2024 AANA Annual Meeting

17. Lin. KY. Biomechanical Comparison of Suture Constructs for Transtibial Pull-Out Repair of Meniscal Root Tear. pdf

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Disclosure of Interest Information

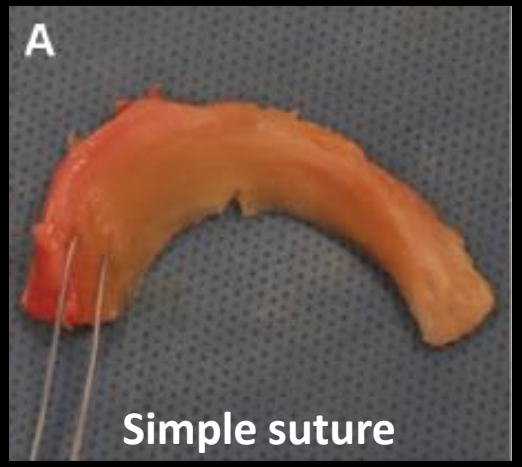
- None pertinent to this presentation

Introduction

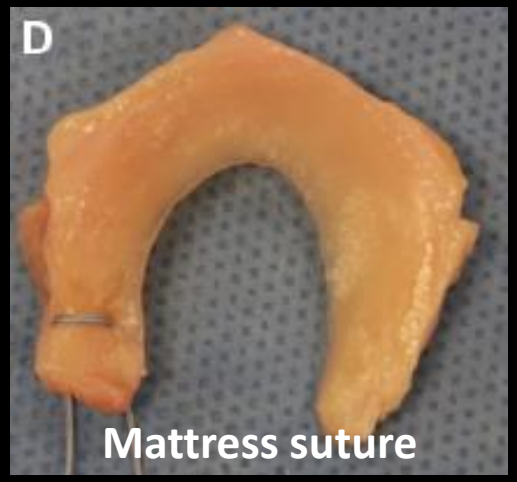
Biomechanical Comparison of Arthroscopic Repair Constructs for Meniscal Root Tears

Adam W. Anz,*†‡ MD, Eric A. Branch,§ MS, and Justin D. Saliman,‖ MD
Investigation performed at the Andrews Research and Education Institute, Gulf Breeze, Florida, USA

2014



Simple suture



Mattress suture

Doube-locking loop suture

- The Double-locking loop suture had significantly the highest ultimate failure loads compared with simple suture and mattress suture
- As the complexity of repair constructs increases, failure load and surgical time increase

But… is the higher the failure load the better ?

