had nearly 4 mm of narrowing. One of the 2 with slight narrowing experienced clinical failure as did the patient with nearly 4 mm of joint space loss. This patient had grade IV changes and uncorrected preoperative valgus and clearly was an inappropriate candidate.

Complications

There were no infections or neurovascular complications. Six patients experienced effusions that resolved within 6 weeks, and 2 patients required aspirations for resolution. At second-look arthroscopy, of the 10 menisci, 5 appeared normal, 3 had some degree of shrinkage, and 2 had recurrent tearing. Interestingly, the recurrent tears were not at the periphery, but rather were located within the body of the meniscus, corresponding to areas of chondral irregularity. One patient undergoing a combined ACL reconstruction and meniscal transplant required a manipulation and lysis of adhesions.

DISCUSSION

Numerous studies have highlighted the variable tasks required of the meniscus, including shock-absorption, lubrication, nutrition, and enhanced knee stability.[2,7,24-27] The renewed appreciation of meniscal tissue has led to greater efforts to preserve, salvage, or replace torn menisci. This investigation focuses on meniscal allograft replacement as a potential early treatment alternative for patients who sustained significant meniscal tissue loss.

Basic science and biomechanical studies have helped researchers determine that allografts heal at the periphery,[18,28,29] are repopulated with viable host cells (although at lower cellular density),[30] generally provoke a subclinical immune response,[29,31,32] maintain a viable collagen content,[29] and are much less prone to shrinkage if cryopreserved rather than freeze-dried.[21,32] Furthermore, several investigators have emphasized that the meniscal allograft should be implanted with bone anchors to achieve the presumed goal of load-sharing.[33,34] Whether the allografts actually prevent or delay postmeniscectomy arthritis continues to be controversial.[35-37] At least 1 animal study refutes the efficacy of immediate meniscal replacement in preventing subsequent degenerative arthritis.[38]

Several investigators have reported on the early benefits of meniscal allograft replacement, primarily derived from pain relief and improved functional level.[18-20,22,23] These same studies have reported a low complication rate and some positive early radiographic stabilization. At least 1 study has yielded results that were uniformly distressing.[39] Our experience to date has yielded optimistic outcomes when measured with standard study instruments such as the Lysholm and Tegner rating criteria. Clearly, the preoperative and postoperative results validate the allografts as a valuable intervention. Furthermore, Outerbridge changes impact the final result, as might be predicted. Loss of congruency leads to abnormal meniscal forces and eventual failure. Therefore, although many patients experienced an early and promising pattern, with time, patients with grade IV exposed subchondral bone fared more poorly than those with lesser changes.

The lack of statistical significance in pretest and post-test Tegner scores was initially puzzling, but may be better understood in the context of patient confidence and fear of recurrent symptoms given the considerable time and emotional investment they had in the allograft procedure. Although pain and functional symptoms had abated, they appeared less willing to "challenge" their knees, and we believe this is reflected in the lower than anticipated post-test Tegner scores. This was further magnified in the Workers' Compensation subgroup, in whom "secondary gain" may have also influenced the final rating.

One might have anticipated a greater perceived benefit in patients undergoing a combined meniscal allograft and ACL reconstruction. Statistically, however, this was not borne out. One possible explanation may derive from the self-imposed activity modification many of these patients described. In several instances, these patients had undergone meniscectomy with the ACL left untreated except through activity modification and bracing. Modifying the risk of the pivot shift potential distilled the symptoms to the pain following meniscectomy rather than instability. However, when queried, these patients clearly recalled their instability as a disabling condition.

The lack of statistical significance associated with the interval before surgery is probably best explained by individual activity modification. The length of time from the initial surgery, although a factor alone, is much less meaningful than the activity level based on frequency, intensity, and duration. Clearly, an individual who self-selects into a less demanding lifestyle experiences less chondral erosion despite a longer interval than the person who continues with unabated impact sports.

We recognize the inherent flaws with a retrospective study lacking a control group. However, we also maintain that a historical control may suffice in that we are all aware of and recognize the certainty of premature degenerative articular cartilage loss in the meniscectomized patient.[1,3,5,39,40] We also recognize that it would be disingenuous to allow that pain relief and functional improvement are equal to normal meniscal function. Longer-term follow-up focusing on arthroscopic and radiographic assessment will eventually unlock the secret of whether or not the implanted allograft maintains its intended function.

When contemplating a meniscal transplant, the ideal candidate is the younger patient (under 45 years of age) with normal weight-bearing alignment,[18-22] Outerbridge grades of I or II, ACL stable, compliant, and experiencing some pain. The great dilemma lies in deciding when to intervene, because many patients who have undergone a subtotal meniscectomy may function quite well before their inexorable decline in knee function, potentially eclipsing their suitability for a transplant. In our opinion, patient education is of paramount importance. Using historical models to alert patients to the long-term consequences of meniscal tissue loss and making them aware of treatment alternatives, combined with a yearly or biannual evaluation, may prevent the "late comer" whose wear pattern is beyond the scope of meniscal replacement.

In summary, meniscal allograft replacement is a desirable alternative in a select group of individuals facing the prospect of premature degenerative arthritis following meniscectomy. That these allografts heal, repopulate, and maintain a collagen matrix while helping diminish pain and improve function continues to be established. Whether these allografts continue to provide durable, protective meniscal function will hopefully be answered as this early patient population continues to be treated and evaluated over time.

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