Bone Plug versus Suture Fixation of the Posterior Horn in Medial Meniscal Allograft Transplantation

A Biomechanical Study

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Abstract

This study was performed to determine if a meniscal allograft with attached bone plug and suture offers superior fixation when compared to allograft affixed with suture alone through a bony tunnel. Seven pairs of human cadaver proximal tibia specimens were obtained. The specimens were then randomly assigned to either Group 1 (suture alone) or Group 2 (bone plug plus suture). All Group 1 specimens had the meniscus detached at the bony insertion of the anterior and posterior horns, with two No. 2 Ethibond sutures placed at the posterior root insertion. All Group 2 specimens had a posterior horn with a bone plug and two No. 2 Ethibond sutures. Both groups had their respective sutures passed through a 7 mm tibial tunnel and secured over a screw and post on the proximal tibia. The specimens were then loaded to failure. The mean failure load for Group 1 was 111.8 N (SD: 21 N) and for Group 2 was 112 N (SD: 32 N). Based on the Wilcoxon Rank-Sum analysis, the two groups were not significantly different. This study demonstrated no difference in the mean pullout strength of medial meniscal allograft posterior horn fixation between the two groups. This biomechanical cadaveric study demonstrated that it may not be necessary to use an attached bone plug for medial meniscal transplant fixation, as using suture alone will suffice. The choice of using suture alone for the posterior horn meniscal attachment eases the technique of surgery when compared to using a bone plug plus suture.

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Osteoarthritis of the knee develops secondary to increased stresses on the articular surfaces that occur from an absent or damaged meniscus. These important fibrocartilaginous structures help to distribute load, increase contact area, decrease contact stress, protect cartilage, enhance stability, and provide lubrication to the joint.[1,2] In a patient with a deficient meniscus, allograft transplantation is a viable option to help reduce the risk of developing osteoarthritis. Recently, arthroscopically-assisted techniques were developed that help to minimize surgical trauma and offer the potential for quicker recovery and return to functional activities.[3] These techniques can be technically demanding, particularly with regard to posterior horn fixation. Two techniques that have been utilized include attachment with or without a bone plug. Sekiya and colleagues[4] indicated, in their study of 25 patients undergoing meniscal transplantation, that clinical outcome of suture fixation was as effective as the utilization of suture in addition to a bone plug. The only detected difference was that the bone plug group had a significantly better range of motion at latest follow-up.

Numerous studies support improved knee function in patients undergoing the aforementioned procedures.[5-9] Typical indications for meniscal allograft transplant include patients with symptoms consistent with a meniscal deficiency and no more than a grade II chondral lesion. In addition, patients undergoing anterior cruciate ligament (ACL) reconstruction may be candidates for meniscal allograft transplant, if indicated. Finally, meniscal transplant may be indicated early in young patients undergoing meniscectomy to prevent progression of osteoarthritis.[10]

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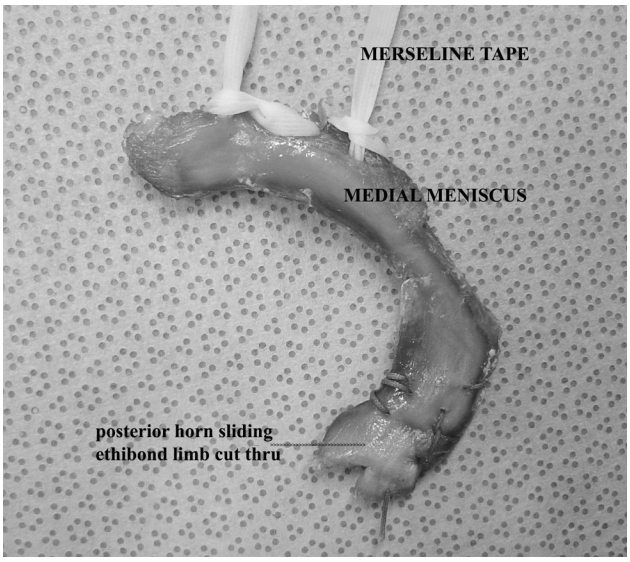

Figure 1 Meniscal allograft with suture alone. The specimen failed when the Ethibond suture cut through the tissue.

Given that there are numerous factors that might contribute to outcome, the purpose of this experiment was to specifically study the pullout strength of meniscal allograft posterior horn fixation, using sutures with and without the assistance of bone graft.