Cyclic Displacement After Meniscal Root Repair Fixation

A Human Biomechanical Evaluation

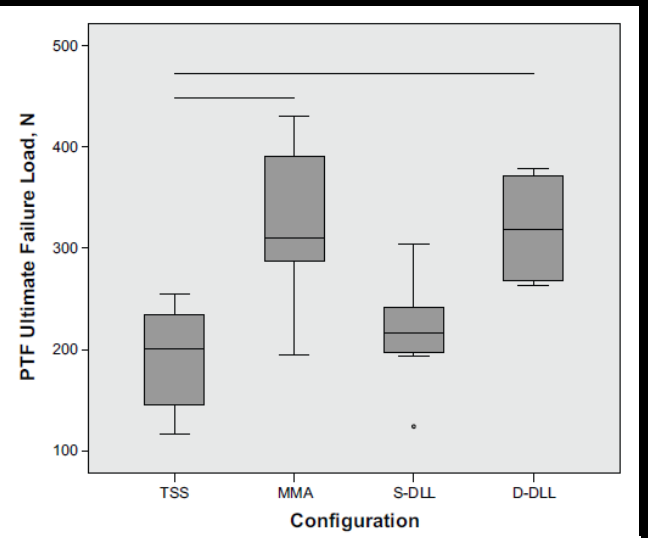
2015

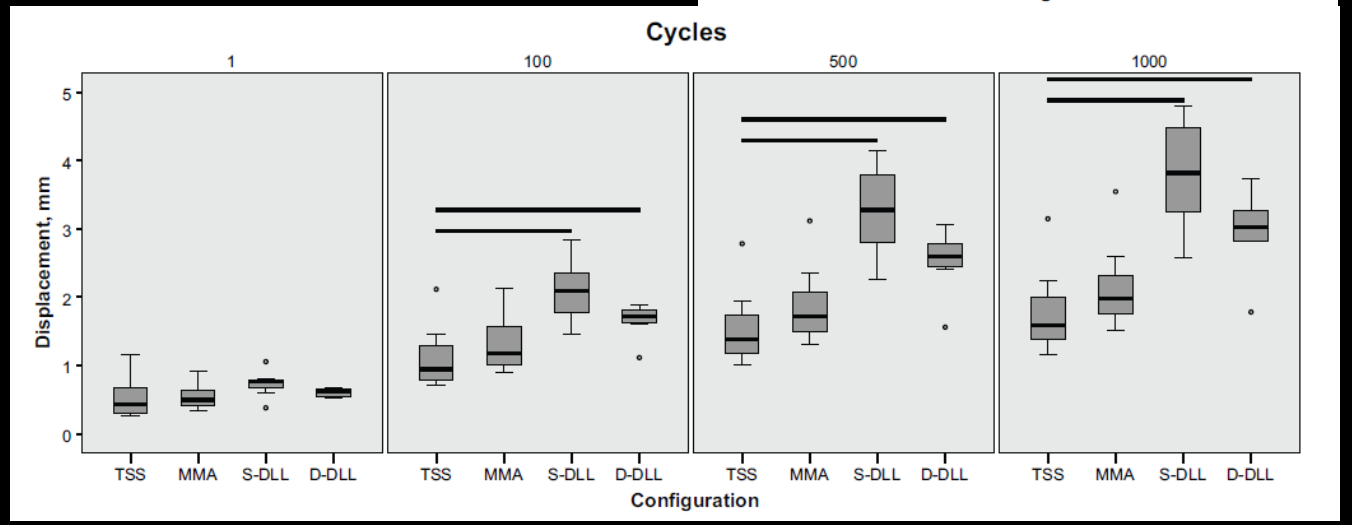
Robert F. LaPrade,*†‡ MD, PhD, Christopher M. LaPrade,† BA, Michael B. Ellman,†‡ MD, Travis Lee Turnbull,† PhD, Anthony J. Cerminara,†‡ MD, and Coen A. Wijdicks,† PhD
Investigation performed at the Department of BioMedical Engineering, Steadman Philippon Research Institute, Vail, Colorado, USA

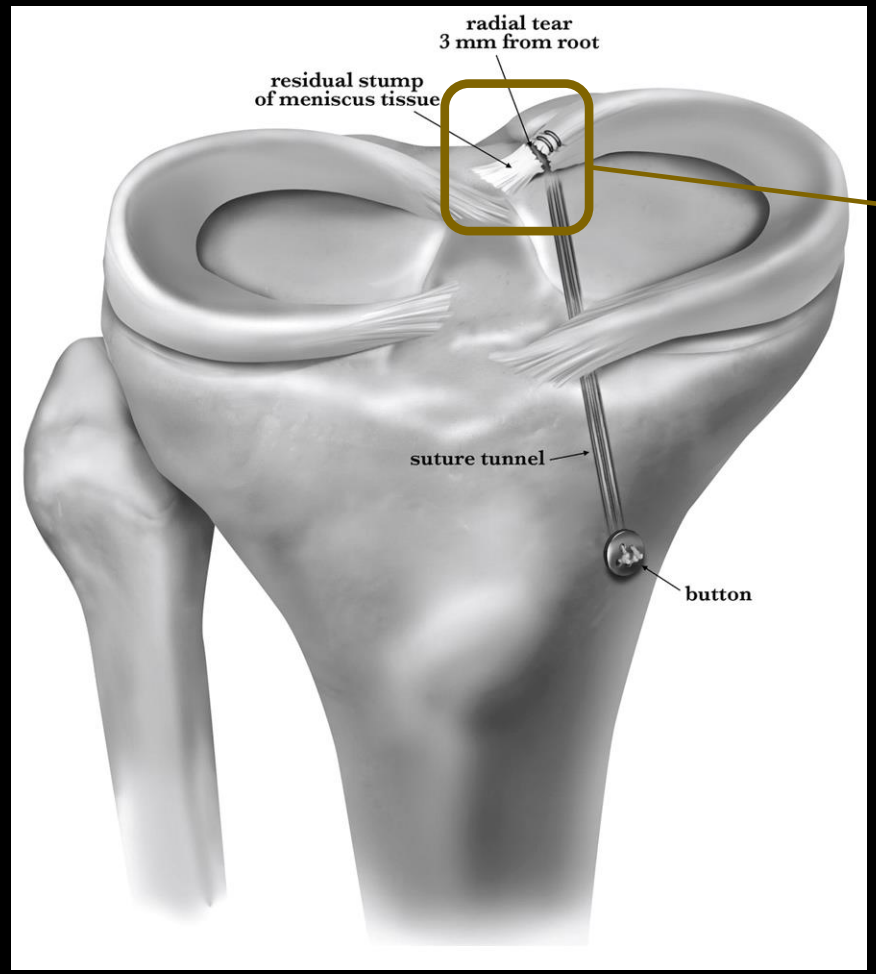
The Two Simple-suture fixation technique:

