Review

Synthetic mesh vs. allograft extensor mechanism reconstruction in total knee arthroplasty — A systematic review of the literature and meta-analysis

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A B S T R A C T

Background: Extensor mechanism disruption after total knee arthroplasty (TKA) is a devastating complication. Reconstruction with allograft and synthetic mesh has been described. However, these reports have typically been small case series, and controversy exists with regard to which reconstruction technique is optimal.

Methods: The authors performed a systematic review using PUBMED, MEDLINE, EMBASE, BIOSIS, ClinicalTrials.gov, and Cochrane Database of Systematic Reviews identifying 14 articles meeting inclusion criteria and producing 204 knees for comparison. Studies with repairs performed under full knee extension were included. Case reports and non-English studies were excluded. Available demographics and clinical outcome data were collected from each study. Appropriate statistical analysis was performed to compare the variables.

Results: Baseline demographics and patient complexity were similar between the two cohorts. Reconstruction success rates (76% allograft vs. 74% mesh), average time to diagnosis/treatment, Knee Society Scores (KSS), knee range of motion/extensor lag, and complication rates yielded no statistical difference. Synthetic mesh was used more frequently with concomitant revision of components.

Discussion: This systematic review shows equivalent success of allograft and synthetic mesh with approximately 25% failure rate in both groups. Periprosthetic joint infection remains a common and significant complication and reason for failure in both groups. Overall, synthetic mesh showed equivalent extensor mechanism reconstruction success as allograft but with much lower cost, near universal availability, lack of disease transmission, and potential for diminishing graft stretch-out. Future research in larger case series or comparative study is needed to help aid in management of this largely unsolved problem in total knee reconstruction.

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1. Introduction

Extensor mechanism disruption after total knee arthroplasty (TKA) is an uncommon [1–3] but devastating complication that can result in significant functional impairments such as difficulty with ambulation, lack of active knee extension, knee instability, and recurrent falls. There are multiple potential causes for extensor mechanism disruption including trauma, diabetes, chronic steroid use, multiple knee operations, and iatrogenic etiology [4]. Patients will often force the knee into hyperextension in the stance phase of gait (back-knee gait), which can lead to implant loosening [2]. Traditional surgical management has consisted of primary repair vs. reconstruction.

Although primary repair may be attempted in select cases of acute or partial extensor mechanism disruption, the outcomes of primary repair have had dismal results in the literature [5]. Direct repair has largely been abandoned as treatment for chronic extensor mechanism disruption, and reconstruction with allograft or synthetic mesh has been the mainstay of surgical treatment. Multiple allograft techniques have been described, but Achilles tendon with a calcaneal bone block and whole extensor mechanism allograft have been the most commonly used methods of allograft reconstruction [6]. The mid-term and long-term results of allograft reconstruction have been variable, with progressive extensor lag being noted, especially when the graft is not tensioned in extension [7]. Further issues with allograft include availability, graft mismatch to host, immune reaction, disease transmission, and cost [4]. The concerns with allograft repair have prompted surgeons to investigate synthetic material such as Marlex Mesh (C.R. Bard, Murray Hill, NJ) for use in chronic extensor mechanism reconstruction. Several small series have reported on monofilament polypropylene synthetic mesh with a majority of patients having successful and durable outcomes [9]. Although allografts and synthetic mesh for extensor mechanism reconstructions have been reported on, there is still significant debate regarding which method is superior, and there are no published data comparing the two techniques. In this paper, the authors performed a systematic review of the literature to determine if one method of reconstruction was superior with regard to success of reconstruction, knee outcome scores, range of motion, and complications.

