Biomechanical Comparison of Suture Constructs for Transtibial Pull-Out Repair of Meniscal Root Tear

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INTRODUCTION: The meniscus-suture interface has been biomechanically shown to contribute significantly more displacement than the button-bone interface or suture elongation in the transtibial pull-out repair construct. Optimizing the stability of the meniscus-suture interface should thus be the main objective in such root repair technique. This study aims to compare the biomechanical properties of four different meniscal-suture constructs. The hypothesis is that the novel slip-knot technique is biomechanically compatible to the other three fixation methods at time-zero.

METHODS: Thirty-two fresh-frozen medial and lateral menisci from cadaveric knees were randomly assigned to four meniscus-suture fixation constructs: Two simple-sutures (SS), two slip-knot sutures (SK), two cinch-loop sutures (CL), and two Modified Mason-Allen sutures (MMA). The menisci were subjected to cyclic loading from 5 N to 20N for 1,000 cycles at 0.5 Hz, and then loaded to failure at 0.5mm/s. Analysis of variance was used to compare load-to-failure and displacement of all 4 groups, whereas the Kruskal-Wallis test was used for the comparison of stiffness.

RESULTS: After 1,000 cycles, the CL construct significantly displaced the most (mean ± SD, 6.78 ± 1.32mm; P = 0.000), followed by the MMA (2.83 ± 0.90mm), SK (2.33 ± 0.57mm), and SS (2.03 ± 0.62mm) groups; in fact, during all cyclic-loading tests (1, 100, 500, and 1000 cycles), the CL group consistently displaced the most, while there was no significant difference between the SK and the other two groups. On ultimate load to failure, there is no significant difference exhibited by the SK group (123.48 ± 27.24 N, P > 0.05) in comparing to the other three groups (SS, 94.65 ± 25.33 N; MMA, 168.38 ±23.24 N; CL, 170.54 ± 57.32 N); however, both the SK and SS groups showed significantly less displacement at their respective ultimate failure loads comparing to those of the MMA and CL groups. There was no significant difference in stiffness among the tested groups (SK, 25.54 ± 4.21 N/mm; SS, 25.25 ± 4.67; MMA, 23.09±3.05; CL, 19.67 ± 10.57).

DISCUSSION AND CONCLUSION: The slip-knot suture technique provides a strong and reliable meniscal root fixation at time-zero as it demonstrated a compatible ultimate failure load yet with less displacement in comparing to other suturing techniques. Considering its technical simplicity, time saving, and minimal meniscal piercing, the slip-knot technique can be a viable option for meniscal root pull-out repairs.

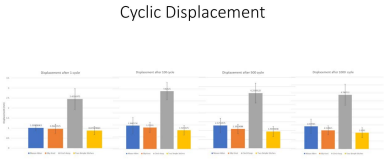

Table 1. Displacement During Cyclic Loading, mm

	After 1 Cycle	After 100 Cycles	After 500 Cycles	After 1000 Cycles
MMA	0.14±1.01 [a]	0.68±1.95 [b]	0.82±2.58 [c]	0.90±2.83 [d]
SK	0.23±0.97 [a]	0.44±1.79 [b]	0.53±2.19 [c]	0.57±2.33 [d]
CL	2.45±0.51	4.83±0.72	6.26±1.13	6.78±1.32
TSS	0.20±0.88 [a]	0.40±1.57 [b]	0.56±1.90 [c]	0.62±2.03 [d]

Data are shown as mean ± standard deviation (95% confidence interval).MMA, modified Mason Allen, SK, Slip Knot, CL, Cinch Loop, TSS, Two Simple Stiches
[a] Significant difference compared with CL after 1 cycle (p<0.00 in all comparison)
[b] Significant difference compared with CL after 100 cycle (p=0.00 in all comparison)
[c] Significant difference compared with CL after 500 cycle (p=0.00 in all comparison)
[d] Significant difference compared with CL after 500 cycle (p=0.00 in all comparison)

Table 2. Yield Load, Displacement at Yield Load, Ultimate Failure Load, Displacement at failure and Stiffness

	MMA	SK	CL	TSS
Yield load, N	21.08±133.90 [d]	28.42±102.90 [c]	65.05±164.04 [a,d]	22.12±73.64 [a,c]
Displacement at yield load, mm	0.83±4.74 [c]	0.92±3.30 [c]	4.26±6.67 [a,b,d]	0.94±2.30 [c]
Ultimate failure load, N	23.24±168.38 [d]	123.48±27.24	57.32±170.54 [d]	25.33±94.65 [a,c]
Displacement at ultimate failure, mm	2.18±9.53 [a,d]	1.25±5.53 [a,c]	4.25±11.82 [a,d]	2.19±5.67 [a,c]
Stiffness, N/mm	23.15±2.90	24.95±4.01	19.61±13.33	23.84±10.65

Data are shown as mean ± standard deviation (95% confidence interval). MMA, modified Mason Allen, SK, Slip Knot, CL, Cinch Loop, TSS, Two Simple Stiches
[a] Significant difference compared with Mason Allen
[b] Significant difference compared with Slip knot
[c] Significant difference compared with Cinch loop
[d] Significant difference compared with Two simple Stiches