Interval Arthrometric Comparison of Anterior Cruciate Ligament Reconstruction Using Bone–Patellar Tendon–Bone Autograft Versus Allograft

Do Grafts Attenuate Within the First Year Postoperatively?

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Investigation performed at Rush University Medical Center, Chicago, Illinois

**Background:** There is little information regarding the incremental changes in the postoperative laxity of patellar tendon (PT) autografts versus allografts in anterior cruciate ligament (ACL) reconstruction.

**Hypotheses:** (1) There would be no significant increase in laxity between 6 weeks and 1 year postoperatively with PT autografts or allografts, (2) there would be no significant difference in laxity between PT autografts and allografts, (3) there would not be a significant difference in laxity between nonirradiated and low dose–irradiated PT allograft tissues, and (4) the physical examination findings would correlate with the instrumented laxity outcomes.

**Study Design:** Cohort study; Level of evidence, 3.

**Methods:** A retrospective review of 238 ACL-deficient patients who underwent single-incision endoscopic ACL reconstruction with a PT autograft (n = 132) or allograft (n = 106; 58 irradiated and 48 nonirradiated) from a single surgeon was made looking at data from preoperatively and from 6 weeks to 1 year postoperatively. The objective measurements of ligament integrity included range of motion, Lachman test, pivot-shift test, and KT-1000 arthrometer instrumented laxity examination. Failure was defined as arthrometric side-to-side differences (maximum manual difference) ≥3 mm or a positive pivot shift. Statistical significance was defined as P < .05.

**Results:** There were no differences in postoperative examination findings or instrumented laxity between PT autografts and allografts (irradiated or nonirradiated) in either subgroup. The postoperative improvement based on the Lachman examination, pivot-shift test, and arthrometric data in all study groups was significant (P < .001) in 98% (autograft: n = 130; allograft: n = 104) of patients, and arthrometric failure correlated with failure by physical examination. There was no significant change in graft laxity, as measured by KT-1000 arthrometer, from 6 weeks to 1 year postoperatively for 98% of patients. Finally, there was no statistical correlation in instrumented laxity results for either the autograft or allograft group with reference to age, gender, concomitant meniscectomy, meniscal repairs, interval to surgery, postoperative patellar pain, time to surgery, or irradiated versus nonirradiated allograft.

**Conclusion:** Laxity is not increased after the initial 6 weeks for either PT allograft or autograft constructs during the first postoperative year. There was no correlation between age, gender, concomitant injury, interval to surgery, or radiation of the graft with instrumented laxity results. Furthermore, our arthrometric data paralleled our clinical findings of stability at follow-up.

**Keywords:** knee outcome; anterior cruciate ligament; KT-1000 arthrometer; patellar tendon; allograft; autograft

The strength and ultimate failure of allograft tissue have shown no statistically significant difference when compared with autografts. In the clinical setting, there have been conflicting results, with some authors demonstrating significantly higher failure rates with allografts, especially in the younger patient. Others suggest that the clinical outcomes of anterior cruciate ligament (ACL) reconstruction using allograft tissue are similar to those of autografts.

The KT-1000 arthrometer (MEDmetric Inc, San Diego, California) has been used to assess preoperative, intraoperative, and postoperative anteroposterior (AP) tibial...
translation after ACL reconstruction for more than 25 years. Devices such as the KT-1000 arthrometer are used to confirm and quantify the amount of anterior translation present in the knee after injury or surgical intervention. As an adjunct to physical examination, the KT-1000 arthrometer provides an objective measure of AP translation that may be used as both a diagnostic tool after injury as well as to monitor graft stability postoperatively. Many clinical outcome studies comparing allograft and autograft reconstructions have used the arthrometer to compare the affected with the unaffected knee (side-to-side difference) preoperatively and at final follow-up. The results have been used to confirm the clinical outcomes in multiple studies. However, many of these studies do not follow arthrometric measurements at each office visit to determine if there are any changes as the graft matures. A study by Shelton et al did examine differences between autografts and allografts at 3, 6, 12, and 24 months, but they had only 30 patients in each group, and the study may have been underpowered as no differences were found.

