Hypothesis: Direct inguinal hernia repair with acellular human dermis (AHD) may offer greater symptom improvement and lower risk of hernia recurrence than anatomical repair without mesh (AWM) after mesh removal (with or without neurectomy) for postherniorrhaphy inguinodynia.

Design: Retrospective cohort study with long-term follow-up.

Setting: Tertiary referral center for mesh inguinodynia.

Patients: Patients undergoing meshectomy (with or without neurectomy) for postherniorrhaphy inguinodynia were identified. Medical records were reviewed, and patients were contacted to evaluate outcomes. Patients whose postmeshectomy hernias were repaired using AHD vs AWM were compared.

Main Outcome Measures: Patient satisfaction and recurrence.

Results: Sixty-seven patients (35 in the AHD group and 32 in the AWM group) completed the follow-up. Patient demographics, duration and severity of symptoms, and time to meshectomy were similar between groups. The mean length of follow-up was 31.9 months for the AHD group and 80.2 months for the AWM group (P < .001). Fewer neurectomies were performed in the AHD group than in the AWM group (43% [15 of 35] vs 72% [23 of 32], P = .03). Eighty-three percent (29 of 35) of patients in the AHD group reported good or excellent groin pain improvement compared with 72% (23 of 32) of patients in the AWM group (P = .38). Eighty-three percent (29 of 35) of patients in the AHD group were satisfied with results compared with 81% (26 of 32) of patients in the AWM group (P = .99). The AHD vs AWM procedures were associated with similar recovery, time to hernia recurrence, complication rates (11% [4 of 35] vs 3% [1 of 32], P = .36), and hernia recurrence rates (9% [3 of 35] vs 12% [4 of 32], P = .80). Predictors of patient dissatisfaction with meshectomy included patient smoking (odds ratio, 9.1; P = .01) and filing of workers’ compensation claims (odds ratio, 12.8; P = .02).

Conclusions: Meshectomy (with or without neurectomy) for postherniorrhaphy inguinodynia leads to significant symptom improvement and patient satisfaction, with acceptable morbidity and recurrence rates. The use of AHD vs AWM does not improve iatrogenic hernia recurrence.

SEVERE CHRONIC POSTHERNIORRHAPHY inguinodynia (groin pain) has an incidence of 1% to 2.7%.1,2 Mesh implantation has been shown to cause ilioinguinal nerve edema and fibrosis3 and may be a cause of postherniorrhaphy inguinodynia. Heise and Starling4 reported that mesh removal (meshectomy) improves symptoms in 60% of patients experiencing postherniorrhaphy inguinodynia. Recent prospective studies5,6 demonstrate improved pain 6 months to 1 year after revisional meshectomy and selective neurectomy. However, despite promising short-term outcomes after meshectomy for inguinodynia, there are no studies to date that evaluate long-term results of this treatment.

Meshectomy creates an iatrogenic direct hernia, and reintroduction of mesh to repair the defect risks recurrent mesh inguinodynia. Traditional options for repair include anatomical repair without mesh (AWM) using modified Bassini or McVay repair.3 However, these repairs use native tissue that has undergone significant trauma and extensive scarring after the previous mesh repair and often difficult groin dissection. In addition, open anterior AWM arguably places the tissues under tension, and the published recurrence rates for these repairs after recurrent hernia surgery range from 9% to 18%.7,8 Remedial laparoscopic repair would obviate a possible tension repair, but mesh implantation is required.

Biologic materials provide a possible alternative to native tissue and mesh repairs of the iatrogenic hernia defect after meshectomy for mesh inguinodynia. Acellular human dermis (AHD) is a biologic graft derived from human donors that has been treated to remove immune cells and cellular compo-
nents. It has been used to repair ventral hernias in place of mesh when the surgical field has been compromised. The use of AHD in place of mesh may enable a tension-free repair of the postmeshectomy hernia defect without the foreign body reaction of mesh, potentially reducing the risk of recurrent hernia and inguinodynia. However, it is unknown if a tension-free repair using AHD has a lower risk of recurrence than AWM, as AHD is not commonly used in the inguinal position, and the only study to date using AHD for inguinal hernia repair had a small sample size and a short follow-up period. Therefore, the objectives of this study were to assess the long-term effects of meshectomy on groin pain symptoms and to document the rate of hernia recurrence after recurrent hernia repair with AHD or AWM.

