Clinical Outcomes Following Isolated Lateral Meniscal Allograft Transplantation

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Purpose: The purpose of our study was to determine the clinical outcomes following isolated lateral meniscal allograft transplantation. **Methods:** Thirty-two patients were retrospectively reviewed following isolated lateral meniscal allograft transplantation. Twenty-five were available for subjective follow-up, and 17 were available for a complete physical examination and postoperative radiographs. The average duration of follow-up was 3.3 years (range, 2 to 6 years), and the average age of the subjects was 30 years (range, 19 to 45 years). In all, 17 patients had bony fixation and 8 had suture fixation of the anterior and posterior horns of the meniscal allograft. **Results:** Ninety-six percent of patients believed that their overall function and activity level were improved following surgery. Short Form-36 (SF-36) physical and mental component summary scores for these subjects were higher than age- and sex-matched scores from the US population. Joint space narrowing of the transplanted lateral compartments was not significantly different when compared with the joint space narrowing of the lateral compartment of the contralateral knee. In addition, preoperative and postoperative radiographic joint space measurements of the involved lateral compartment were significantly associated with subjective assessment, symptoms, sports activity score, Lysholm score, and final International Knee Documentation Committee (IKDC) rating at latest follow-up. Finally, patients fixed with the bony technique had significantly better range of motion, according to IKDC criteria at latest follow-up, compared with the suture fixation group. **Conclusions:** Our results suggest that isolated meniscal allograft transplantation can be a beneficial procedure in properly selected symptomatic patients with a lateral meniscus–deficient knee. The data also suggest that earlier meniscal transplantation, before the onset of significant joint space narrowing, may result in improved outcomes. Finally, bony fixation may have a significant advantage over suture fixation, particularly with regard to knee range of motion. **Level of Evidence:** Level IV, therapeutic case series. **Key Words:** Lateral meniscus—Arthritis—Transplant—Allograft.

T. J. Fairbank was credited as the first to describe the predictable degenerative changes following meniscectomy in 1948.[1] Since then, numerous studies have elucidated the important role of the meniscus in load transmission and joint stability.[2-5] In the past, total or subtotal meniscectomy was routinely performed for documented or suspected meniscal disease. More recently, meniscal preservation is usually attempted whenever possible with the use of standard repair techniques; if the tear is irreparable, minimal or partial resection of the torn portion only is recommended.[5] Nonetheless, circumstances remain in which subtotal or total meniscectomy is the only option, usually because of extensive meniscal damage and degeneration. Although a small subset of these patients with meniscus-deficient knees may do reasonably well, many others have persistent compartmental

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symptoms with progressive degeneration of the affected compartment and joint space narrowing.[1,6,7]

It has been our experience that patients who have undergone lateral meniscectomy do worse clinically than those who have undergone medial meniscectomy, and several clinical studies in the literature corroborate this finding.[8,9] In addition, the degenerative changes noted following lateral meniscectomy are often more rapid than those seen following medial meniscectomy.[1] These findings may in part result from the fact that the lateral compartment has fewer congruent articular surfaces and these articular surfaces undergo a greater degree of translation than the medial compartment. In addition, up to 60% of the load across the knee is transmitted through the menisci, with the lateral meniscus playing a more critical role than the medial meniscus.[4]

Treatment options for this difficult problem are somewhat limited. Realignment procedures, including tibial or distal femoral osteotomy, are reasonable surgical options when lower extremity malalignment is present, particularly if the patient is bearing weight through his or her meniscus-deficient compartment. Recently, meniscal transplantation has emerged as a potential surgical option for replacing the absent meniscus with allograft tissue.

Several clinical and basic science studies have been conducted since the first meniscal transplant was performed by Milachowski in 1984, and these studies have greatly contributed to our understanding of this treatment modality.[10-20] Unfortunately, most clinical studies that concern meniscal allograft transplantation are combined with other surgical interventions, most commonly anterior cruciate ligament (ACL) reconstruction or osteotomy.[19-22]

In addition, controversy exists as to the appropriate method of fixation for the meniscal allograft. A significant body of knowledge suggests that fixation of the meniscal allograft with bone attached to the anterior and posterior horns provides superior stability and is a necessary requirement for a successful outcome.[11,23,24] Others suggest that bony fixation of the anterior and posterior horns is unnecessary, and that suture fixation through transosseous tunnels and creation of a peripheral vascularized trough to receive the meniscal insertions are sufficient for allograft healing and restoration of function.[25]