There is some concern that allografts may undergo slower or incomplete ligamentization compared with autografts and that this may affect clinical results. However, both graft sources must undergo a maturation process that includes regaining a blood supply and synovial lining and a change in the collagen structure to that of a ligament, but it is not known if changes in graft laxity occur as the graft changes. The purposes of this study were as follows: (1) to assess the temporal course of laxity in both patellar tendon (PT) autograft and allograft constructs over the first year postoperatively and (2) to determine if the failures detected by physical examination would also have the highest side-to-side difference with manual maximum testing using the KT-1000 arthrometer. We hypothesized that (1) there would be no significant increase in laxity between 6 weeks postoperatively and 1 year postoperatively among both PT autografts and allografts, (2) no significant KT-1000 arthrometer differences between PT autografts and allografts would exist, (3) there would not be significant laxity differences between nonirradiated and low dose–irradiated PT allograft tissues, and (4) the failures detected by physical examination would also have the highest side-to-side difference with manual maximum testing using the KT-1000 arthrometer.

MATERIALS AND METHODS

A retrospective review of patients undergoing ACL reconstruction from March 2002 to April 2006 identified a total of 380 consecutive patients who had arthrometric data performed at prospectively determined intervals from ACL reconstruction (preoperatively, 6 weeks, 3 months, 18 weeks, 6 months, 9 months, and 1 year postoperatively). Patients with bilateral ACL deficiency, contralateral ACL deficiency, high tibial osteotomy, or previous ACL reconstruction on either knee were excluded from this study group. Patients who underwent extra-articular reconstruction or had concomitant posterolateral or posterior cruciate ligament reconstruction were also excluded from this group. Any patient with a medial collateral ligament injury, including a grade 1 sprain, was excluded from the study group. These exclusion criteria reduced the study population by 142 patients, leaving a total of 238 patients included in the study population. Approval for this study, including waiver of informed consent, was obtained through the institutional review board for the study of human participants.

One hundred thirty-two patients (55%) underwent ACL reconstruction with free autogenous middle-third PT grafts. One hundred six (45%) of 238 patients underwent ACL reconstruction with PT allografts. After June 2004, all patients who underwent ACL reconstruction with allograft tissue received low dose (1.0-1.3 mrads)–irradiated PT allograft tissue. Fifty-eight (55%) patients in the allograft group received irradiated PT grafts compared with 48 (45%) who received nonirradiated allografts. All allograft tissue was obtained from a single tissue bank (AlloSource, Denver, Colorado). The study group included a total of 115 men and 123 women whose mean age was 25 years (range, 11-61 years) at the time of the original injury (Table 1). The mean age ± standard deviation of the allograft group was 35.0 ± 12.7 years compared with 24.0 ± 9.5 years in the autograft group (P < .0001). The mean interval to reconstruction was 18.5 months (range, 10 days to 16.5 years). There were 44 patients with acute (defined as ≤3 weeks from injury) and 194 patients with subacute or chronic (>3 weeks) reconstructions. The number of months until reconstruction and percentage of acute reconstructions for the 2 study groups are reported in Table 1.

Physical Examination

All patients were examined clinically by the senior surgeon preoperatively and postoperatively at all visits. A complete examination included alignment, varus-valgus stability at 0° and 30° of knee flexion, and Lachman, anterior and

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*References 4, 9, 10, 17, 19, 21, 28, 33, 35.
†References 9, 10, 17, 19-21, 28, 29, 33, 35.

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posterior drawer, pivot-shift, and posterolateral instability tests. Knee instability on Lachman examination was numerically graded as 1 (0-5 mm), 2 (6-10 mm), or 3 (>10 mm). The pivot-shift test was graded as negative, 1+ (glide), 2+ (jump), or 3+ (transient lock) in the position of thigh abduction and tibial external rotation to maximize the pivot-shift sign. Range of motion was measured with a goniometer with the patient in the supine position. Knee flexion contractures were assessed with the patient in a prone position with measurement of heel-height differences.