### OUTCOMES AND STATISTICAL ANALYSIS

The AHD group was compared with the AWM group for patient demographics and outcomes using the Wilcoxon rank sum test for continuous variables and Fisher exact test for discrete variables. Rates of recurrence, return to work, return to activities of daily living, and return to exercise were estimated using the Kaplan-Meier method and were compared between treatment groups using the log-rank test. Recurrence was defined as a reoperation for recurrent hernia or as detection of a recurrent hernia by the patient or his or her health care provider. Univariate and multivariate analyses were performed using logistic regression to further identify predictors of satisfaction after surgery. P < .05 was considered statistically significant. All analyses were performed by biostatisticians using commercially available software (SAS, version 9.1; SAS Institute Inc, Cary, North Carolina).

Of 119 patients who had a meshectomy performed by one of us (J.R.S.) between November 12, 1997, and June 15, 2007, a total of 71 patients underwent AWM, and 48 underwent AHD repair. Attempts were made to contact all 119 patients, and 70 patients were successfully contacted. Sixty-seven patients (56% of 119) consented to participate in the study and completed the telephone interview. The remaining 3 patients were unable to be contacted because of outdated contacts. All analyses were performed by biostatisticians using commercially available software (SAS, version 9.1; SAS Institute Inc, Cary, North Carolina).

### METHODS

One hundred nineteen patients undergoing meshectomy (with or without neurectomy) for postherniorrhaphy inguinodynia between November 12, 1997, and June 15, 2007, were identified using Current Procedural Terminology codes. After approval by the institutional review board at our institution, the medical record of each patient was examined to confirm that he or she received a meshectomy for postherniorrhaphy inguinodynia. After a signed consent was obtained by mail, patients underwent a scripted telephone interview by 3 of us (M.C.K., B.H.Y., and J.R.S.), who were blinded to the repair method, and their medical records were reviewed to evaluate outcomes.

### SURGERY

In all patients, groin exploration was performed using an anterolateral approach through the previous incision (in the case of prior open repair) or through a new groin incision (for prior laparoscopic repair). Surgical exploration proceeded until the mesh was encountered, and meshectomy was performed. Before 2002, neurectomy was performed in all cases in which the inguinal nerves (ilioinguinal, iliohypogastric, or genital branch of the genitofemoral nerve) could be identified. Beginning in 2002, our practice was to perform neurectomy only in those cases in which nerve entrapment from sutures, scar, mesh, or tacks (for prior laparoscopic repairs) was suspected. In all patients before 2002, the iatrogenic hernia defect after meshectomy was closed anatomically without mesh using a modified Bassini or McVay repair (AWM group). All patients undergoing meshectomy from January 1, 2002, to the present underwent iatrogenic hernia defect closure using a modified Lichtenstein repair with AHD (Alloderm; LifeCell, Branchburg, New Jersey) in place of the explanted mesh (AHD group). The AHD was purchased by our institution.

### PATIENTS

One hundred nineteen patients undergoing meshectomy (with or without neurectomy) for postherniorrhaphy inguinodynia between November 12, 1997, and June 15, 2007, were identified using Current Procedural Terminology codes. After approval by the institutional review board at our institution, the medical record of each patient was examined to confirm that he or she received a meshectomy for postherniorrhaphy inguinodynia. After a signed consent was obtained by mail, patients underwent a scripted telephone interview by 3 of us (M.C.K., B.H.Y., and J.R.S.), who were blinded to the repair method, and their medical records were reviewed to evaluate outcomes.

### RESULTS

Of 119 patients who had a meshectomy performed by one of us (J.R.S.) between November 12, 1997, and June 15, 2007, a total of 71 patients underwent AWM, and 48 underwent AHD repair. Attempts were made to contact all 119 patients, and 70 patients were successfully contacted. Sixty-seven patients (56% of 119) consented to participate in the study and completed the telephone interview. The remaining 3 patients were unable to be contacted because of outdated contact information, despite numerous attempts with current listings, and these patients were similar to those who were contacted except for a higher rate of neurectomy among the AHD group that was not contacted compared with those who were contacted. Sixty-seven patients (35 in the AHD group and 32 in the AWM group) completed the follow-up and are included in the study (Table 1). The mean length of