2. Methods

2.1. Search strategy

All methods used in this meta-analysis follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist, which can be accessed at prisma-statement.org. Extensive electronic searches were conducted with the aid of an experienced medical university librarian in October of 2016. We searched for extensor mechanism reconstruction after total knee arthroplasty. The databases searched include PUBMED, MEDLINE, MEDLINE In-Process, EMBASE, BIOSIS, Clinicaltrials.gov, and Cochrane Database of Systematic Reviews. Full text searching of key surgical journals was also performed including Clinical Orthopaedics and Related Research, Journal of Arthroplasty, Journal of Bone and Joint Surgery American, and Journal of Bone and Joint Surgery British. Searches were not restricted by study design, publication year, or language, and conference proceedings and abstracts were included in the search to aid in the identification of full length peer reviewed articles for review. Reference lists of all included studies were scanned to identify additional relevant studies. Search terms included “extensor mechanism”, “allografts,” “synthetic mesh,” and “revision”.

Any reports meeting the following criteria were excluded: (1) studies not in English; (2) extensor mechanisms not tensioned in extension; (3) review articles and letters to the editor; (4) non-clinical outcome measures; (5) reports of treatment of any joint other than knee; (5) studies using non-human subjects or in vitro studies (including biomechanical studies); and (6) case reports or summary papers with less than five patients. The systematic search generated 78 studies from the above-mentioned electronic sources. No additional studies meeting the inclusion criteria were identified with the previously described technique. From the initial 78 studies, 64 studies were excluded based on the above-mentioned criteria leaving 14 studies for review as summarized by Table 1. Data was extracted from these 14 studies.

2.2. Methodology, level of evidence assessment, and assessment of risk bias

Two reviewers independently screened titles, abstracts, and full text papers for eligibility, extracted data via a standard form, and evaluated the methodological quality of the articles. Any disagreement between the two reviewers was resolved through
consultation with a third reviewer. Studies were placed in either the allograft group, or the synthetic mesh group. The allograft group included Achilles-calcaneal bone blocks and whole extensor mechanism allografts. The mesh group including Marlex (C.R. Bard, Murray Hill, NJ). Study design, level of evidence, demographics, number of complex vs. non-complex patients, Knee Society Score outcome measures (KSS), range of motion, acute vs. chronic ruptures, type of allograft used, time from diagnosis to treatment and extensor lag, success of reconstruction, and complications were all recorded. Studies were also stratified by level of evidence and the level of case complexity. The level of evidence was graded based on the classification introduced by Wright et al. [8]. Criteria for a complex patient included prior TKA infection, revision TKA, prior extensor mechanism repairs, and/or has been on chronic steroids. Patients with diabetes and rheumatoid arthritis were not considered complex. The complex data was then compared to non-complex data to elucidate differences in case complexity for group.

2.3. Statistical analysis

For the subsample of studies that reported each outcome, the mean average, range of averages, and weighted mean of the study sample size were calculated. Few studies reported standard deviations or standard errors precluding the prediction of inter-study variability by meta-analytic methods. For continuous data, we made normal-theory assumptions and used one-way analysis of variance (ANOVA) to compare continuous data. For categorical data, the chi square and Fisher exact tests were used for analysis.

3. Results

3.1. Demographics

Patient demographics are summarized in Table 2. A total of 204 patients who underwent reconstruction for failed extensor mechanism following total knee arthroplasty were identified from 14 studies. There were 175 patients who underwent an allograft repair and 29 patients who underwent repair utilizing synthetic mesh. Of the 14 studies included [7,9–15,17,18–22,23], 10 evaluated outcomes of allograft repair. Of these 10 studies, two were level III and eight were level IV evidence. Alternatively, four studies evaluated the outcomes of synthetic mesh repair, and all of these were level IV evidence. The weighted mean patient age in the allograft group was 66.1 years with a standard deviation of 6.4 (32–36.4) and 34.5 for the mesh group with a standard deviation of 7.7 (31–36), p-value of 0.5964. Six studies [9,10,18,20,21,23] reported absence/presence of rheumatoid arthritis calculated to an 8% prevalence within the allograft group, eight percent prevalence for the mesh group, and 11% overall prevalence with a p-value of 0.7165. Two studies [18,22] reported absence/presence of osteoarthritis calculated to an 89% prevalence within the allograft group, 100% prevalence for the mesh group, and 92% overall prevalence with a p-value of 1.000. Finally, based on the studies reporting smoking history [10,21], we found that eight percent of the allograft and 17% of the mesh group were smokers with an overall prevalence of 10%, p-value of 0.4883. These comparisons were all non-statistically significant.