- Currently the standard
- The lowest technical difficulty
- The highest resistance to displacement at time zero
- Less meniscal invasion
- Time saving

2-SS *vs.* MMA *vs.* 1-DLL *vs.* 2-DLL







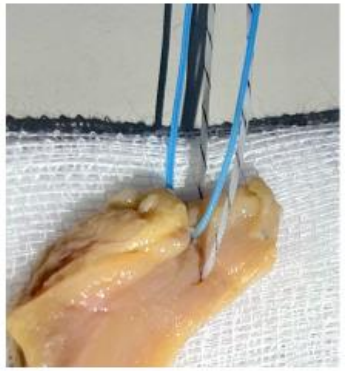
Meniscus-suture interface is the primary target of eliminating the displacement of transtibial pull-out repair

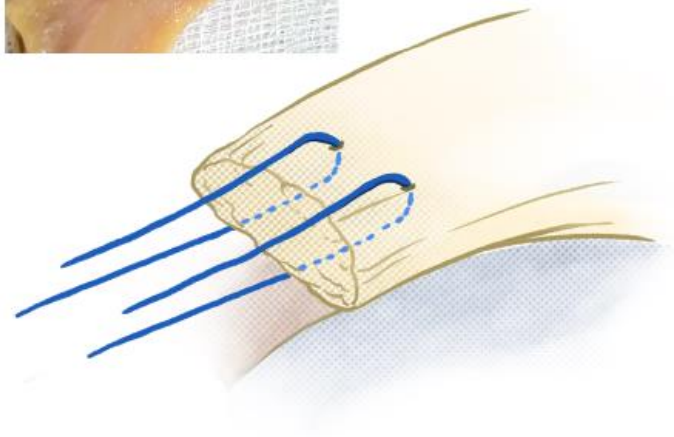
Biomechanical Evaluation of a Transtibial Pull-out Meniscal Root Repair

Challenging the Bungee Effect 2014

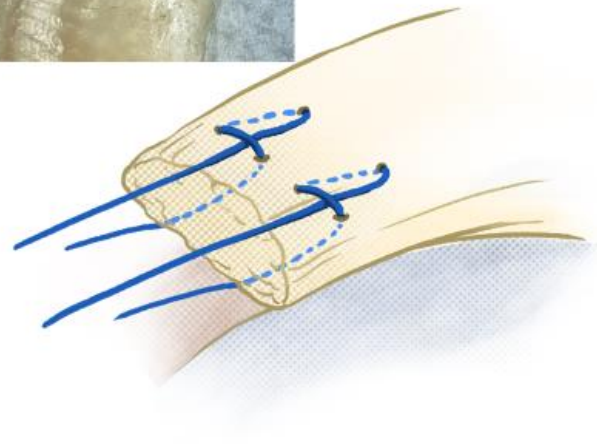
Anthony J. Cerminara,*† MD, Christopher M. LaPrade,* BA, Sean D. Smith,* MSc, Michael B. Ellman,*† MD, Coen A. Wijdicks,* PhD, and Robert F. LaPrade,*†‡ MD, PhD
Investigation performed at the Department of BioMedical Engineering, Steadman Philippon Research Institute, Vail, Colorado, USA

Suture Techniques

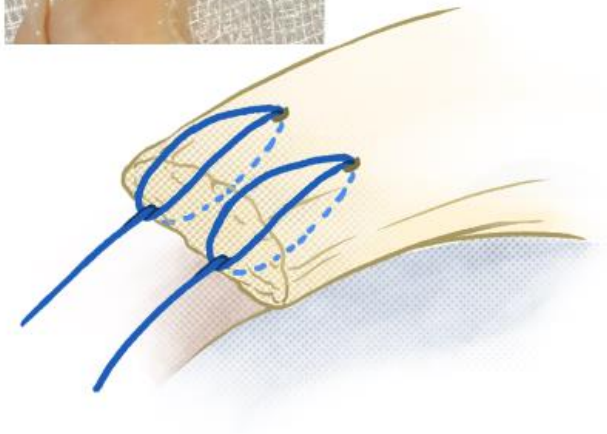




Two Simple Suture (TSS)