KT-1000 Arthrometric Evaluation Technique

All KT-1000 arthrometric evaluations were performed by the same independent, experienced examiner preoperatively and postoperatively (6 weeks, 12 weeks, 18 weeks, 6 months, 9 months, and 1 year) as described by Daniel et al. The following tests were performed on the affected and unaffected leg: (1) a passive anterior Lachman test at 30° of flexion with a force of 15 lb, (2) a passive anterior Lachman test at 30° of flexion with a force of 20 lb, and (3) a maximum anterior force at 30° of knee flexion (maximum manual test). From these data, the side-to-side (affected-unaffected) differences were calculated at 20 lb (20-D) and maximum manual (MM-D) testing and were used for statistical analysis. All tests were performed twice, averaged, and maintained on a data sheet. An arthrometric failure was defined objectively as MM-D ≥5 mm. For data analysis, the side-to-side difference measurements (20-D and MM-D) were used.

Review of Surgical Technique

All 238 patients underwent an arthroscopically assisted single-incision transtibial ACL reconstruction at our institution by the senior author. All patients were informed of the risks, complications, and advantages of the autograft versus allograft and were given the option to choose autograft versus allograft reconstruction. The key principles employed during this technique included adequate notch preparation, appropriate oblique orientation of the tibial tunnel, transtibial drilling of the femoral tunnel, rigid fixation of the graft using interference screws, and securing the tibial bone plug with the knee in extension. In brief, a 10-mm middle-third PT graft was obtained with 25-mm bone plugs on either end. Allograft tissue was prepared in a similar fashion to the PT autograft. A 7 × 25-mm metal cannulated interference screw was used for femoral fixation in all patients. A 9 × 20-mm metal screw was used on the tibial side in almost all patients unless the graft was slightly recessed within the tibial tunnel; in these situations, a 9 × 25-mm or 9 × 30-mm screw was used. The interference screw was placed anterior to the graft in the femoral tunnel with the cortical edge of the bone plug facing posteriorly. The tibial screw was placed anteriorly to the bone plug as well; however, the cortical surface of the tibial bone plug was oriented anteriorly.

Rehabilitation

All surgeries were performed on an outpatient basis. All patients were placed in a hinged knee brace with immediate, unrestricted passive range of motion. Weightbearing was allowed as tolerated with the brace locked in full extension. Range of motion was allowed to progress through passive, active, and resisted motion as tolerated with the goal of full extension by 2 weeks and 120° of flexion by 6 weeks postreconstruction. Bicycling was allowed at 2 weeks, running at 8 to 10 weeks, and gradual return to sport at 4 to 6 months postoperatively if rehabilitation criteria were met. A customized ACL orthosis was worn for sports activities from 4 months to 1 year. This rehabilitation protocol, including brace wear duration, was identical for allograft and autograft patients.

Data Acquisition and Analysis

A research assistant not involved with the surgery or patient follow-up independently reviewed the chart and recorded the preoperative, intraoperative, and postoperative data. A subset of patients who had complete data (n = 111) was compared with all available KT-1000

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**TABLE 1**

Demographic Data for Autograft and Allograft Groups

<table>
<thead>
<tr>
<th></th>
<th>Autograft Group (n = 132)</th>
<th>Allograft Group (n = 106)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD, y</td>
<td>24 ± 9.5</td>
<td>35 ± 12.7</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Sex, % male</td>
<td>57</td>
<td>38</td>
<td>.003</td>
</tr>
<tr>
<td>Side, % right</td>
<td>51</td>
<td>42</td>
<td>.20</td>
</tr>
<tr>
<td>Time from injury to surgery, mean ± SD, mo</td>
<td>12.8 ± 31.4</td>
<td>25.5 ± 64.5</td>
<td>.049</td>
</tr>
<tr>
<td>Chronic injuries, %</td>
<td>75</td>
<td>89</td>
<td>.007</td>
</tr>
<tr>
<td>MMT, n (%)</td>
<td>31 (24)</td>
<td>30 (28)</td>
<td>.40</td>
</tr>
<tr>
<td>STMM, n (%)</td>
<td>14 (11)</td>
<td>21 (20)</td>
<td>.09</td>
</tr>
<tr>
<td>MMR, n (%)</td>
<td>17 (13)</td>
<td>9 (8)</td>
<td>.28</td>
</tr>
<tr>
<td>LMT, n (%)</td>
<td>24 (18)</td>
<td>21 (20)</td>
<td>.75</td>
</tr>
<tr>
<td>STLM, n (%)</td>
<td>19 (14)</td>
<td>18 (17)</td>
<td>.58</td>
</tr>
<tr>
<td>LMR, n (%)</td>
<td>5 (4)</td>
<td>3 (3)</td>
<td>.71</td>
</tr>
</tbody>
</table>