3.2. Study characteristics

A sub-analysis of complex vs. non-complex patients was performed to further analyze potential differences between the allograft and mesh groups. Twelve studies [7,9–12,14,15,18,20,21–23] included sufficient data to stratify by our definition of complexity, and 60% of these 152 patients were considered complex, with 59% in the allograft group and 66% in the mesh group, p-value.
of 0.4903. Categorization as non-complex could be determined for 138 patients in 12 studies [7.9–12,14,15,18,20,21–23] yielding an overall 46%, derived from 49% and 34% within the allograft and mesh groups, respectively (p-value of 0.1742).

We used seven studies [10,11,14,20–22] accounting for 91 patients to separate between mechanism disruption after primary vs. revision TKA. Overall, 45% of the repairs occurred in the context of primary TKA, and allograft was used in 51% of extensor mechanism disruptions associated with a primary knee replacement vs. 26% mesh, which was statistically significant (p-value of 0.0344). Similarly, we used six studies [8,13,18,20,22,23] accounting for 66 patients to separate between repair following acute vs. chronic mechanism disruption and found that overall, 48% of the repairs followed acute disruption comprised of 55% of the allograft group and 38% of the mesh group, which was non-statistically significant (p-value of 0.1771).

The average time from diagnosis of extensor mechanism disruption to surgical repair was reported for 76 patients as 19.5 months with a standard deviation of 55 (5.1 to nine) for the mesh group [9,21–23] with 29 patients reported post-operative extensor lag for the mesh group yielding a weighted mean of 18.0°, again not statistically significant (p-value of 0.1771). Four papers [7,11,13,14] accounting for 39 articles [21–23] with a total of 145 patients reported data on repair success with an overall success rate of 76.4% with a mean average of 9.5° with a standard deviation of 21.4° (1.25 to 84°). Three studies in the mesh group [9,21–23] totaling 38% of the mesh group, which was non-statistically significant (p-value of 0.7264).

We used seven studies [10,11,14,15,18,20,21–23] for a weighted mean average of 7.7° with a standard deviation of 12.4° (95° to 23°) for the 174 patients in the allograft group [7,10,11–15,17,18,20] and 4.2 with a standard deviation of 8.1 (1.6 to nine) for the 29 patients with the mesh group [9,21–23], yielding non-statistically significant difference (p-value of 0.7893).

3.3. Clinical outcomes

3.3.1. Success of reconstruction

Fourteen studies [7.9–15,17,18,20–23] accounting for 213 patients reported data on repair success with an overall success rate of 76%. The success rate in the allograft group was 76% and 74% in the mesh group (p-value of 0.8451). Three studies in the mesh group [21–23] and four studies in the allograft group [7,10,18,20] totaling 90 patients reported average patient age in successful mechanism repair. The weighted mean year-follow-up was 4.2 with a standard deviation of 4.6 (2.1 to 5.7) for the 174 patients in the allograft group [7,10,11–15,17,18,20] and 4.2 with a standard deviation of 8.1 (1.6 to nine) for the 29 patients with the mesh group [9,21–23], yielding non-statistically significant difference (p-value of 0.7893).

3.3.2. Knee outcome scores

Six studies [7,11,13,15,17,18] with a total of 104 patients included pre-operative KSS (function) scores with a mean of 55 (1.1 to 26) based on three studies [11,17,18] for the allograft group, and three months based on one study [21] from the mesh group. The weighted mean year-follow-up was 4.2 with a standard deviation of 4.6 (2.1 to 5.7) for the 174 patients in the allograft group [7,10,11–15,17,18,20] and 4.2 with a standard deviation of 8.1 (1.6 to nine) for the 29 patients with the mesh group [9,21–23], yielding non-statistically significant difference (p-value of 0.7893).

The weighted mean average age for success was 66.8 years with a standard deviation of 7.1 (64–68) for the mesh studies and 65.1 with a standard deviation of 13.3 (59–69) for the allograft studies.