The purpose of this study was to determine patient-reported and clinical outcomes following isolated lateral meniscal allograft transplantation with a minimum of 2 years' follow-up in a select group of patients with symptoms secondary to a previous lateral meniscectomy. Our hypothesis was that following this procedure, patients would experience relief of symptoms with satisfactory patient-reported and clinical outcomes. A secondary goal of this study was to determine the effects of preoperative and postoperative joint space narrowing on patient-reported and clinical outcomes following isolated lateral meniscal allograft transplantation.

METHODS

Between 1993 and 1998, 32 patients underwent isolated lateral meniscal allograft transplantation. Of these, 25 patients could be located for follow-up. All 25 patients completed the subjective forms, 20 were available for postoperative radiographs, and 17 underwent complete follow-up with examination and radiographs. The average duration of follow-up was 3.3 years (range, 2 to 6 years). The group studied consisted of 16 males and 9 females with an average age of 30 years (range, 19 to 45 years) at the time of surgery. Patients averaged 2.4 surgical procedures (range, 1 to 4) before undergoing transplantation. The average interval between initial injury and meniscal transplantation was 5.7 years (range, 9 months to 26 years). Informed consent was obtained at the time of participation in this retrospective research study, and the study was approved by our institutional review board for biomedical research.

Preoperative Considerations

Indications for Meniscal Transplantation: Criteria used in our series to select patients for the procedure included patient-reported (i.e., pain referable to the lateral knee compartment) and clinical measures (i.e., articular cartilage status, focal lateral joint line pain, mechanical alignment). Although no formal age limitations were stated, typical patients were "younger" individuals who had undergone a previous lateral meniscectomy. All patients described persistent joint line or compartmental pain during activities of daily living and/or sports, had failed a trial of conservative therapy, and thus were considered good candidates for meniscal allograft transplantation. Patients with symptoms of instability and an ACL-deficient or a previously ACL-reconstructed knee were excluded from this study.

Preoperatively, all patients had 45° posteroanterior (PA) flexion weight-bearing, lateral, and Merchant view radiographs.[26] If the joint space was less than 2 mm on either film, the patient was not considered a candidate for transplantation because of the presence of advanced degenerative arthritis. In a number of

cases, we could not completely assess the status of the articular cartilage radiographically and deferred our final assessment to diagnostic arthroscopy. Most patients had grade II and small (less than 1 cm^2) focal areas of grade III or IV chondrosis. Large areas of grade III and grade IV chondrosis discovered at the time of arthroscopy precluded patients from undergoing isolated meniscal transplantation. Patients with "kissing lesions" of the tibial plateau and the femoral condyle were also excluded from the study (Fig 1).

Donor/Recipient Matching: Meniscal allografts were sized on the basis of preoperative lateral and PA radiographic measurements.[27,28] We used a single tissue bank for all patients included in the study (Cryolife, Atlanta, GA). All tissues were sterilely harvested and cryopreserved at −80°C. None of the grafts was irradiated, and appropriate screening was performed for all meniscal allografts.

Surgical Technique

Our technique for lateral meniscal transplantation has been previously described.[19,20] An examination under anesthesia was performed in all cases to document knee range of motion and stability. Arthroscopy was then performed and the degree of meniscus deficiency and the condition of the articular cartilage were assessed in the involved lateral compartment. Patients with previous subtotal or total meniscectomies and isolated chondral lesions were considered candidates for a meniscal transplantation. If the knee was considered appropriate for meniscal transplantation, the meniscal allograft was thawed and reconstituted according to standard protocol.

FIGURE 1. A small lateral parapatellar arthrotomy was utilized for graft passage and open suture fixation of the anterior aspect of the meniscal allograft. Note that the transosseous sutures that were used to secure the bone bridge into the trough are also used to assist with graft passage.

The involved posterior horn and the body of the native meniscus were trimmed to provide a fresh bleeding surface to which the meniscal allograft could be repaired. A small lateral parapatellar arthrotomy was used for graft passage and open suture fixation of the anterior aspect of the meniscal allograft (Fig 1). The anterior horn of the native meniscus was trimmed to a fresh, bleeding rim. A small posterolateral approach to the knee was performed to expose the joint line for later meniscus repair.