### Table 1. Patient Demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>AHD Group (n=35)</th>
<th>AWM Group (n=32)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SE), y</td>
<td>44.8 (2.2)</td>
<td>41.4 (2.1)</td>
<td>.29</td>
</tr>
<tr>
<td>Male sex, No./total No. (%)</td>
<td>29/35 (83)</td>
<td>27/32 (84)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>BMI, mean (SE)</td>
<td>27.6 (1.4)</td>
<td>27.2 (0.6)</td>
<td>.66</td>
</tr>
<tr>
<td>Patient smoking, No./total No. (%)</td>
<td>10/25 (40)</td>
<td>15/32 (47)</td>
<td>.79</td>
</tr>
<tr>
<td>Time from initial herniorrhaphy to meshectomy, mean (SE), wk</td>
<td>119.6 (20.0)</td>
<td>95.7 (13.0)</td>
<td>.42</td>
</tr>
<tr>
<td>Duration of symptoms before herniorrhaphy, mean (SE), wk</td>
<td>102.5 (17.0)</td>
<td>79.3 (12.0)</td>
<td>.40</td>
</tr>
<tr>
<td>Follow-up, mean (SE), mo</td>
<td>31.9 (3.0)</td>
<td>80.2 (4.0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Filing of workers’ compensation claims, No./total No. (%)</td>
<td>14/25 (56)</td>
<td>18/32 (56)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Primary laparoscopic repair, No./total No. (%)</td>
<td>4/31 (13)</td>
<td>9/32 (28)</td>
<td>.21</td>
</tr>
<tr>
<td>Moderate to severe groin pain, No./total No. (%)</td>
<td>31/35 (89)</td>
<td>30/32 (94)</td>
<td>.28</td>
</tr>
<tr>
<td>Testicular pain among men, No./total No. (%)</td>
<td>11/33 (33)</td>
<td>18/32 (56)</td>
<td>.08</td>
</tr>
<tr>
<td>Neurectomy, No./total No. (%)</td>
<td>15/35 (43)</td>
<td>23/32 (72)</td>
<td>.03</td>
</tr>
</tbody>
</table>

Abbreviations: AHD, acellular human dermis; AWM, anatomical repair without mesh; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

a No patients had diabetes.

b Using Wilcoxon rank sum test for continuous variables and Fisher exact test for discrete variables.
follow-up was 31.9 months for the AHD group and 80.2 months for the AWM group (P < .001). Patient demographics (including age, body mass index, smoking status, diabetes rates, and workers’ compensation claim status) were similar between groups. In addition, no significant differences were noted in the percentage of primary laparoscopic repairs, the duration or severity of symptoms before meshectomy, or the time from initial herniorrhaphy to meshectomy. However, there was a trend toward increased testicular pain as a co-primary symptom among men in the AWM group (56% [18 of 32]) compared with the AHD group (33% [11 of 33]) (P = .08). Patients in both groups had a similar number of total hernia operations and operations for groin pain before their meshectomy (data not shown). More neurectomies were performed in the AWM group (72% [23 of 32]) compared with the AHD group (43% [15 of 35]) (P = .03) (Table 1).

There were no significant differences in groin pain improvement or satisfaction with results between the 2 groups (Table 2). Twenty-nine patients (83%) undergoing AHD repair reported good or excellent groin pain improvement, with an 83% (29 of 35) overall satisfaction rate. This was similar to the finding of 23 patients (72%) undergoing AWM reporting good or excellent groin pain improvement, with an 81% (26 of 32) overall satisfaction rate. No significant difference was noted in complication rates between groups, with 4 complications (11%) in the AHD group and 1 complication (3%) in the AWM group. The 4 complications in the AHD group were deep vein thrombosis and pulmonary embolism, urinary tract infection, wound hematoma, and wound dehiscence. The single complication in the AWM group was testicular infarction. There were 3 hernia recurrences (9%) in the AHD group and 4 hernia recurrences in the AWM group (12%) (P = .80). Because of the significantly longer follow-up period in the AWM group, the time to hernia recurrence was examined and found to be similar between groups (Figure). No differences were noted in the time to return to work, exercise, or normal activity (data not shown).