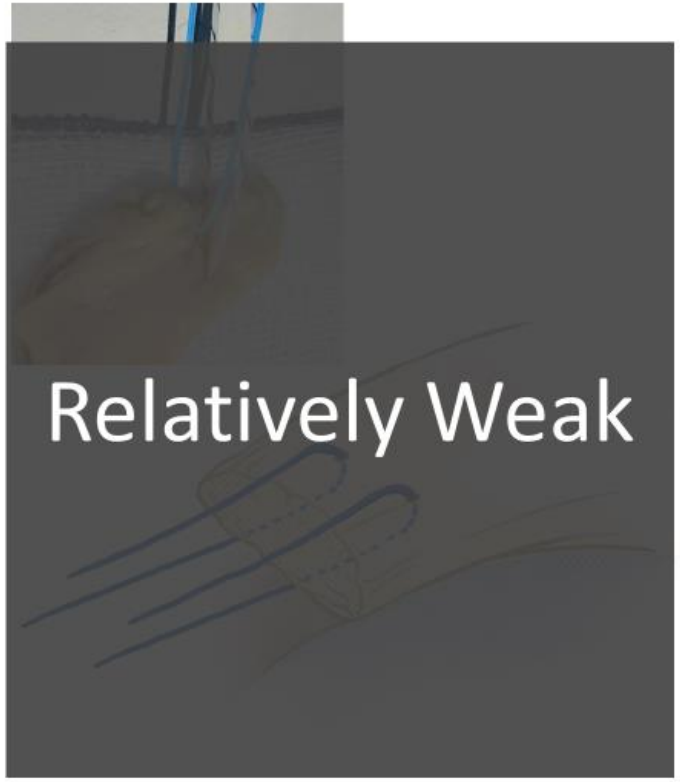


Two Modified Mason Allen (TMMA)

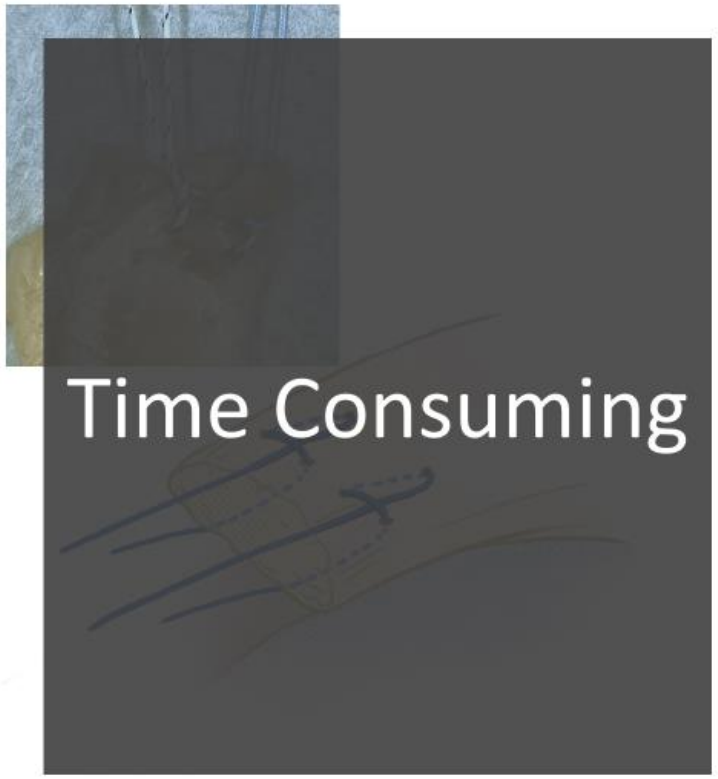


Two Cinch Loop (TCL)

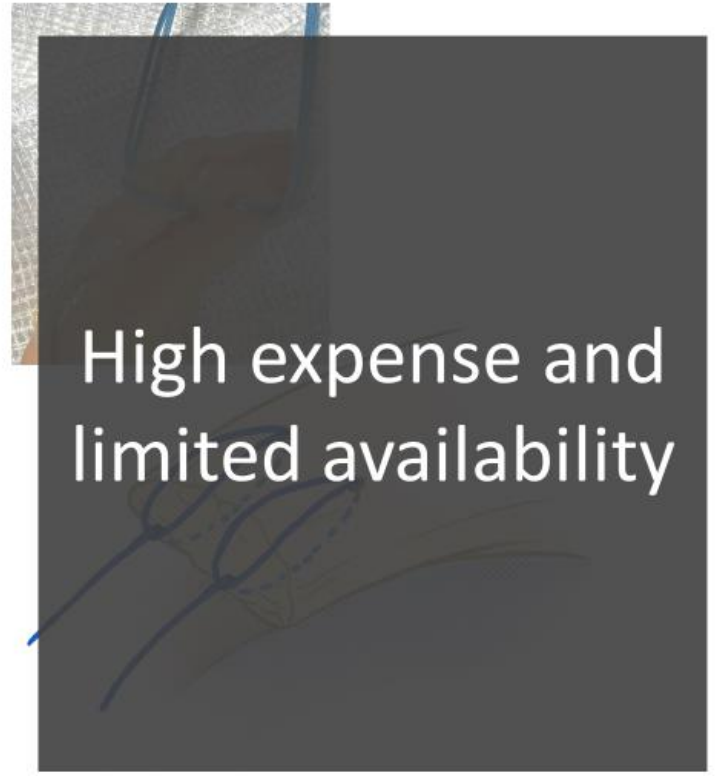
Suture Techniques



Two Simple Suture (TSS)