3.3.3. Range of motion

In the allograft group, three papers [10,11,13] accounting for 45 patients reported knee flexion as a component of pre-operative range of motion yielding a weighted mean of 100.1° with a standard deviation of 33.3° (84° to 105°). In the mesh group, two papers [9,22] accounting for 16 patients reported pre-operative knee flexion with a weighted mean of 107.5° and a standard deviation of 37.5° (103° to 127°), which was not statistically significant (p-value of 0.5720). Four papers [7,11,13,14] accounting for 39 patients within the allograft group reported range of motion for pre-operative knee flexion yielding a weighted mean of 99.1° with a standard deviation of 12.4° (95° to 104°). In the mesh group, four papers [9,21–23] with 29 patients reported post-operative knee flexion with a weighted mean of 107.5° with a standard deviation of 16.3° (100° to 115°), which was also non-statistically significant (p-value of 0.0905). The average post-operative extensor lag following successful repair was reported by eight studies [7,11–13,15,17,18,20] with 145 patients in the allograft group for a weighted mean average of 7.7° with a standard deviation of 21.2° (1.0° to 14.6°). Three studies [21–23] with 26 patients reported on extensor lag for the mesh group yielding a weighted mean average of 9.5° with a standard deviation of 21.4° (1.25 to 18.0°), again not statistically significant (p-value of 0.7264).

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3.3.4. Complications

Fourteen studies [7,9-15,17,18,20-23] accounting for 213 patients reported data on mechanism failure with an overall failure rate of 23% based on a 23% failure rate in both the allograft and mesh groups (p-value of 0.9516). One study in the mesh group [21] and three studies in the allograft group [10,18,20] totaling 67 patients reported average patient age in failure. The weighted mean average age in failure was 61 years for the mesh study and 67.2 with a standard deviation of 35.2 (60-77) for the allograft studies. As shown in Table 3, there were four studies [9,10,17,21] representing 103 patients that reported data on mechanism failure due to infection. The combined failure rate due to infection was 13% based on a 12% failure rate in the allograft group and a 15% failure rate in the mesh group, which is not statistically significant (p-value of 0.7212).

4. Discussion

Disruption of the extensor mechanism continues to be one of the most challenging complications to manage after TKA. The incidence is low (0.10% to 2.5%) [16] but disruption results in significant morbidity due to inability to ambulate and knee instability. For these reasons, operative intervention is typically indicated but with variable outcomes. The literature has been limited to small case series from a few centers and there has been variability in recently described techniques, such as tensioning the graft in extension. In general, extensor mechanism reconstruction is performed using allograft (full extensor mechanism, Achilles allograft) or synthetic mesh [9,17,18].

Recent studies of extensor mechanism allograft have shown modest results at longer follow-up including degradation of the allograft with estimated 10-year survivorship of 56.2% [17]. Booth and Nazarian [19], who originally described the technique, reported higher success rates with 34 of 36 deemed successful; however, eight patients required a revision extensor mechanism for recurrent failure. Burnett et al. [7], demonstrated significant improvements in Knee Society Scores for allograft reconstruction with an 89% patient satisfaction rate at follow-up at 56 months. Reasonable results with Achilles allograft (preservation of host patella) have been reported [18] but are also variable. Díaz-Ledezma et al. [20] demonstrated a 58.6% success rate in 29 knees at 3.5 years. Although preservation of host patella may be desirable, many surgeons prefer a full extensor mechanism due to more robust distal and proximal fixation. Achilles allograft has a smaller bone block, and the graft itself thins out proximally. This can make proximal fixation more tenuous, and the allograft itself can remain subcutaneous rather than covered by host tissue. Other cons of allograft use are high cost, lack of availability, graft host mismatch, disease transmission, and late stretching of the graft.