Before 1994, lateral meniscal allografts were transplanted with the use of individual bone plugs for the anterior and posterior horns. This was the case for 5 patients included in this study. In 1994, the technique was modified to include use of a bone bridge instead of individual bone plugs because of the close proximity of the anterior and posterior horns (average, 8 mm; range, 6 to 10 mm).[29] This was the case for most of our lateral meniscal transplants (12 patients), in which a trough was created in the lateral tibial plateau and the bone bridge attached to the anterior and posterior horns was fixed into the trough by means of transosseous suture fixation.

For 8 of our patients, no bony fixation was used and the anterior and posterior horns of the lateral meniscal allograft were secured with No. 2 braided nonabsorbable suture passed through transosseous tunnels to their anatomic insertion sites after a circumferential osseocancellous trough had been created. The anterior horn of the transplanted meniscus was then sutured to the native meniscus with No. 0 braided, nonabsorbable sutures placed through the arthrotomy. The remaining meniscal allograft was then secured with the use of arthroscopic inside-out techniques. All wounds were copiously irrigated with antibiotic solution and closed in standard fashion. The patient was placed in a compression dressing with a continuous cooling device, and a hinged-knee brace was locked in extension.

These 3 techniques that were used for the transplantation were not randomized. Before 1994, 2 bone plugs were used for the transplantation. After 1994, the 2 primary surgeons modified their techniques. One of these surgeons used the all–soft tissue method, and the other used the bony trough technique.

Postoperative Management

Postoperatively, all patients followed a standardized rehabilitation program.[30] Immediately after surgery, patients began quadriceps sets, straight leg raises, and calf pumps. Twenty-four hours after surgery, passive range of motion with a continuous passive motion (CPM) machine was begun and continued for 1 month. Goals for range of motion were to achieve full knee extension symmetrical to the noninvolved side within 1 week and 90° of flexion within 4 to 6 weeks. Immediately after surgery, patients were restricted to partial weight bearing with crutches with the brace locked in full extension. After 1 week, weight bearing was progressed to weight bearing as tolerated. Crutches were discontinued 4 to 6 weeks after surgery, provided the patient had full knee extension without a quadriceps lag, 90° to 100° of knee flexion, and minimal swelling, and was able to walk without a bent-knee gait. Rehabilitation continued for 2 to 3 months with an emphasis on restoring full motion and strength. Closed chain exercises were initiated 6 weeks after surgery from 0° to 45° and were gradually progressed to 75° of flexion. Low-impact aerobic activities (walking, cycling, swimming) were initiated after 8 weeks. Patients returned to sedentary work after 1 week and to strenuous work after 5 to 6 months. Patients were allowed to return to running after 5 to 6 months, and to light and moderate sports after 6 to 9 months. Return to strenuous sports was not recommended.

Follow-up Evaluation

Twenty-five of 32 patients were available for follow-up. Seventeen of these patients returned to the clinic for a comprehensive physical and radiographic examination. All patients completed several specific and general patient-reported measures of health-related quality of life. Specific measures of health status included the Lysholm Knee Score[31] and the Knee Outcome Survey.[32] The Short Form-36 (SF-36)[33] was used as a measure of general health status.

The Lysholm Knee Score is a measure of symptoms and functional limitations that was originally developed for patients with ACL injuries but has subsequently been applied to individuals with a variety of knee problems, including meniscectomy and meniscus repair. The Lysholm Knee Score ranges from 0 to 100 points and is interpreted as excellent for >94 points, good for 84 to 94, fair for 65 to 83, and poor for <65 points.[31]

The Knee Outcome Survey is a knee-specific measure of symptoms and functional limitations that has been developed for individuals with a variety of knee problems, including meniscal injuries. The Knee Outcome Survey consists of 2 separate scales. The Activities of Daily Living Scale (ADLS) includes items related to symptoms and functional limitations experienced during activities of daily living; the Sports Activity Scale (SAS) consists of items related to symptoms and functional limitations commonly experienced during sports activities. Each scale is scored from 0 to 100, with 100 representing the absence of symptoms and higher levels of function.