Materials and Methods

Seven pairs of randomly selected human cadaver proximal tibia specimens were obtained. These specimens were dissected free of all soft tissue with the exception of the medial meniscus. There was no evidence of osteophytes, chondrocalcinosis, articular wear, meniscal degeneration, or meniscal tears in the cadaver models. The specimens were then randomly assigned to either Group 1 (suture) or Group 2 (bone plug plus suture). All Group 1 specimens had the meniscus detached at the bony insertion of the anterior and posterior horns. A guide wire was then drilled from the anteromedial aspect of the proximal tibia, exiting at the posterior horn insertion footprint. A 7-mm coring reamer (Arthrex Inc., Naples, Florida) was then used to create a bone tunnel. A Krakow stitch with two No. 2 Ethibond sutures (Ethicon, Somerville, New Jersey) was attached at the posterior horn of the medial meniscus. The free suture ends were then passed through the tibial tunnel and tied over a 4.5 mm partially threaded bicortical cancellous screw, with a washer on the anteromedial aspect of the tibia (Fig. 1).

In Group 2, a tibial plateau was removed and the bone attached to the posterior horn was fashioned into a 7 x 25 mm bone plug. A Keith needle was used to create a hole in the bone plug and two No. 2 Ethibond sutures were then passed. The sutures and bone plug were subsequently inserted into the bone tunnel, with the sutures being tied around the 4.5 mm partially threaded bicortical cancellous screw, with a washer on the anteromedial aspect of the tibia (Fig. 2). Seven millimeter bone tunnels were used in both groups in an attempt to eliminate this as a variable in the fixation of the allograft.

Both groups had No. 5 Mersiline tape sutured into the anterior horn and body of the meniscus. The specimens were then mounted on the MTS machine (MTS Systems Corp., Eden Prairie, Minnesota) (Fig. 3). The machine was calibrated, the specimens were preloaded with a minimal 5N preload and were subsequently loaded to failure. Once all specimens were tested, the data was collected and the force to failure was calculated. Although the meniscus is loaded in shear, load to failure was chosen in this model to answer the question as to fixation stability at the posterior horn. In an attempt to isolate one aspect of fixation, specimens were loaded only to failure without performing cyclical testing. The mean and standard deviation for both groups were calculated, and an analysis of variance (ANOVA), combined with multiple comparison Student t-tests were utilized to

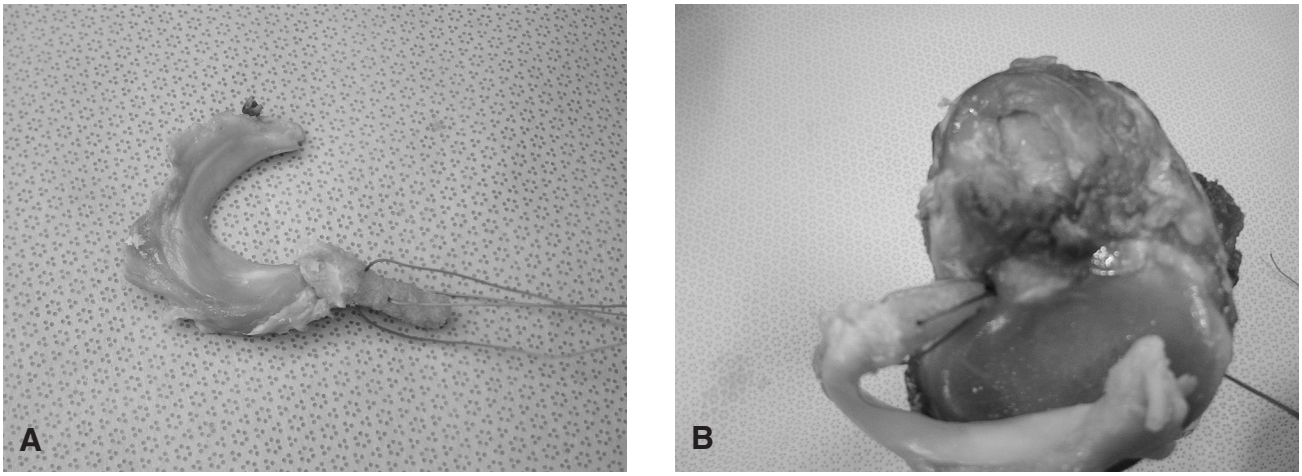

Figure 2 Meniscal allograft with suture and bone plug. **A**, Specimen with bone plug and suture. **B**, Bone plug placement into tunnel.