*SD, standard deviation; MMT, medial meniscus tear; STMM, subtotal medial meniscectomy; MMR, medial meniscus repair; LMT, lateral meniscus tear; STLM, subtotal lateral meniscectomy; LMR, lateral meniscus repair.
arthrometer measurements at each time interval to ensure there was no difference between these groups. Data analysis was performed by an experienced statistician. Statistical analysis included a paired \( t \) test of preoperative and postoperative variables, descriptive statistics, analysis of variance (ANOVA) testing for multiple variables, and \( \chi^2 \) analysis when applicable. Statistical significance was established at \( P < .05 \). Dichotomous variables analyzed with a \( \chi^2 \) statistical model included patellar pain, acute versus chronic tears, irradiated versus nonirradiated grafts, meniscal surgery, and gender. Continuous variables analyzed with an ANOVA model included age, interval time from injury to surgery, and arthrometric data.

**RESULTS**

**Demographics**

The average age for the bone-PT-bone autograft group was significantly less than for the allograft group. There were more men and more acute injuries in the autograft group. There were a total of 31 (24%) medial meniscal tears and 24 (18%) lateral meniscal tears in the autograft group. This was not significantly different than the 30 (28%) medial meniscus tears and 21 (20%) lateral meniscal tears in the allograft group. The number of partial meniscectomies and meniscal repairs was not different between groups (Table 1).

**Physical Examination Findings**

Of the 238 patients, 131 (99%) patients with autografts had a negative pivot-shift result compared with 105 (99%) patients in the allograft group at 1-year follow-up (Table 2). The one failure in each group by examination also had subjective complaints of instability. Postoperative reductions of magnitude in both the Lachman and pivot-shift tests were statistically significant after ACL reconstruction with either PT autografts \( (P < .001) \) or allografts \( (P < .001) \). There were no significant differences between preoperative and 1-year postoperative range of motion.

The failures detected by physical examination also were noted to have the highest side-to-side difference with manual maximum testing using the KT-1000 arthrometer. While the average side-to-side difference increased with each preoperative Lachman grade (6.3, 6.4, and 7.1 for grade 1, 2, and 3, respectively) and pivot shift (6.3, 6.5, and 7.4), there was too little variation in data points to achieve statistical significance correlation with the numbers available for this study.

**KT-1000 Arthrometric Evaluation**

The arthrometric criteria used to define ACL deficiency preoperatively were consistent with the modified diagnostic criteria proposed by Bach et al \( ^6 \) (20 lb or maximum manual anterior translation \( \geq 10 \) mm; 20-D or MM-D \( \geq 5 \) mm). There were no significant differences in postoperative arthrometric measurements between the irradiated versus nonirradiated allograft groups at any time point \( (P > .05) \), and thus, they were combined for data analysis (Appendix, available in the online version of this article at http://ajs.sagepub.com/supplemental/). Postoperatively, no patients had \( >10 \)-mm absolute anterior translation at 20 lb of force in either the allograft or autograft groups \( (5.01 \pm 1.37 \) range, 2-9)\). The absolute anterior translation at maximum manual testing was \( >10 \) mm in 2 patients (3%) in the autograft group versus 3 patients (6%) in the allograft group. There was a significant reduction \( (P < .0001) \) in the absolute anterior translations from preoperative testing to postoperative follow-up at 1 year in affected knees of both groups; however, there was no difference between the absolute maximum manual anterior translation in the allograft and autograft groups at 1 year postoperatively \( (P = .11) \). Figure 1 shows the preoperative and postoperative anterior translation distributions for autograft and allograft reconstruction.

