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Extensor Mechanism Allograft Reconstruction for Extensor Mechanism Failure Following Total Knee Arthroplasty

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Background: Extensor mechanism disruption following total knee arthroplasty is a rare but devastating complication. The purpose of this study was to report our experience with extensor mechanism allograft reconstruction for chronic extensor mechanism failure.

Methods: Fifty consecutive extensor mechanism allograft reconstructions were performed in forty-seven patients with a mean age of 67.6 years who were followed for a mean time of 57.6 months (range, twenty-four to 125 months). The operative technique included the use of a fresh-frozen, correctly sized full extensor mechanism allograft that was tensioned tightly in full extension. Patients were evaluated clinically with use of the Knee Society score, and reconstructions were considered failures if the patient had a score of <60 points or a recurrent extensor lag of >30° or if they required revision or removal of the allograft.

Results: Nineteen reconstructions (38%) were considered failures, including four revised to a second extensor mechanism allograft due to failure of the allograft, five for deep infection, and ten considered clinical failures secondary to a Knee Society score of <60 points or an extensor lag of >30°. The mean Knee Society score improved from 33.9 to 75.9 points ($p < 0.0001$). The estimated Kaplan-Meier survivorship with failure for any reason as the end point was 56.2% (95% confidence interval, 39.4% to 70.1%) at ten years.

Conclusions: Extensor mechanism disruption following total knee arthroplasty is a difficult complication to treat, with modest outcomes. Extensor mechanism allograft reconstruction is a reasonable option; however, patients must be informed regarding the substantial risk of complications, and although initial extensor mechanism function may be restored, expectations regarding longer-term outcomes are more guarded.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Peer Review: This article was reviewed by the Editor-in-Chief and one Deputy Editor, and it underwent blinded review by two or more outside experts. The Deputy Editor reviewed each revision of the article, and it underwent a final review by the Editor-in-Chief prior to publication. Final corrections and clarifications occurred during one or more exchanges between the author(s) and copyeditors.

Extensor mechanism failure following total knee arthroplasty is a rare[1-3] but serious complication that leads to substantial patient morbidity. Patients often have difficulty walking, given the loss of active knee extension, and instability that typically manifests as recurrent falls. There are several different options for treatment including use of a brace[4];

Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. One or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

primary repair[5]; and augmentation with native tissue[6,7], allograft[8,9], autograft[1], or synthetic materials[10]. The results of operative treatment have been variable with many series reporting poor outcomes[1-3,11-14]; however, nonoperative treatment is typically not well tolerated. Hence, the optimal form of management is controversial. Prior studies showing the results of operative treatment in general have described small cohorts with relatively short follow-up.

We previously reported the results of twenty consecutive complete extensor mechanism allograft reconstructions[15] that included the tibial tubercle, patellar tendon, patella, and quadriceps tendon. Seven knees underwent reconstruction utilizing the technique of Emerson et al.[16,17], in which the allograft was tensioned to allow for 60° of passive intraoperative flexion, and all of these reconstructions went on to failure. Thirteen knees underwent reconstruction using the technique of Nazarian and Booth[18], in which the allograft was tensioned tightly in full extension. With a mean follow-up of thirty-seven months, all of these reconstructions were considered successes. The purpose of the present study was to report the results of a larger series of complete extensor mechanism allografts that were performed with the allograft tensioned tightly in full extension. We were particularly interested to determine whether our originally reported results were durable over time, what the most common complications were, and if there were any technical or patient-related factors that predicted success or failure.

Materials and Methods

Sixty-four consecutive knees reconstructed with a complete extensor mechanism allograft that was tensioned tightly in full extension (see Appendix) were performed in sixty-one patients by four surgeons (three of whom [C.J.D.V., R.A.B., and S.M.S.] were authors in this study) at the same institution following institutional review board approval. All knees had extensor mechanism failure following total knee arthroplasty, and the mean patient age at the time of surgery was 67.6 years (range, forty-one to eighty-seven years). Of the thirteen patients described in our original report, eleven were included in this analysis as they had had additional follow-up, one was excluded because the extensor mechanism allograft had been performed as part of a two-stage exchange, and one was lost to follow-up. Additional patients who were excluded from this analysis included five who had undergone revision extensor mechanism allograft and three who had undergone the procedure performed as part of a two-stage exchange. One additional patient was lost to follow-up and three patients died prior to the two-year follow-up, leaving fifty reconstructions in forty-seven patients (fifteen men and thirty-two women) available for study at a minimum two years of follow-up. Of the fifty reconstructions, treatment was for twenty-two patellar tendon tears; twelve quadriceps tendon tears; eight patellar fractures that were united and associated with incompetence of the extensor mechanism; six knee instabilities, extensor mechanism subluxations, and extensor lags without a discrete extensor mechanism disruption (a prior patellectomy had been performed in five knees); and two severe patella baja with associated stiffness. For patients with an extensor mechanism disruption, the mean time from diagnosis to final extensor mechanism allograft reconstruction was twenty-six months (range, one to 161 months).