Two Modified Mason Allen (TMMA)



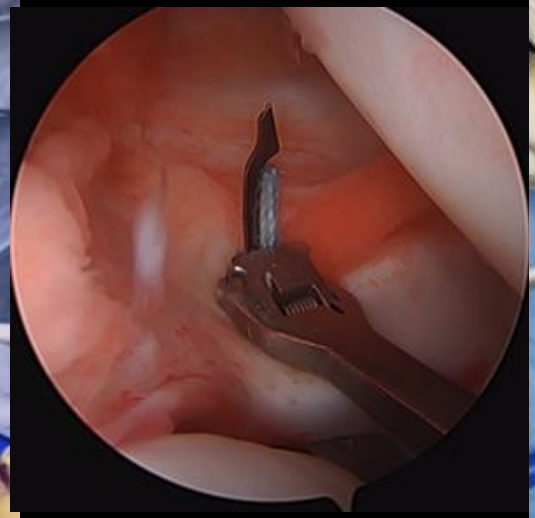
Two Cinch Loop (TCL)

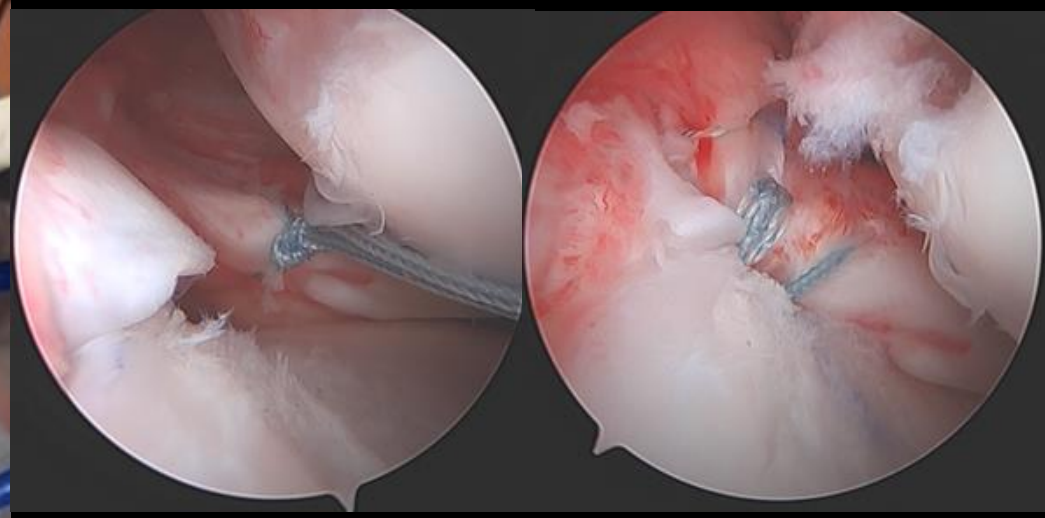
Arthroscopic Transtibial Pull-Out Repair for Meniscal Posterior Root Tear: The Slip Knot Technique

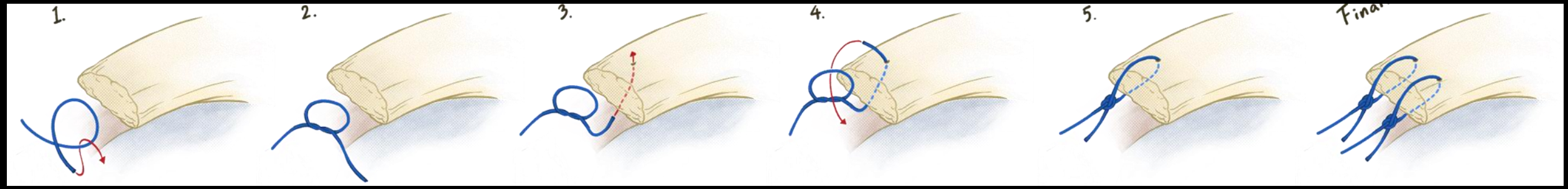
Hsin-Ya Chen, B.S., and Kuan-Yu Lin, M.D., Ph.D.

