

Meniscal suture spacing influences biomechanics of meniscal repair

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INTRODUCTION: There is a widespread consensus that preserving the meniscus is preferable to meniscectomy to prevent the onset of degenerative changes in the knee¹. Several meniscal repair techniques have been described with suture placement playing a crucial role in repair biomechanics^{2,3,4}. Longitudinal meniscus tears are common in clinical practice and are considered a standard indication for meniscus repair⁵. The most effective suture spacing in terms of cost and performance is not well described in literature. This study hypothesized that there would be a maximum spacing beyond which the mechanical performance would significantly decrease.

METHODS: No institutional approval was required for removing the meniscus roots from 50 bovine medial and lateral menisci and dividing remaining meniscus radially into two (anterior and posterior) samples. In each sample, a full longitudinal meniscal tear was created 5mm from the peripheral meniscal rim using a no. 15 blade. The tears were repaired using two 2-0 braided sutures (Ultrabraid, Smith&Nephew) with vertical mattress sutures 3mm from the torn edges with five different suture spacings: 3, 5, 7, 9, and 11mm. The sutures were tensioned to 30 N using a tensiometer and securely tied to the meniscus base with a sliding knot. Additionally, to prevent slippage, five alternating half-hitch simple knots were performed. To allow for radial loading of the repair, three #5 braided polyester loading sutures were placed at the peripheral meniscal rim, spaced equally at intervals of 10mm measured from the center of the sample (Fig. 1). Each sample underwent 5-20 N (combined suture load) for 1000 cycles at a crosshead speed of 75 mm/min using a material testing machine. The tear opening gap at the 1000th cycle was measured using a digital image correlation system. An ANOVA test with a Bonferroni correction was performed to determine differences in gap opening displacement between groups at the 1000th cycle.

RESULTS SECTION: The mean \pm standard deviation of the tear gap for each repair spacing is given in Figure 2. Groups with suture distances of 3mm, 5mm, and 7mm demonstrated 36% smaller displacements (1.6 ± 0.3 mm; 1.7 ± 0.5 mm; 1.7 ± 0.5 mm, resp.) compared to the groups with suture distances of 9mm and 11mm (2.5 ± 0.3 mm; 2.7 ± 0.6 mm), respectively. Displacement among suture distances of 3mm, 5mm, and 7mm exhibited no significant differences. Similarly, no significant difference in displacement between groups of 9mm and 11mm was observed. Failure mode did not correlate with suture distance. Sutures broke in 76% (38/50) and cut through the meniscus tissue in 22% (11/50), while a combination of one suture breakage and one tissue transection was observed in 2% (1/50).

DISCUSSION: The main finding of this study is that meniscal repairs with a suture distance greater than 9mm demonstrated significantly higher opening displacements compared to those at 7mm and below. Meniscus sutures are clinically placed at varying distances^{5,6}, and the optimal spacing remains undetermined. Based on the current data, a suture distance of 9mm or higher appears to result in a larger displacement and potentially hinder the healing of a meniscus tear. Further biological studies are needed to investigate how the gap size of a tear influences its healing process.

SIGNIFICANCE/CLINICAL RELEVANCE: Tear gaps with sutures positioned at distances of 7mm or less exhibit greater biomechanical stability compared to sutures at 9mm and beyond. Surgeons may want to consider this data when repairing longitudinal meniscal tears.

REFERENCES:

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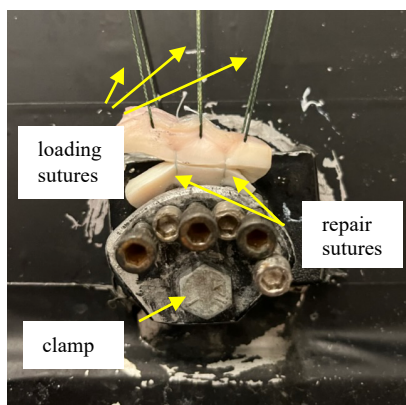


Figure 1 Clamped inner edge of meniscus wedge with three loading sutures placed at the peripheral meniscal rim

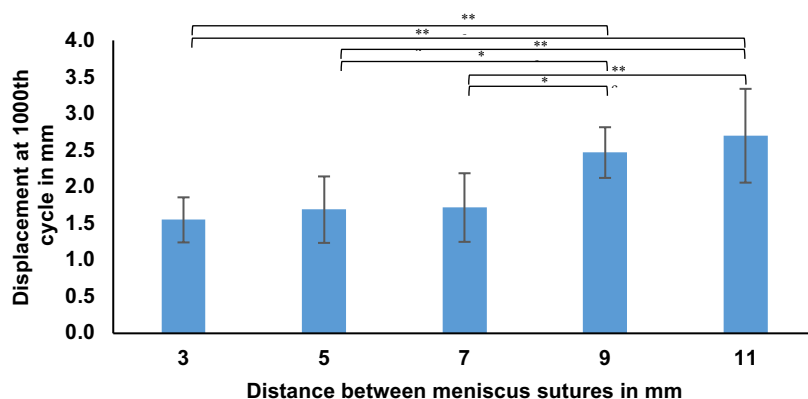


Figure 2 Gap opening increases from unloaded state to 1000th load cycle. The bars show the mean \pm standard deviation. * $p \leq 0.05$; ** $p \leq 0.01$