Clinical and radiographic evaluation was performed at six weeks, at twelve weeks, at six months, at one year, and yearly thereafter. Knee Society scores were obtained at each visit. Hospital for Special Surgery knee scores were used in the original study[15]; however, our institution has converted to using the Knee Society score and, therefore, we used this scoring system in the present study[19]. Failure was defined as a Knee Society score of <60 points, an extensor lag of >30°, or revision surgery requiring repeat extensor mechanism allograft reconstruction, amputation, or fusion.

The operative technique was unchanged from our prior report[15]. Briefly, this included the use of a same sided, correctly sized fresh-frozen extensor mechanism allograft including the proximal tibia. Twenty grafts (40%) were nonirradiated, and the balance, after 2005, was sterilized by the supplier (AlloSource, Chicago, Illinois) at 1.0 to 1.3 Mrads on the basis of the U.S. Food and Drug Administration (FDA) recommendations. A trough was fashioned in the proximal tibia to accept the tibial tubercle bone block, which was press-fit into place and then was fixed with two or three 16-gauge wires (forty-seven knees), two 6.5-mm cancellous screws (two knees), or two 16-gauge wires with one screw (one knee). The graft was then tensioned tightly in full extension and was covered with as much host tissue as possible; the allograft patella was not resurfaced. The postoperative regimen included immobilization in extension for six weeks followed by progressive range of motion starting at 0° to 30° in a hinged knee brace advancing 10° per week. Seventeen (34%) of the fifty knees had undergone a prior attempt at primary repair (mean, 1.4 prior attempts [range, one to three prior attempts]) and a concomitant revision of both components was performed in twenty-three knees (46%).

Survivorship analysis with failure for any reason was calculated with use of the Kaplan-Meier method. The Student t test was used to analyze continuous variables with significance set at $p < 0.05$. Multivariate regression analysis was performed to identify variables associated with failure. Variables examined included age, sex, location of tear, time between tear and reconstruction, time between index procedure and reconstruction, and concomitant component revision.

Source of Funding

There was no external funding for this study.

Results

At a mean follow-up time of 57.6 months (range, twenty-four to 125 months), the mean Knee Society score improved from 33.9 to 75.9 points (range, 8 to 100 points) ($p < 0.0001$) (see Appendix). Twenty-one (44.7%) of forty-seven patients were walking with no assistive device and twenty-five (50%) of fifty knees had full or near full active extension (an extensor lag of <10°), with an overall mean extensor lag of 13° (range, 0° to 90°). Forty-six (92%) of fifty knees had full or near-full active extension (extensor lag, <10°) at some point in their early postoperative course (within three months), with a mean extensor lag of 3° (range, 0° to 50°) at the three-month postoperative time point.

Nineteen (38%) of the fifty knees were considered failures. Four required a repeat extensor mechanism allograft reconstruction (three for recurrent instability secondary to stretching of the graft and one for an extensor mechanism rupture), five failed secondary to a deep infection (two eventually were treated with amputation, two were treated with a knee arthrodesis, and one was treated with a revision extensor mechanism allograft reconstruction following a two-stage exchange), and ten were deemed clinical failures secondary to a Knee Society score of <60 points or an extensor lag of >30°. Failure occurred at a mean time of twenty-one months after extensor mechanism allograft reconstruction. The Kaplan-Meier estimated survivorship with failure for any reason as the end point was 56.2% (95% confidence interval [95% CI], 39.4% to 70.1%) at ten years (Fig. 1). With the numbers available for study, no specific variables were identified that correlated with failure.