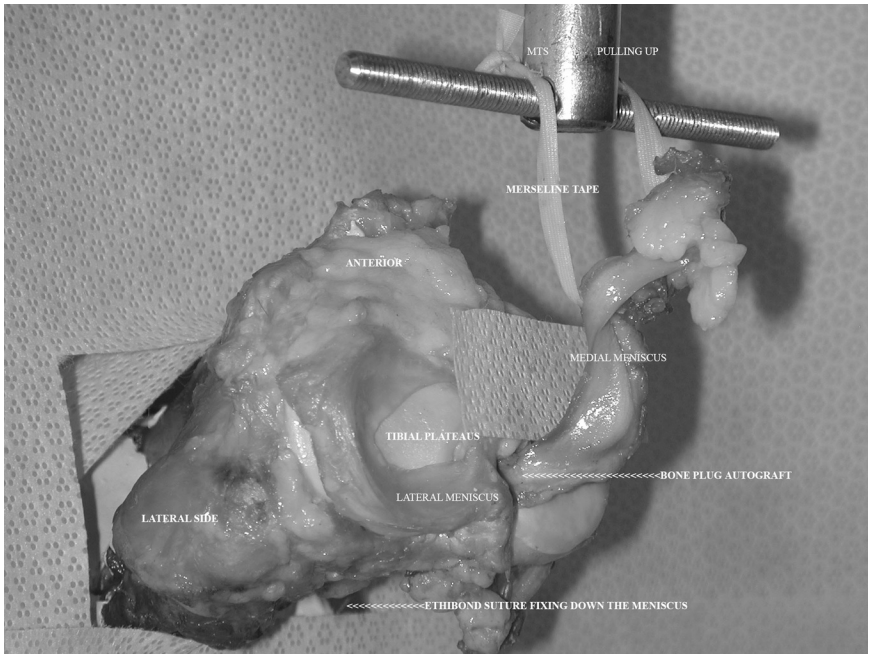

Figure 3 Specimen attached to MTS machine prior to load testing.

compare the two groups. A p value of < 0.05 was used as the level of significance.

Results

Seven specimens were tested in each group. The mean to failure for Group 1 was 111.8 N (SD 21.11). The mean to failure for Group 2 was 112.00 N (SD 32.39). The mode of failure for all specimens in Group 1 was observed to be slippage of the posterior horn along the suture (Fig. 1). In contrast, all specimens in Group 2 failed at the bone suture interface, (i.e., at the most proximal suture position) (Fig. 4). Based on the Wilcoxon Rank-Sum analysis, the difference observed between the two groups was not statistically significant ($p > 0.05$). Post hoc power analysis shows that the present study had an 80% power to detect a difference in load to failure between the two groups.

Discussion

Despite different mechanisms of failure between the two groups in the study, load to failure of fixation of the posterior horn between the two groups was not significantly different. The investigators feel that fixation with a bone plug is technically more demanding than suture fixation alone. In addition, bone plug fixation requires near anatomic placement of the graft in order to potentially prevent an increase in degenerative changes. Similar findings have not been reported in the literature when using suture fixation alone. The study outcome suggests that suture fixation alone is a viable alternative to meniscal allograft fixation with a bone plug. Multiple sutures in shorter tunnels can enhance fixa-