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**TABLE 2**

**Physical Examination Findings Preoperatively and at 1 Year Postoperatively for Autograft and Allograft Groups**

<table>
<thead>
<tr>
<th>Test</th>
<th>Preoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Autograft</td>
<td>Allograft</td>
</tr>
<tr>
<td>Lachman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3 (2)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>2</td>
<td>97 (73)</td>
<td>73 (69)</td>
</tr>
<tr>
<td>3</td>
<td>32 (24)</td>
<td>30 (28)</td>
</tr>
<tr>
<td>Pivot shift</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>1+</td>
<td>21 (16)</td>
<td>19 (18)</td>
</tr>
<tr>
<td>2+</td>
<td>84 (64)</td>
<td>62 (58)</td>
</tr>
<tr>
<td>3+</td>
<td>27 (20)</td>
<td>25 (24)</td>
</tr>
<tr>
<td>Anterior drawer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>89 (67)</td>
<td>71 (67)</td>
</tr>
<tr>
<td>Negative</td>
<td>43 (33)</td>
<td>35 (33)</td>
</tr>
</tbody>
</table>

\( ^a \) Values are expressed as n (%).
When comparing preoperative and postoperative side-to-side difference, there was a significant reduction in the side-to-side difference postoperatively both with 20-D and MM-D measurements \((P < .0001)\). Postoperatively, the MM-D for the allograft group was \(\leq 3\) mm for 98% of patients. Similarly, 98% in the autograft group had MM-D of \(\leq 3\) mm. Table 3 shows the postoperative stratification of side-to-side difference (MM-D) in both patient groups. There was no statistically significant side-to-side difference between PT allograft and autograft reconstructions preoperatively or postoperatively (Table 4). A post hoc power analysis was performed, which demonstrated with the numbers available in this study and using standard values of \(\alpha\) of .05 and \(\beta\) of .20 that this study was powered to determine a 0.8-mm side-to-side difference in KT-1000 arthrometer measurements. Table 4 again provides a summary of the preoperative and 1-year postoperative KT-1000 arthrometer data for the 2 patient groups (allograft and autograft) at 20-D and MM-D testing. Postoperatively, there was no statistically significant correlation in 20-D and MM-D results for either the autograft or allograft group with reference to the following factors: (1) age or gender, (2) concomitant meniscectomy or meniscal repair, (3) interval to surgery, (4) postoperative patellar pain, (5) acute or chronic subgroups, and (6) irradiated versus nonirradiated allograft.

Arthrometric data were analyzed at 6 weeks and 1 year postoperatively to determine the durability of the KT-1000 arthrometer results. When comparing the autograft and allograft groups, the average increase in laxity from 6 weeks postoperatively to 1 year was 0.3 mm (standard error of the mean [SEM], 1.9 mm) for the autograft group and 0.1 mm (SEM, 2.3 mm) in the allograft group. The MM-D at 6 weeks was not significantly different than the MM-D at 1 year in the autograft group \((P = .10)\) or the allograft group \((P = .46)\).

One hundred eleven patients (47%) had full data, including KT-1000 arthrometer and physical examination results, at the preoperative visit and at 6 weeks, 3 months, 18 weeks, 6 months, 9 months, and 1 year. This group was analyzed as a subgroup to determine the mean change in maximum manual laxity at each time interval up to 1 year, and there was no significant difference at any time interval for either group. Table 2 in the Appendix (available online) summarizes the mean increase in arthrometric laxity for the allograft and autograft group at each time interval. Figure 1 in the Appendix (available online) graphically depicts the change in graft laxity over time, showing the dramatic reduction in maximum manual testing postoperatively and the relative stability of instrumented laxity testing from 6 weeks to 1 year postoperatively. There was no difference between the subgroup of 111 patients compared with the entire 238 patient group at the preoperative \((P = .96)\), 6-week postoperative \((P = .34, .61)\), and 1-year postoperative \((P = .35, .62)\) time points for autograft and allograft groups, respectively.

DISCUSSION

The principal findings in this study demonstrate that (1) KT-1000 arthrometer laxity testing does not increase after the initial 6-week testing for either PT allograft or autograft constructs during the first year postoperatively, (2) there were no significant differences between PT autografts and allografts, (3) there were no differences between nonirradiated and low dose–irradiated grafts, and (4) failures detected by physical examination also were noted to have the highest side-to-side difference with manual maximum testing using the KT1000 arthrometer.