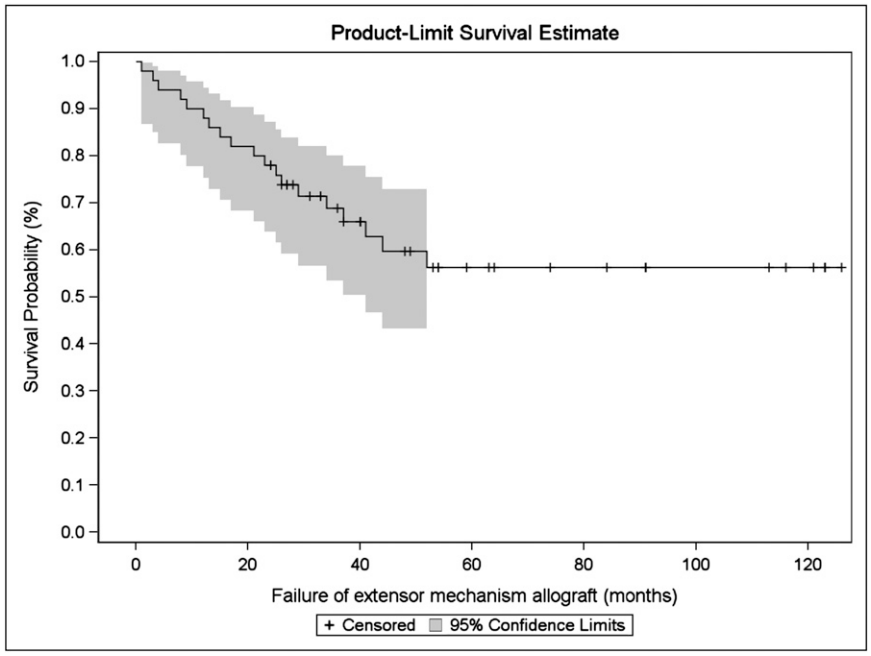

Fig. 1

Kaplan-Meier survival showing a periprosthetic fracture of the tibia following extensor mechanism allograft reconstruction in a patient in whom concomitant revision was not performed.

Additional complications included six revisions of the tibial bone block fixation (all had been fixed with wires alone and five of the six bone blocks went on to successful union), three periprosthetic fractures of the tibia at the site of the tibial bone block (all were seen in cases in which the tibial component was short and not concomitantly revised or when a short stem was used for the revision) (see Appendix), four periprosthetic femoral fractures secondary to falls, one manipulation under anesthesia, and one partial quadriceps tear requiring operative repair. The periprosthetic tibial fractures were all treated nonoperatively; however, two of the reconstructions were considered failures, both secondary to a Knee Society score of <60 points. Three of the four periprosthetic femoral fractures were treated with open reduction and internal fixation; one of these was considered a failure secondary to an extensor lag of >30° and a Knee Society score of 55 points.

Discussion

Although extensor mechanism disruption is a rare complication following total knee arthroplasty with incidence ranging from 0.10% to 2.5%[1-3,20], it results in substantial morbidity and is typically not well tolerated in patients secondary to difficulty walking and severe knee instability. Hence, operative treatment is typically attempted, but the outcomes have been mixed[8,14,15,17,18,21], and the ideal method of treatment remains unclear. The current study demonstrates that, although our initial experience with a complete extensor mechanism allograft tensioned tightly in full extension was good, the overall complication rate is high and the results have degraded over time with an estimated ten-year survivorship of just over 50%[15]. Although some of the differences in the reported results may be due to a stricter definition of failure that considers a Knee Society score of <60 points as a clinical failure, these findings do provide both patients and surgeons with more realistic expectations for the outcomes of the treatment for this complication.

When compared with prior studies of a complete extensor mechanism allograft, our results show a higher rate of failure with longer-term follow-up. Burnett et al.[22] reported on nineteen patients with extensor mechanism reconstruction at a mean follow-up time of fifty-six months. They demonstrated an increase in the Knee Society score from 27 points preoperatively to 76 points postoperatively, which is consistent with our findings. They cited an 89% patient satisfaction rate; however, three patients were clinical failures applying the same criteria as in our study. Additionally, only nine of the nineteen patients underwent reconstruction with a complete extensor mechanism composite as was used in our study; the other ten patients underwent an Achilles tendon allograft with a calcaneal bone block. Nazarian and Booth[18] originally described the technique and reported successful clinical results in thirty-four of thirty-six patients at a mean of 3.6 years and showed an average increase in the Knee Society score from 37 to 68 points. However, eight of these patients required a second revision extensor mechanism allograft for recurrent failure and, if the same criteria from our study had been applied, the failure rate would have been higher.