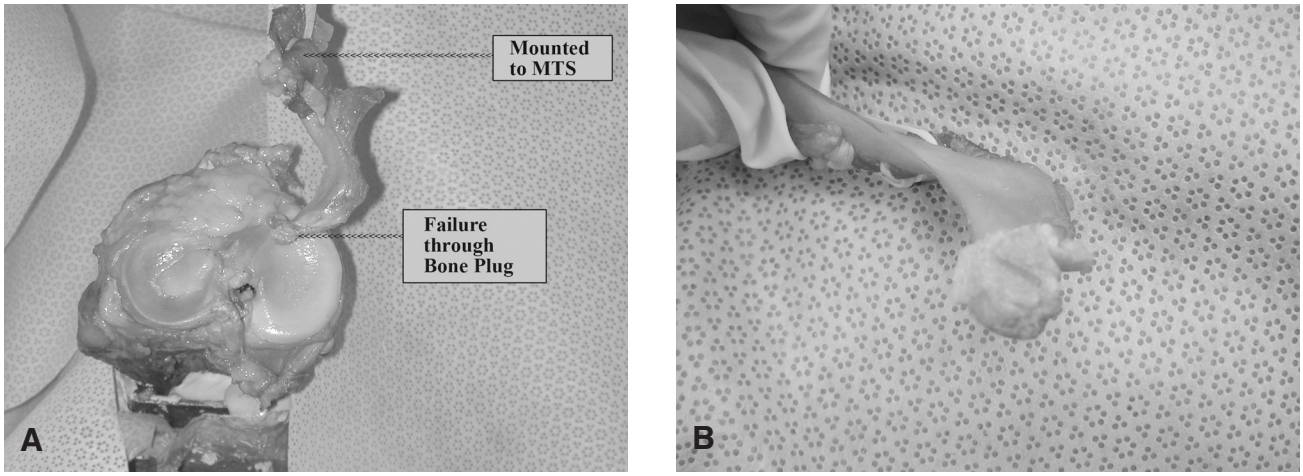

Figure 4 **A**, Failure of the bone plug specimen on the MTS machine. **B**, Area of suture cut out in the bone plug.

tion by increasing implant stiffness and improving contact mechanics.[5]

Meniscal allografts serve to recreate the appropriate joint load distribution. Numerous surgical techniques have been established for fixation of the meniscal allograft, with controversy existing as to the most effective method.

Several studies argue that bone plugs are paramount to fixation of the meniscal allograft, with joint distributions similar to knees having undergone meniscectomy with suture fixation alone.[11,12] In addition, experiments have suggested that suture fixation allows lateral dislocation of the meniscal transplant, which does not serve to protect the articular surfaces.[13-15]

However, the literature also supports meniscal allograft fixation with sutures alone. Lazovic and coworkers[16] demonstrated that an improper bone block fixation might lead to enhanced articular cartilage degeneration. A cadaveric model supported these findings, demonstrating that nonanatomic bony fixation may have adverse effects on successful outcomes.[17] Rodeo and associates[18] also provided histologic evidence that meniscal transplant with suture alone is superior to bony fixation. Clinical outcomes of allograft transplant without bone plugs has also shown satisfactory results in several studies.[7,19] Further long-term follow up studies need to be performed in order to elucidate the technique that will give patients the most successful clinical outcome. Currently, given no clear superior technique, the present study evaluated a portion of fixation of a medial meniscal allograft.

There are several limitations of this study. First, the investigators analyzed only load to failure of fixation of the posterior horn of a meniscal allograft. In addition to the fixation of the posterior horn, the body of the meniscus would be sutured to the joint capsule, and the anterior horn would be attached to its anatomic position. This fixation may provide some additional stability to the posterior horn that would alleviate some of the stress. Also, cyclical testing was not performed on the specimens, an obvious limitation of this study. However, this study was not meant to be a comprehensive testing, but rather meant to isolate one aspect of fixation.

Second, the quality of the meniscal allografts was not the same as the meniscal allografts used in vivo. In particular, the bone quality of the cadaveric specimens was not of the same quality of fresh frozen meniscal allograft bone. In our experience, the cadaveric bone plugs in Group 2 were more friable than current fresh frozen allograft bone specimens. The quality of the bone plug would be a significant factor in interpreting the results of this study. In addition, based on the mode of failure, we would expect that a higher quality of bone plugs would have a higher strength before the sutures cut out.

Third, this is an in vitro study and only evaluates the immediate fixation of the posterior horn. It does not account for the ingrowth and incorporation of the posterior horn into the proximal tibia.[7] Specifically, this variable would affect short- and long-term stability of the transplanted meniscus.

Conclusion

The study demonstrated no difference in the mean pullout strength of medial meniscal allograft posterior horn fixation between the two groups when loaded to failure. The data suggest that it may not be necessary to maintain the bone plug for medial meniscal transplant fixation, as suture alone will suffice. However, further studies, including cyclical testing and isolation of the numerous other variables involved in allograft fixation, are needed in order to make a clinical recommendation.

Disclosure Statement

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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