The KT-1000 arthrometer measurements at 20-lb and maximum manual absolute translations in both the allograft and autograft populations in each subgroup analyzed were similar and did not deteriorate at final follow-up. This suggests that arthrometric results at 6 weeks are predictive of arthrometric results at 1-year follow-up in patients after transtibial single-bundle ACL reconstruction. These data also suggest that the surgical technique and rehabilitation protocol used by the senior author provide for excellent knee stability at 1-year follow-up. These observations are important when taken in the context that many surgeons rehabilitate PT allograft patients differently based on basic science data suggestive of a longer interval to graft incorporation compared with a PT autograft. The clinical implications of using irradiated PT tissue on graft incorporation and laxity remain largely unknown. In 1995, Fideler et al\(^{15}\) demonstrated a dose-dependent effect of irradiation on both the structural and mechanical properties of human PT allograft. Curran et al\(^{12}\) studied the effect of 2 mrad on the cyclic and failure properties of human PT allograft and showed a 27% increase in elongation after cyclic loading and a 20% decrease in strength.
compared with nonirradiated grafts. Our data indicate that there were no significant differences in arthrometric or clinical analyses in patients who received nonirradiated PT allograft tissue versus patients who received low dose–irradiated (1.0-1.3 mrad) PT allograft tissue. Our results compare favorably with those from a study by Rihn et al in which 102 patients underwent ACL reconstruction with either PT autograft or irradiated PT allograft tissue and had no significant differences in KT-1000 arthrometric data or clinical outcomes. Furthermore, there was no correlation between differences in KT-1000 arthrometric parameters and interval to surgery (acute vs chronic ACL reconstruction). These results indicate that single-incision endoscopic ACL reconstructions with either PT allografts or autografts provide similar arthrometric results of graft stability in patients who achieve full preoperative range of motion, regardless of interval to surgery.

When comparing allograft versus autograft ACL reconstruction, our data compare favorably with those previously reported. The results of the present study are similar to those of studies measuring KT-1000 arthrometer results of PT autografts. O’Brien et al observed that 24 of 31 (77%) patients had a maximum manual difference ≤3 mm, but only 7% of their patients had a maximum manual difference of >5 mm. Another study demonstrated 90% of 62 patients who underwent PT autograft reconstruction of the ACL had a maximum manual difference ≤3 mm. In a 5- to 9-year follow-up study of 97 patients who underwent an arthroscopically assisted 2-incision ACL reconstruction with PT autografts, Bach et al reported 96% of patients had <5-mm difference in manual maximum side-to-side testing. This study found no statistically significant difference between allografts and autografts with regard to arthrometric measurements at final follow-up and was in concordance with several previously reported smaller studies comparing autografts and allografts. In a retrospective study comparing 64 patients who received PT allografts versus 26 patients who received PT autografts, Harner et al reported no significant difference in arthrometric measurements at 3- to 5-year follow-up. In a prospective study of 30 patients with PT allografts and 30 patients with PT autografts, Shelton et al reported no statistically significant differences in the pivot-shift test or arthrometric assessment at 2-year follow-up. Victor et al prospectively studied 73 ACL reconstructions with either a PT autograft or allograft. They reported no statistical differences between the 2 graft types at 12 months but did show a trend toward increasing laxity with time in the allograft group.

There are several limitations to this study. Numerous studies have shown the role of ACL reconstruction as a means to regain AP and rotational stability. The KT-1000 arthrometer measures AP stability and does not quantitate rotational stability. While the pivot shift is a better test for rotational stability, it is a subjective

### TABLE 3
Stratification of KT-1000 Arthrometer Maximum Manual Side-to-Side Differences (MM-D) Postoperatively in Autograft and Allograft Groups

<table>
<thead>
<tr>
<th>MM-D, mm</th>
<th>Autograft Group</th>
<th></th>
<th></th>
<th>Allograft Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>&lt;-3</td>
<td>3</td>
<td>2.3</td>
<td>1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>-3 to -1</td>
<td>10</td>
<td>7.6</td>
<td>6</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>-1 to 0</td>
<td>10</td>
<td>7.6</td>
<td>13</td>
<td>12.3</td>
<td></td>
</tr>
<tr>
<td>0 to 3</td>
<td>106</td>
<td>80.0</td>
<td>84</td>
<td>79.2</td>
<td></td>
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<tr>
<td>3 to 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>&gt;5</td>
<td>3</td>
<td>2.3</td>
<td>2</td>
<td>1.9</td>
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### TABLE 4
Comparison of Preoperative and 1-Year Postoperative KT-1000 Arthrometer Results in Autograft and Allograft Groups