2022

Arthroscopy Techniques







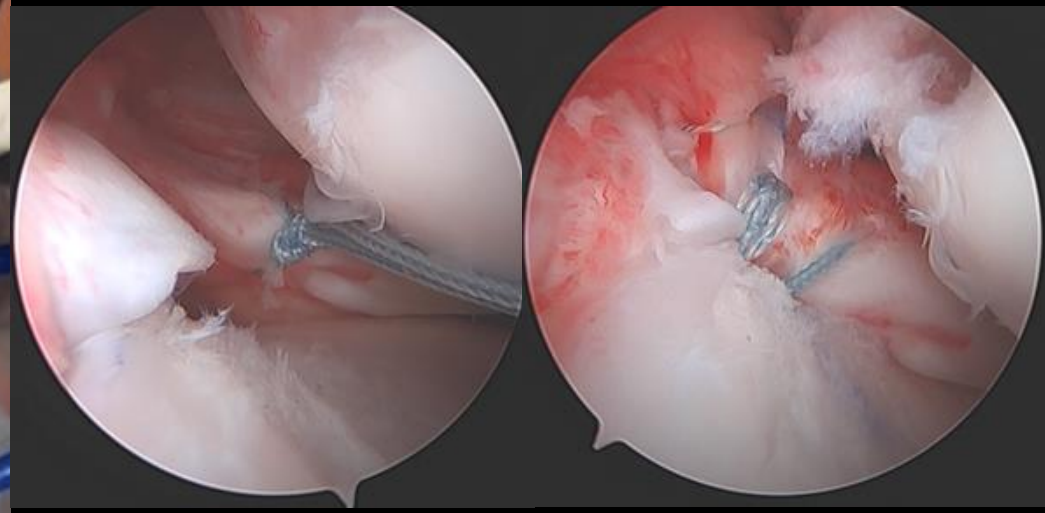
Arthroscopic Transtibial Pull-Out Repair for Meniscal Posterior Root Tear: The Slip Knot Technique

Hsin-Ya Chen, B.S., and Kuan-Yu Lin, M.D., Ph.D.