An alternative treatment has been the use of synthetic mesh (Marlex mesh; C.R. Bard, Murray Hill, New Jersey). Browne and Hanssen [9] used mesh to reconstruct 13 patients with a mean follow-up of 42 months. Three patients had mechanical failure, and one infection resulting in clinical success in 69% of patients. The clinical outcomes of this mesh study are similar to that of allografts in the literature. Nodzo and Rachala [21] evaluated seven quadriceps tendon ruptures treated with synthetic mesh at 34-months of follow-up. Four of the seven were considered clinical success (extensor lag < 30°). Two of the failures re-ruptured and became infected. The third had an extensor lag >40° but did not require reoperation. Some advantages to synthetic mesh over allograft are near universal availability, lower cost, no disease transmission, and no graft-host mismatch. One disadvantage can be distal fixation of the mesh when a concomitant tibial revision is not being performed. Despite some potential advantages there has not been a clinical superiority to the mesh in the literature.

Our paper compares allograft and synthetic mesh extensor mechanism reconstruction techniques to determine if one method is clinically superior to the other. As mentioned, one of the major limitations in the literature is the lack of large prospective randomized studies. Most studies are level III or level IV small case series with inability to compare one technique to other. The incidence of extensor mechanism disruption is low and along with reporting, a systematic review is necessary to pool patient to allow for comparison. In this study, the patients were demographically matched and the control for case-complexity was similar between groups. Average time to diagnosis and treatment was also similar with equivalent reconstruction success rates (76% allograft vs. 74% mesh). There was no difference between KSS scores or range of motion. Interestingly, allograft was used in 51% of extensor mechanism disruptions associated with a primary knee replacement vs. 26% mesh (p-value of 0.0344). One explanation for this finding is that anchoring mesh distally when the tibia is not being revised can be difficult. It requires a trough to be burred along with screw and cement fixation. Conversely, when the tibial component is being revised, achieving distal fixation with mesh is facile, simply placing the mesh anterior in the tibia and cementing the tibial component in for distal fixation. Surgeons may have a predilection for using mesh when the tibial component is being revised to avoid the need for fashioning a dovetail trough to accept allograft bone in the tibial tubercle. For similar reasons allograft was used with higher frequency in acute disruptions compared to mesh, although not statistically significant.

This study has several limitations. This systematic review has several confounders including the inhomogeneous data pool from which data were extracted. There was no standardization between papers with regard to surgical technique, or postoperative protocols.

Table 3: Complications.

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Allograft</th>
<th>Mesh</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>13/103 (13%)</td>
<td>10/83 (12%)</td>
<td>3/20 (15%)</td>
<td>0.7135</td>
</tr>
<tr>
<td>Patellar tendon rupture</td>
<td>7/54 (13%)</td>
<td>4/47 (9%)</td>
<td>3/7 (43%)</td>
<td>0.0386</td>
</tr>
<tr>
<td>Patellar fracture</td>
<td>1/2 (50%)</td>
<td>1/2 (50%)</td>
<td>N/A</td>
<td>–</td>
</tr>
<tr>
<td>Graft stretching with extensor lag</td>
<td>4/8 (50%)</td>
<td>4/8 (50%)</td>
<td>N/A</td>
<td>–</td>
</tr>
</tbody>
</table>

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Furthermore, there may be inadequate conduct or reporting in the literature itself, since the majority of the analyzed studies are level III and IV levels of evidence. Also, a large proportion of the studies did not report measures of variability (Standard Deviation (SD)) needed for meta-analysis of continuous data. Furthermore, due to the low incidence of extensor mechanism disruption and the number of patients (particularly in the mesh group), this study may fail to detect clinical differences between the two methods when in fact a clinical benefit of one over the other may exist.

In summary, extensor mechanism disruption remains a devastating complication after TKA and this systematic review shows equivalent success of allograft and synthetic mesh with approximately 25% failure rate in both groups. Peri-prosthetic joint infection remains a common and significant complication and reason for failure in both groups. There may be a trend amongst surgeons to utilize synthetic mesh with higher frequency when revising the tibial component due to robust and facile fixation. Overall, synthetic mesh showed equivalent extensor mechanism reconstruction success when compared to allograft but with much lower cost, near universal availability, lack of disease transmission, and potential for diminishing graft stretch-out. Future research in larger case series or comparative study is needed to help aid in management of this largely unsolved problem in total knee reconstruction.

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