The AWM and AHD groups were combined to perform an analysis of predictors of patient satisfaction with the outcomes of meshectomy. Based on univariate and multivariate analysis, significant predictors of dissatisfaction included patient smoking (odds ratio, 9.1; P = .01) and filing a workers’ compensation claim (odds ratio, 12.8; P = .02) (Table 3). In addition, patients who were dissatisfied with the outcome of their meshectomy had a longer median time from their initial herniorrhaphy to meshectomy (152 weeks) and a longer duration of symptoms before meshectomy (130 weeks) compared with patients who were satisfied with their outcomes (96 weeks and 81 weeks, respectively), although these differences did not reach statistical significance.

This study represents the largest case series to date of meshectomy (with or without neurectomy) for postherniorrhaphy inguinodynia and demonstrates that meshectomy results in significant symptom improvement and patient satisfaction, with acceptable morbidity and recurrence rates. It also provides the longest follow-up of any study of meshectomy to date, with a combined follow-up period for both study groups ranging from 4 to 120 months and a mean follow-up period of 50 months, demonstrating long-term symptom improvement and durable hernia repair.

The biologic evidence that mesh implantation alone (without nerve entrapment by suture or tacks) can cause inguinodynia comes from studies that have shown increased nerve edema and fibrosis with polypropylene mesh implantation and inflammation with polytetrafluoroethylene mesh placement. In addition, the rates of symptom improvement and satisfaction were unrelated to the use of neurectomy, as evidenced by similar outcomes, despite reduced use of neurectomy in the AHD group (compared with the AWM group), lending support that meshectomy itself, and not concomitant neurectomy, can
improve inguinodynia that is not neuropathic in origin. Furthermore, neurectomy was not found to be a significant independent predictor of patient satisfaction based on multivariate analysis. Neurectomy alone has been shown to improve inguinal neuralgia in 60% to 80% of patients.\textsuperscript{12,13} It is likely that inguinodynia after mesh herniorrhaphy is a result of heterogeneous pathogenesis. Those cases in which nerve entrapment alone is the cause of inguinodynia will likely benefit from neurectomy alone without mesh removal. Conversely, patients with mesh inguinodynia and no identified nerve involvement can undergo meshectomy without neurectomy, and this practice is supported by the results of this study. In patients with nerve entrapment by the mesh itself, both meshectomy and resection of the involved nerve should be performed.

There was a lack of improvement in symptoms among 22% (15 of 67) of patients undergoing meshectomy, and this is reflected in the 18% (12 of 67) of patients who were not satisfied with the outcome of their operation. Notably, 3 patients who did not have symptom improvement were paradoxically still satisfied with their outcome. These patients attributed their satisfaction to the fact that an attempt was made to treat their condition, which provided a validation of their symptoms and a sense of closure to a prolonged and frustrating preoperative evaluation. Indeed, patients who were dissatisfied with their meshectomy had waited a year longer than satisfied patients before undergoing mesh removal and experienced an extra year of preoperative symptoms. Therefore, a delay in treatment may be associated with a worse outcome after meshectomy. This may be avoided by promptly referring a patient with chronic (ie, >6 months) postherniorrhaphy inguinodynia to a surgeon experienced in groin pain for timely evaluation and treatment.

Patient smoking and filing of workers’ compensation claims were found to be independent predictors of patient dissatisfaction with the outcome of meshectomy. Similarly, a 1994 study\textsuperscript{12} evaluating genitofemoral neurectomy for inguinodynia found worse outcomes in patients with severe preoperative testicular pain. In particular, filing of workers’ compensation claims has been examined in previous studies examining groin pain. Salcedo-Wasiczek and Thirlby\textsuperscript{14} found among patients undergoing primary hernia repair that those with workers’ compensation insurance vs commercial insurance had a significantly longer duration of postoperative pain and time off from work and that insurance type was the only independent variable affecting postoperative pain. In the initial report from our series,\textsuperscript{9} no patients with workers’ compensation insurance had an excellent outcome. These findings should be considered when counseling patients about their expected outcomes after meshectomy, although there is insufficient evidence to support forgoing meshectomy in the case of workers’ compensation status alone.