Check for updates

Arthroscopy Techniques

2022



Simple, fast; yet biomechanically unproven

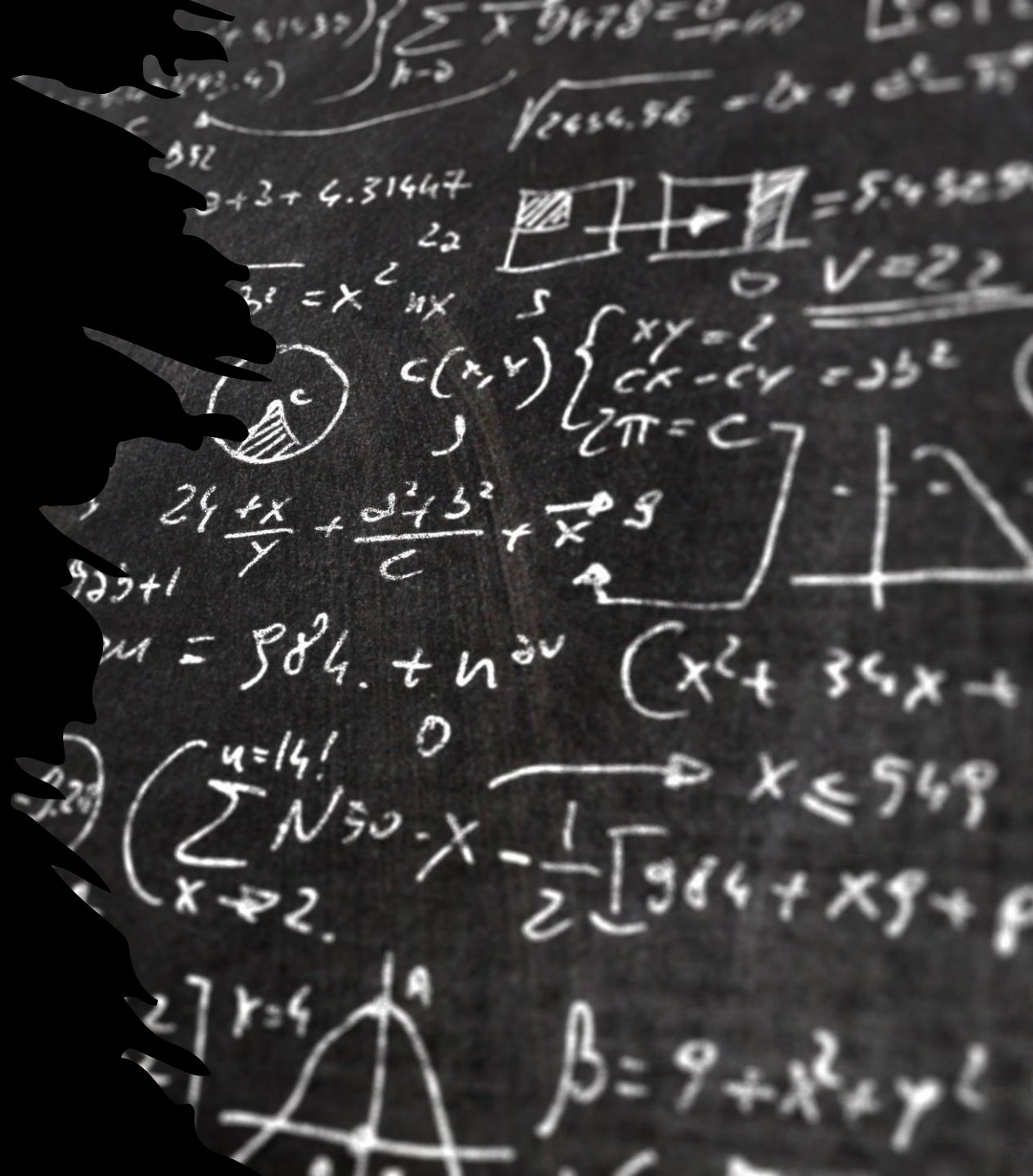
Objective

- Compare the biomechanical properties of 4 suture constructs: Two simple-suture (TSS), two modified Mason-Allen (TMMA), two cinch-loop (TCL), and two slip-knot (TSK)
    - Ultimate failure load
    - Yield load
    - Cyclic displacement (1, 100, 500, and 1000 cycles)
    - Displacement at ultimate failure load
    - Stiffness

Hypothesis

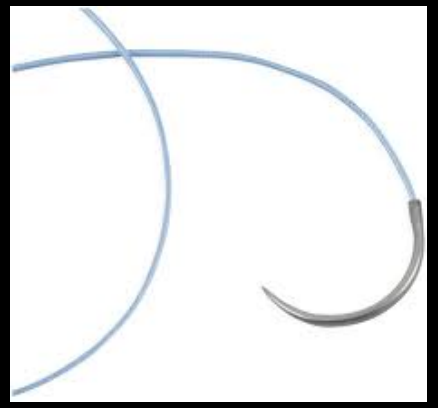
- The slip-knot technique is biomechanically stronger than the standard simple-suture technique, and gives less displacement than the modified Mason-Allen and cinch-loop techniques for the meniscal posterior root pullout repair

Methods and Materials



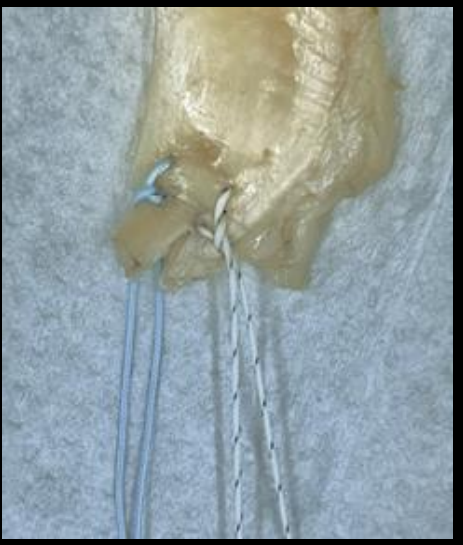
Suture materials

- # 2 fiberwires (Arthrex, USA)