The SF-36 is a general health status measure that is applicable to diverse populations of individuals with a variety of disorders and disease states. The SF-36 consists of 8 scales, including physical function, role limitations due to physical problems, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems, and mental health. The 8 scale scores can be combined into physical and mental component summary scores. The SF-36 has been used to measure general health status for patients with a variety of orthopaedic conditions, including ACL reconstruction[34] and meniscus transplantation.[35]

Follow-up examination was performed by a physical therapist and a physician who was not involved in performing the surgery; it included assessments of swelling, crepitus, range of motion, stability, and functional strength. Crepitus of the patellofemoral, medial, and lateral compartments and swelling were graded by palpation as present or absent. Range of motion was measured with a goniometer, and side-to-side differences for extension and flexion were calculated.

The examination for laxity included Lachman's, pivot-shift, and anterior and posterior drawer tests, as well as tests for anterolateral rotatory, posterolateral rotatory, and varus/valgus laxity. Laxity was graded relative to the contralateral side according to International Knee Documentation Committee (IKDC) guidelines as normal (<2 mm side-to-side difference), nearly normal (3 to 5 mm side-to-side difference), abnormal (6 to 10 mm side-to-side difference), or severely abnormal (>10 mm side-to-side difference).

Functional testing was also performed; this included the single leg hop and vertical jump tests. Both lower extremities were tested, and the results were expressed as a percentage of the noninvolved side.

Radiographs were obtained on the return visit and were compared with those obtained preoperatively. These included PA 45° flexion weight-bearing, lateral, Merchant, and long cassette views. The medial and lateral joint spaces of both knees were measured on

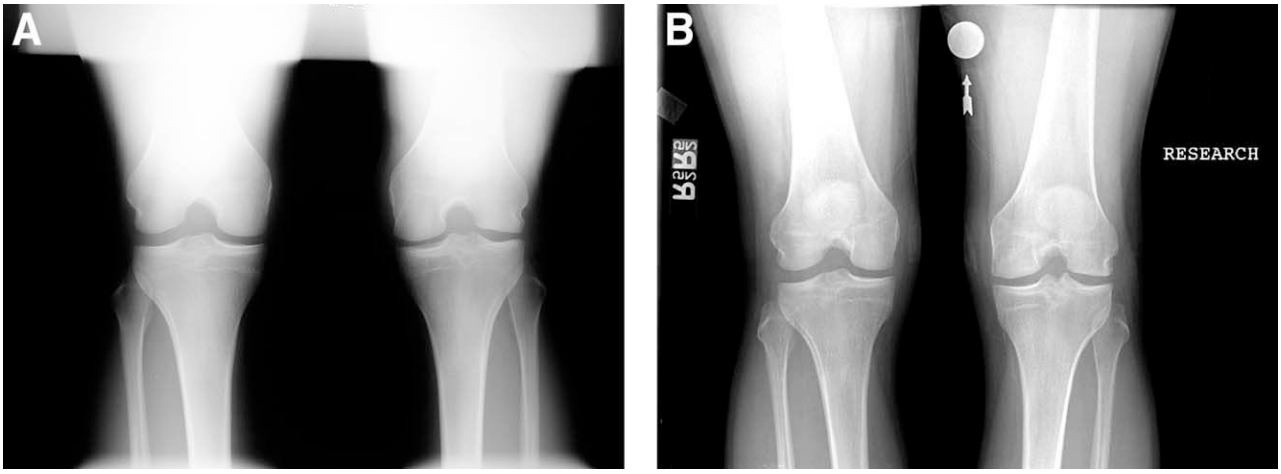

Figure 2. Preoperative and latest follow-up posteroanterior flexion weight-bearing radiographs in a 24-year-old male (at the time of index surgery) undergoing a left knee (the knee on the right) lateral meniscal allograft transplantation. (A) Preoperative radiographs. (B) Radiographs obtained at latest follow-up 3 years after the index procedure. The transplanted lateral compartment joint space increased by 1 mm over time compared with the lateral compartment of the noninvolved knee, which showed no change over time. Although differences in magnification may account for some differences in measurement, use of the contralateral knee as a control prevents this variation from introducing any errors into our analysis.

the PA 45° flexion weight-bearing views with a digital micrometer rounded off to the nearest millimeter. In addition, both preoperative and follow-up radiographs were staged according to IKDC radiographic criteria. This allowed for a comparison of joint space narrowing and IKDC radiographic staging over time with respect to the noninvolved knee (Fig 2).