An alternative for treatment is the use of synthetic mesh (Marlex mesh; C.R. Bard, Murray Hill, New Jersey). Browne

and Hanssen[10] used this material for reconstruction in a cohort of thirteen patients with a mean follow-up of forty-two months. Three patients had failure, and one had developed an infection, leaving nine (69%) of the original thirteen patients with a well-functioning extension mechanism. These results are encouraging; however, this report describes a small cohort followed for a relatively short period of time and not unlike our results, clinical outcomes may deteriorate with time. Unfortunately, our own experience with mesh reconstruction is limited to two cases, both of which meet the definition for failure as defined in our study.

Achilles tendon allograft reconstruction with a calcaneal bone block for tibial fixation has also been used to reconstruct the extensor mechanism. To our knowledge, the first reported series of patients revised with this technique was by Crossett et al.[8], who described nine patients successfully treated with this method at a minimum follow-up of two years. However, there were two early failures requiring repeat repair. As previously mentioned, ten of the patients in the study by Burnett et al.[22] were also reconstructed in this manner. The most comprehensive report on this technique is by Diaz-Ledezma et al.[23] who demonstrated a modest 58.6% success rate in twenty-nine knees at a mean follow-up of 3.5 years. Although an advantage of an Achilles tendon allograft in the case of an isolated patellar tendon disruption is preservation of the native patella, our experience is that proximal fixation of the graft is more difficult as it fans out and thins proximally. Further, it can be difficult to cover the allograft fully with native tissue, and hence the allograft oftentimes lies just beneath the skin. Hence, although the results of an Achilles tendon allograft are similar, our preference remains a full extensor mechanism allograft.

At 10% in our series, deep infection was one of the most common complications and led to many of the poorest outcomes, including the need for amputation and arthrodesis. Many of these patients had undergone multiple prior attempts at surgical treatment, and hence the soft-tissue envelope was likely compromised. Combined with use of a large allograft or other foreign material, this complication has been reported to have a substantial prevalence in most reported series[8,10,23] and is probably common to all of the techniques used in contemporary practice other than those that use autograft tissue for augmentation.

An understanding of patient or technical factors contributing to treatment failures would be useful for surgeons who are treating this complication. Unfortunately, with the number of patients available for study, we are unable to identify any risk factors for failure or for the occurrence of complications. However, on the basis of the results and given the observed 12% rate of failure of distal fixation of the graft in our study, we have altered our surgical technique and now either use screws for adjunctive fixation of the allograft or attempt to pass the fixation wires around the stem of the implant, if a concomitant component revision is performed (see Appendix).

It is important to recognize that nearly half of the patients in this series required a concomitant revision procedure, as instability, stiffness, and component malposition are common in patients who sustain an extensor mechanism disruption, and hence the surgeon should be ready to revise components at the time of extensor allograft reconstruction. Further, given that there were several patients in whom a short stem or a primary component was utilized for reconstruction and who later sustained a stress-type fracture of the tibia, our threshold to revise the components to a reconstruction with a longer tibial stem is lower. However, in cases in which component size, rotation, and overall stability are ideal, we still will retain the original components[24]. Finally, given the frequency with which patients who experience failure report instability, we now typically use a rotating hinge implant if a concomitant revision is performed.

In summary, extensor mechanism disruption following total knee arthroplasty is a difficult complication to treat. Although we still utilize a complete allograft extensor mechanism for treatment of chronic extensor mechanism deficiency, we carefully counsel patients on the seriousness of this complication and that, although initial results may be good, clinical results may deteriorate with time and the overall complication rate associated with the treatment (particularly deep infection) is high. Given the relatively high rate of failure overall, even in patients with well-functioning allografts, we now recommend the use of an assistive device when walking, given the impaired proprioception resulting from the replacement of native tissues with both an implant and an allograft extensor mechanism.

Appendix

(eA) Figures showing radiographs of a patient preoperatively with extensor mechanism disruption following a revision total knee arthroplasty and postoperatively following extensor mechanism allograft reconstruction at five years showing healing of the tibial bone block and correction of the previously seen patella alta and radiographs demonstrating a tibial graft fixation wire passed around the stem of the revision implant and cerclage wires passed around the implant stem for additional fixation strength and a table showing the summary of results are available with the online version of this article as a data supplement at jbjs.org. ■

NOTE: We would like to thank Aaron Rosenberg, Mario Moric, Vamsi Kancherla, and Laura Quigley for their assistance with this study.

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