<table>
<thead>
<tr>
<th>Test, mm</th>
<th>Autograft Group (n = 132)</th>
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<th></th>
<th>Allograft Group (n = 106)</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SEM</td>
<td>Mean</td>
<td>SEM</td>
<td>P Value (Between-Group Comparison)</td>
</tr>
<tr>
<td>Preoperative 20-D</td>
<td>3.3</td>
<td>2.4</td>
<td>3.5</td>
<td>2.4</td>
<td>.21</td>
</tr>
<tr>
<td>Postoperative 20-D</td>
<td>0.4</td>
<td>1.6</td>
<td>0.5</td>
<td>1.7</td>
<td>.24</td>
</tr>
<tr>
<td>Preoperative MM-D</td>
<td>6.6</td>
<td>3.1</td>
<td>6.1</td>
<td>2.9</td>
<td>.90</td>
</tr>
<tr>
<td>Postoperative MM-D</td>
<td>0.3</td>
<td>1.6</td>
<td>0.4</td>
<td>1.8</td>
<td>.93</td>
</tr>
</tbody>
</table>

SEM, standard error of the mean; 20-D, side-to-side difference at 20 lb of force; MM-D, maximum manual side-to-side difference.

References 4, 9, 10, 17, 19-21, 27, 29, 33, 35.
examination. Despite no objective measure of rotational stability, we did find comparable success rates of arthrometric and pivot-shift data using a modification of the classic pivot-shift test, which is a more sensitive test for detecting subtle pivot-shift phenomenon. In addition, this study used a single examiner for pivot-shift testing, which can reduce some of the variability that can result from multiple examiners grading a subjective examination maneuver. An additional limitation of this study is the short follow-up of 1 year. The purpose and value of this study were to demonstrate that the KT-1000 arthrometer data at 6 weeks postoperatively are predictive for arthrometric data at 1 year postoperatively. On the basis of these data, we feel comfortable discharging patients at 6 months postoperatively, thus reducing postoperative office charges. However, this is a single surgeon’s experience, who has performed more than 2000 ACL reconstructions using a modified transtibial approach, and thus, these results may not be transferrable to the orthopaedic surgeon who performs fewer than 10 ACL reconstructions per year or who uses a different technique. Because of the relatively few failures and the vast majority of side-to-side differences between 0 and 3 mm, this makes statistical correlation testing of multiple variables underpowered. Finally, another limitation is that the allograft and autograft groups are different. The allograft group was approximately 10 years older on average compared with the autograft group. We do not have data available to detail the level of activity of each patient before and after surgery; however, typically, the younger patients will return to higher level athletics, potentially placing their graft at greater risk than the older individual. Also, the autograft group had a higher proportion of acute reconstructions and male patients. The larger number of acute reconstructions may place this group at a higher risk for stiffness postoperatively. The chronic reconstructions may have an increased risk of more intra-articular injury, which could cause lower patient-based outcomes scores; however, this was not a focus of this study.

Our data suggest that there is no significant progressive deterioration or graft elongation in either patient population during the first year postoperatively. To avoid selection bias, we included all patients in this study who were evaluated 6 weeks and 1 year postoperatively. Although some patients missed their regularly scheduled postoperative visits from 3 months to 9 months, we believe that the critical postoperative measurements were the 6-week and 1-year visit that would allow evaluation of the change in laxity.

CONCLUSION

We found no statistically significant difference in KT-1000 arthrometer measurements from 6 weeks to 1 year postoperatively between allograft- and autograft-reconstructed knees. There was no correlation between age, gender, concomitant injury, interval to surgery, or radiation of the graft and KT-1000 arthrometer measurements. Our arthrometric data paralleled our clinical findings of stability at follow-up. There was no statistically significant increase in laxity for either the allograft or autograft group between 6 weeks and 1 year postoperatively. The arthrometric translation noted at 6 weeks postoperatively stabilized for the remainder of patients in each group and did not show clinically significant changes when followed at regular time intervals to 1-year follow-up for the subgroup measured at all time points. With the surgical techniques, grafts, and rehabilitation protocol used, there were no significant changes in graft laxity 6 weeks after reconstruction in clinically stable patients. The findings of this study have resulted in discharging patients from follow-up evaluations at 6 months rather than 1 year.

REFERENCES


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