In addition to the IKDC ligament examination and x-ray findings already mentioned, IKDC scores were generated for the categories of subjective assessment, symptoms, range of motion, and laxity, and an overall IKDC score was calculated.

Data Management and Analysis

Descriptive statistics, including frequencies for categorical variables and means and standard deviations for continuous variables, were calculated. To determine the effects of bony versus suture fixation techniques used during lateral meniscal allograft transplantation, we used an independent *t* test for continuous outcome measures and chi-squared tests for categorical outcome measures. A dependent *t* test was used to evaluate changes in joint space from before surgery to follow-up. Pearson's correlation coefficients were calculated to determine the relationship between joint space narrowing and patient-reported and clinical outcome measurements.

RESULTS

Patient-Reported Results

IKDC Subjective Assessment: The IKDC subjective evaluation showed that 5 patients were normal, 15 were nearly normal, 4 were abnormal, and 1 was severely abnormal regarding level of function. In terms of current activity level, 10 patients reported a normal level of activity, 10 reported a nearly normal level of activity, 4 had an abnormal level of activity, and 1 reported that level of activity was severely abnormal. No difference was noted between suture and bony fixation of the meniscal transplant for either knee function or current activity level ($P = .26$ and .35, respectively).

Patients' subjective assessments of function and current activity level were combined according to IKDC guidelines to create an IKDC group rating for subjective assessment (Table 1). No difference was noted between suture and bony fixation of the meniscal transplant with regard to overall subjective assessment ($P = .54$).

Symptoms: Symptoms were graded according to the highest level of activity (strenuous, moderate, light, or sedentary) that the patient could perform without significant pain, swelling, or instability. Relatively few patients had symptoms during activities of daily living (ADL). On the basis of the IKDC assessment of symptoms, 83% of patients had no pain or

Table 1. *Summary of IKDC Results*

Category	A	B	C	D
Subjective assessment	5	15	3	2
Symptoms	4	4	12	5
Range of motion	0	5	9	2
Ligament examination (overall)	12	4	1	0
Overall evaluation	0	4	6	7

NOTE. A, normal; B, nearly normal; C, abnormal; D, severely abnormal.

swelling during ADL, and 92% had no episodes of instability during ADL. Forty-two percent of patients could participate in moderate or strenuous sports without pain, 38% could participate without swelling, and 67% could participate in these activities without instability. No difference was observed between suture and bony fixation of the meniscal transplant with regard to pain ($P = .79$), swelling ($P = .78$), partial giving way ($P = .53$), or complete giving way ($P = .65$).

The highest levels of activity without significant pain, swelling, or instability were combined according to the IKDC guidelines to create a group rating for symptoms (Table 1).

Lysholm and Knee Outcome Survey (ADLS and SAS): Knee-specific measures of health status following lateral meniscal transplantation included the ADLS, the SAS, and the Lysholm Knee Scale. In general, patients had higher levels of function during activities of daily living than during sports activities. Scores were reported as follows: ADLS, 79.6; SAS, 74.9; and Lysholm Knee Scale, 79.3. No difference was seen between suture and bony fixation of the meniscal transplant with regard to Lysholm ($P = .86$), ADLS ($P = .88$), or SAS ($P = .77$) scores.

SF-36 Scores: SF-36 results are reported in Table 2. To compare the SF-36 scores with age- and sex-matched US population norms, standard scores (i.e., z-scores) were created for each individual by subtracting the age- and sex-matched population average from the individual's score, and then dividing by the age- and sex-matched population standard deviation. As shown in Table 2, a score of 0.32 for General Health indicates that following isolated lateral meniscal transplantation, individuals are on average approximately 32% of a standard deviation above their age- and sex-matched population scores for that category. Review of the 8 SF-36 scale scores suggests that overall, patients are functioning physically, mentally, and socially at high levels. No difference was observed between suture and bony fixation of the meniscal transplant with regard to all 8 SF-36 categories ($P > .34$).

Physical and mental component summary scores are transformed scores that combine the 8 SF-36 scale scores into 2 scores that represent physical and mental function, respectively. In the US population, these scores have a mean of 50 and a standard deviation of 10. The average physical component summary score for these patients was 51.0 ± 8.7, and the average mental component summary score was 53.8 ± 7.0. No differences were noted between suture and bony fixation of the meniscal transplant with regard to physical ($P = .96$) and mental ($P = .81$) component summary scores.