The rates of hernia recurrence after repair of the post-meshectomy hernia defect in this study are comparable to those reported in other investigations of recurrent hernia repairs without mesh.\textsuperscript{7} In addition, we found that the use of AHD to repair the resulting hernia did not improve hernia recurrence compared with AWM. Albo et al\textsuperscript{16} were the first to describe the use of AHD in the inguinal position. They used AHD (Alloderm) to repair hernias in 12 patients with contaminated surgical fields and reported no hernia recurrences at a median follow-up period of 9 months. The present study is the largest series of inguinal hernia repairs using AHD reported to date and is the only study that includes assessment of hernia recurrence and a long-term follow-up period. The remaining studies in the literature examining the use of biologic grafts in inguinal hernia repair have used porcine small intestine submucosa (SIS). Most of these studies are limited by small sample sizes and short follow-up periods; however, no hernia recurrences had been identified through 2 years of follow-up.\textsuperscript{15-20} A randomized controlled trial comparing the use of polypropylene mesh and SIS in Lichtenstein’s repair is the largest investigation of SIS to date and had shown no hernia recurrences with SIS at 3 years.\textsuperscript{21} Therefore, while our data did not show that using AHD in repairing iatrogenic hernia defects is superior to using AWM, there may be a role for the use of SIS or newer biologic grafts in closing these defects after meshectomy.

Our study has several limitations. It is a retrospective study comparing 2 cohorts with different follow-up times, with the AHD group having a significantly shorter follow-up period than the AWM group, potentially decreasing the detection of late hernia recurrences in this group. We attempted to account for this difference in follow-up periods by including time to hernia recurrence in our analysis. In addition, we used telephone interviews to assess hernia recurrence as opposed to physical examination, which would potentially prevent the detection of asymptomatic or occult recurrences. Furthermore, we did not use standardized or validated instruments to assess pain or satisfaction, potentially introducing variation because of the subjective nature of the patient responses. Another limitation is that only 56% (67 of 119) of the study population were included in the final analysis owing to an inability to contact many patients. This is due to the fact that most patients were referred to one

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|}
\hline
\textbf{Predictor} & \textbf{Univariate Analysis} & \textbf{Multivariate Analysis} & \\
 & \textbf{Odds Ratio (95\% Confidence Interval)} & \textbf{Value} & \textbf{Value} \\
\hline
Patient smoking & 8.4 (1.6-43.8) & .01 & 9.1 (1.6-52.2) & .01 \\
Filing of workers’ compensation claims & 10.9 (1.3-92.3) & .03 & 12.8 (1.4-118.1) & .02 \\
\hline
\end{tabular}
\caption{Predictors of Patient Dissatisfaction With Meshectomy by Univariate and Multivariate Analysis\textsuperscript{a}}
\end{table}

\textsuperscript{a}Odds ratios exceeding 1.0 indicate a greater likelihood of patient dissatisfaction based on logistic regression analysis.
of us (J.R.S.) specifically for this specialized procedure, and we did not have updated contact information in our system at the time of the study.

In conclusion, meshectomy with selective neurectomy for postherniorrhaphy mesh inguinodynia results in symptom improvement and patient satisfaction rates that approach 80% among the cohort of 67 patients identified from our database. Complication and recurrence rates after AHD repair were comparable to those for recurrent hernia repairs without mesh. Given the equivalent outcomes between the use of AHD and AWM to repair the iatrogenic hernia defect after meshectomy, as well as the high cost of AHD products, AHD repair can only be cautiously recommended at this time. Further studies are needed to identify patient groups that are most likely to benefit from this procedure and to test alternative methods for closing the postmeshectomy defect to reduce hernia recurrence rates.

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Correspondence: James R. Starling, MD, Division of General Surgery, Department of Surgery, University of Wisconsin–Madison, 600 Highland Ave, Madison, WI 53792 (starling@surgery.wisc.edu).

Author Contributions: Drs Koopmann, Yamane, and Starling had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Koopmann, Yamane, and Starling. Acquisition of data: Koopmann, Yamane, and Starling. Analysis and interpretation of data: Koopmann, Yamane, and Starling. Drafting of the manuscript: Koopmann and Starling. Critical revision of the manuscript for important intellectual content: Koopmann, Yamane, and Starling. Statistical analysis: Koopmann. Obtained funding: Starling. Administrative, technical, and material support: Starling. Study supervision: Starling.

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