Overall Self-Rating: Patients were asked to rate their degree of change in overall function and activity level from before surgery to the current follow-up on a 7-point ordinal scale that ranged from greatly better to greatly worse. Overall, 13 patients stated that they were "greatly better," 7 were "somewhat better," 4 were "slightly better," and 1 patient reported a "somewhat worse" condition as a result of the surgery. No difference was seen between suture and bony fixation of the meniscal transplant with regard to patients' overall self-rating of change in function and activity level from before surgery to current follow-up ($P = .59$).

Clinical Results

Seventeen patients underwent physical and radiographic examination, along with a series of functional

Table 2. *SF-36 and Standardized SF-36 Scores*

Category	SF-36 Score*	Standardized SF-36 Score†
Physical function	83.9 (18.8)‡	−0.62 (1.5)
Role limitation due to physical problems	84.4 (32.0)	−0.19 (1.3)
Bodily pain	78.7 (21.7)	−0.08 (1.0)
General health	83.0 (15.5)	0.32 (0.95)
Vitality	67.3 (16.9)	0.22 (0.92)
Social function	9.1 (15.4)	0.30 (0.76)
Role limitations due to emotional problems	88.9 (30.6)	0.20 (0.97)
Mental health	80.3 (10.7)	0.33 (0.63)

*Scores for individual domains of SF-36. Each score ranges from 0 to 100 with 100 representing optimal health.

†SF-36 score standardized to age- and sex-matched US population norms for each individual patient.

‡Values represent means (standard deviations).

tests. The results of these objective parameters are as follows.

Range of Motion: The average loss of flexion compared with the noninvolved knee was 10° ± 8°. Average loss of extension compared with the noninvolved knee was 4° ± 4°. A significant difference was observed between suture and bony fixation of the meniscal transplant with regard to loss of passive knee extension, with the bony fixation group having better extension (average, 4°) compared with the suture fixation group ($P = .03$).

The IKDC group rating for range of motion is presented in Table 1. A significant difference was noted between suture and bony fixation of the meniscal transplant with regard to overall IKDC range of motion score, with the bony fixation group having better motion than the suture fixation group ($P = .01$).

Stability Testing: Knee stability was assessed according to IKDC guidelines; 14 patients had a normal Lachman's (0 to 2 mm side-to-side difference), 2 had a nearly normal Lachman's (3 to 5 mm side-to-side difference), and 1 had an abnormal Lachman's test result (6 to 10 mm side-to-side difference). For the pivot-shift test, 14 patients had a normal result; 2 had a nearly normal (1+ glide) pivot-shift and 1 had an abnormal (2+ clunk) pivot-shift. Seventeen patients had a normal posterior sag test, and 15 of 16 patients had normal lateral and medial joint space opening, respectively, with stress testing.

The results of each of the laxity tests were combined according to IKDC guidelines to create an IKDC laxity group rating (Table 1). No difference was seen between suture and bony fixation of the meniscal transplant with regard to the IKDC laxity group rating ($P = .81$).

Functional Testing: Single leg hop and vertical jump tests were performed for assessment of functional strength. Expressed as a percentage of the noninvolved leg, the single leg hop and vertical jump averaged 91% ± 18% (range, 27% to 110%) and 85% ± 21% (range, 17% to 106%), respectively. No difference was observed between suture and bony fixation of the meniscal transplant with regard to single leg hop or vertical jump tests ($P = .79$ and 0.70, respectively).

Radiographic Evaluation: All patients were evaluated with preoperative radiographs, and 20 patients had postoperative radiographs obtained at latest follow-up. Preoperatively, the involved (transplanted) lateral compartment averaged 3.70 mm, compared with 3.65 mm at latest follow-up. The uninvolved (contralateral, nontransplanted) lateral compartment averaged 6.32 mm preoperatively and 6.15 mm at latest follow-up. A statistically significant difference was noted in the joint space measurement between involved and uninvolved (contralateral, nontransplanted) lateral compartments preoperatively and at latest follow-up ($P < .0001$ for both).

Table 3. *IKDC Radiographic Results*

Category	A	B	C	D
Involved lateral compartment, preoperative	2	9	5	4
Involved lateral compartment, latest follow-up	1	10	6	3
Group rating, preoperative	2	9	5	4
Group rating, latest follow-up	1	9	6	4

NOTE. A, normal; B, nearly normal; C, abnormal; D, severely abnormal.

An average of 0.17 mm of joint space narrowing of the involved (transplanted) lateral compartment was seen from preoperative radiographs to those obtained at latest follow-up. Compared with an average joint space narrowing of 0.24 mm in the uninvolved (contralateral, nontransplanted) lateral compartment, no statistically significant difference was noted ($P = .48$). No difference was observed between suture and bony fixation of the meniscal transplant with regard to joint space narrowing over time of the involved lateral compartment ($P = .17$).

The involved (transplanted) lateral compartment was rated according to IKDC radiographic criteria, both preoperatively and at latest follow-up (Table 3). The IKDC radiographic group rating was also calculated for the involved (transplanted) knee preoperatively and at latest follow-up (Table 3). This group rating takes the worst rating of the 2 compartments (medial and lateral—patellofemoral was not included) as the overall score.

Final IKDC Assessment: Because the final IKDC rating combines information from the patient's self-report and findings from the physical examination, we were able to calculate the final IKDC rating for only those 17 patients who returned for the physical examination (Table 1).

Correlation of Patient-Reported and Clinical Outcome With Radiographic Findings: We calculated Pearson's correlation coefficients to determine the relationship between joint space of the involved lateral compartment before surgery and at latest follow-up to patient-reported and clinical outcomes. The results are reported in Table 4. The preoperative width

TABLE 4. *Outcome Correlation With Radiographic Measurements of Involved Lateral Compartment Joint Space*

Outcome Parameter	Preoperative	Latest Follow-up
IKDC subjective	0.40	0.56*
IKDC symptoms	0.41	0.43
ADLS	0.22	0.38
SAS	0.37	0.56*
Lysholm knee scale	0.30	0.49*
IKDC overall	0.68*	0.66*

*Correlation is significant at the 0.05 level (2-tailed).

of the joint space of the involved lateral compartment was related to lower IKDC subjective assessment scores at final follow-up. The width of the joint space at final follow-up was related to IKDC group ratings for subjective assessment ($P = .004$) and symptoms ($P = .04$), the final IKDC rating ($P = .02$), the SAS score of the Knee Outcome Survey ($P = .01$), and the Lysholm Knee Scale score ($P = .04$).

DISCUSSION

Progressive degeneration and arthritic changes of the involved compartment following subtotal or complete meniscectomy are well described in the literature.[1,6-7] In addition, several studies suggest that the degenerative changes noted following lateral meniscectomy are often more rapid and severe than those seen following medial meniscectomy.[1] Because of limited surgical options available for this patient population affected by meniscectomy, meniscal allograft transplantation has emerged as a potential treatment option. Although several human clinical studies have been conducted since the first meniscal transplant was performed by Milachowski in 1984, most clinical studies concerning meniscal allograft transplantation are combined with other surgical interventions, most commonly, ACL reconstruction or osteotomy.[17,22] This makes it difficult for one to draw conclusions as to whether it is the meniscal transplant, osteotomy, ACL reconstruction, or a combination that is responsible for the clinical outcome of a particular procedure.

Our results following isolated lateral meniscal allograft transplantation revealed that patient-reported and clinical outcomes after lateral meniscal transplantation were very good. All but 1 patient involved in this study were satisfied with the condition of their knee following lateral meniscus transplant. This was reflected in the scores on the patient-reported outcomes measures, including the Lysholm Knee Scale, the ADLS and SAS of the Knee Outcome Survey, and SF-36 scores. SF-36 scores were higher than those of US population age- and sex-matched averages for 6 of the 8 scales, reflecting an overall sense of well-being in these patients after lateral meniscus transplantation. Of note, however, only 42% of these patients could participate in moderate or strenuous sports without pain, highlighting the importance of appropriate indications and expectations following this operation. Although we encourage no-impact or low-impact aerobic activities after a successful rehabilitation program, vigorous sporting activities are strongly discouraged.[30]

Findings from clinical examination in this study were equally encouraging. Patients did not have a clinically important loss of motion, and functional testing (i.e., 1-legged hop and 1-legged vertical jump tests) was nearly equal to that in the contralateral limb. Swelling was not a problem. This study excluded patients with concomitant ligamentous deficiencies determined on the basis of preoperative examination and magnetic resonance imaging, as well as surgical findings. However, 1 patient was found to have abnormal Lachman's and pivot-shift test results. This abnormal finding may be the result of a postoperative injury that was not reported, or it may have been caused by a difference in examination techniques because a blinded surgeon performed the examination.

Radiographic findings were extremely useful as these data allowed us to compare changes over time. Similar minimal joint space narrowing of the transplanted lateral compartment compared with the contralateral normal compartment suggests that the meniscal transplant did afford some protection to hyaline cartilage surfaces. Although differences in magnification could account for some of the values that were measured, all radiographs were obtained according to a standardized protocol. In addition, because the contralateral knee was used as a control both preoperatively and at latest follow-up, any error that could be introduced as the result of magnification would be the same for both the involved and the noninvolved knee. Therefore, we believe our conclusions are valid.

In addition, narrower preoperative and latest follow-up radiographic joint space measurements of the involved lateral compartment were associated with lesser patient-reported and objective clinical outcomes at latest follow-up. This has significant implications when the timing of meniscal allograft transplantation is considered. Because extensive degenerative changes of the involved meniscus-deficient compartment are a clear contraindication to surgery, on the basis of our study

results, earlier transplantation before the onset of significant arthritic changes may be likely to yield better results.

Our study also provides some objective clinical evidence concerning the appropriate method of fixation for the meniscal allograft.[11,23-25] In our analysis, significant differences in range of motion were seen between the 2 groups, with the bony fixation group having an average 4° greater passive extension compared with the group undergoing suture soft tissue fixation. In addition, this motion difference translated into significantly better IKDC range of motion ratings for the bony fixation group. Because both bony and soft tissue fixation techniques presumably restored the anatomic insertion sites, we assume that the improved range of motion was due to better fixation with the bone trough group. In addition, no patients in the suture fixation group had normal or nearly normal overall IKDC scores, but 4 of 11 patients with bony fixation had overall scores that were nearly normal. This comparison did not reach statistical significance. Although other differences may exist between the 2 groups, our sample size is too small for us to detect them.

This study had several limitations. First, this was a retrospective study with no control group. Second, 3 different techniques were used for meniscal allograft transplantation. Third, only 17 of 25 patients were available for follow-up examination and radiographs. Next, we did not obtain preoperative measures of function. Finally, the follow-up period was relatively short.

Unfortunately, we were unable to directly compare isolated lateral meniscal allograft transplantation versus a control group of lateral meniscus–deficient knees because we did not prospectively randomize our methods of treatment. It is inherently difficult to do a controlled randomized clinical trial when the ideal control group would involve no treatment for lateral meniscal deficiency. These patients often present to a surgeon for help with their condition, and many would be unwilling to participate in a randomized study if they thought that they would not receive the "ideal" surgical treatment.

The 3 techniques used for transplantation were not randomized. Before 1994, 2 bone plugs were used for transplantation. After 1994, the 2 primary surgeons modified their techniques. One of the surgeons used the all–soft tissue method, and the other used the bony trough technique. Because of the small sample size, the only significant difference that we found between the 2 groups was improved extension in the bony fixation group.

Of the initial 32 patients identified, only 25 were available for follow-up. Our center is a tertiary care center, and we get referrals from national and international colleagues. Many of our patients travel a long distance, making follow-up examinations and radiographs very difficult. Therefore, we were able to examine and obtain follow-up radiographs on only 17 of these 25 patients.

Because our study was retrospective, we did not obtain any preoperative measures of function. Therefore, it is not possible to state with certainty that the meniscal transplant procedure resulted in improved patient-reported and clinical outcomes when compared with no treatment at all. Finally, this study was limited by a relatively short follow-up (average, 3.3 years). Because the lateral meniscal transplant is a relatively new and uncommon surgical procedure, our follow-up ranged from 2 to 6 years.

Despite the limitations of our study, our results suggest that isolated meniscal allograft transplantation can be a beneficial procedure in properly selected symptomatic patients with a lateral meniscus–deficient knee. The data also suggest that earlier meniscal transplantation, before the onset of significant joint space narrowing, may result in improved outcomes. Finally, bony fixation may offer a significant advantage over suture fixation, particularly with regard to knee range of motion.

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