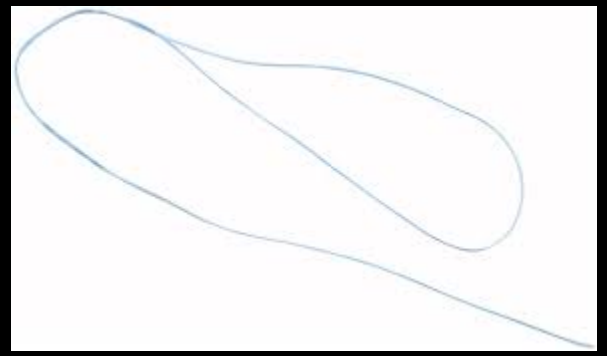
Simple Suture

Modified Mason-Allen



Slip-Knot

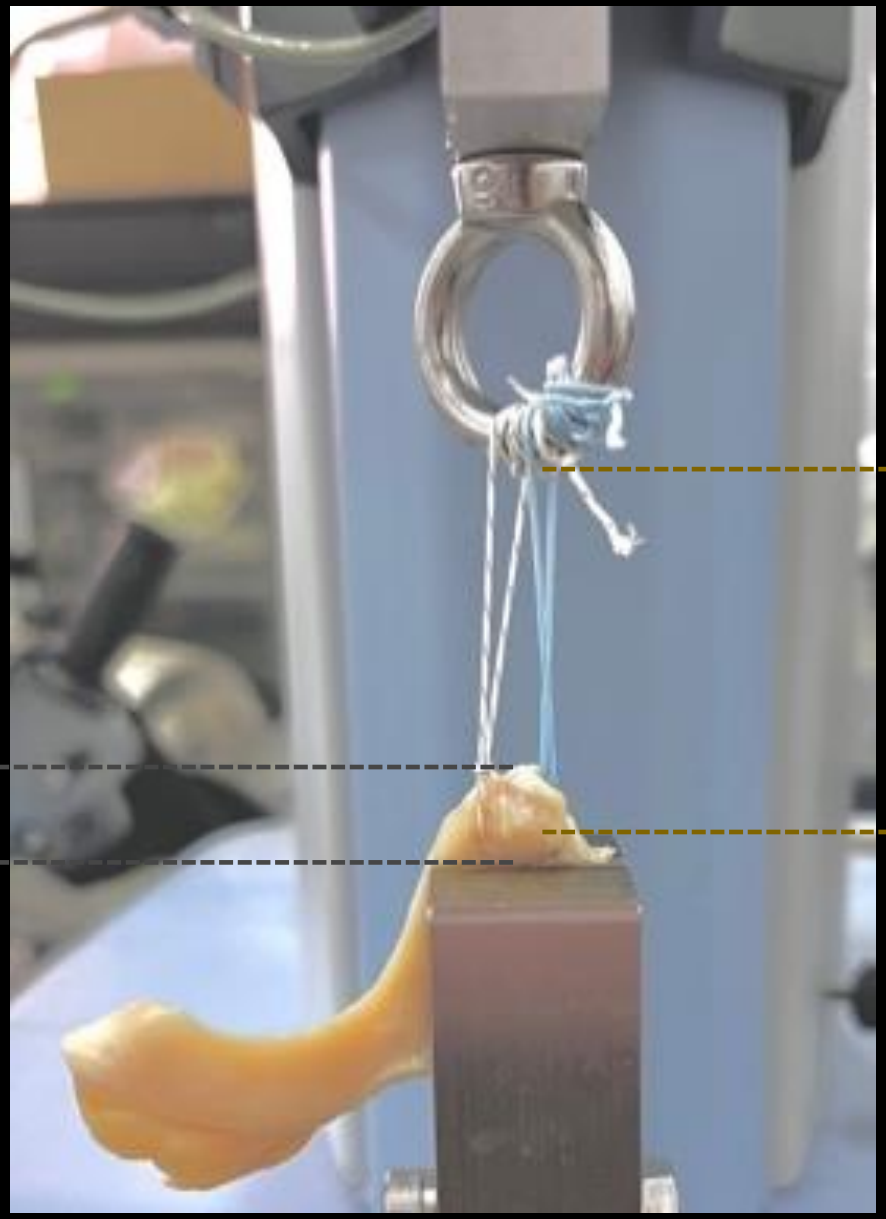
- # 2 Fiberlink (Arthrex, USA)
  - Cinch-loop suture

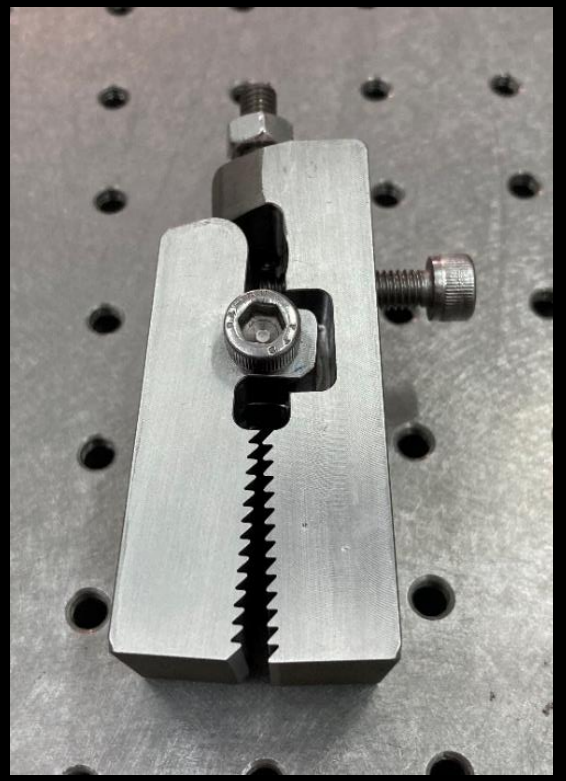


Specimen

- 16 human cadaveric knees (8M, 8F)
- mean age of 76 ± 7 years (range, 62 – 87 years)
- 32 menisci (16 M, 16 L)
- Randomly assigned to 4 groups (8 menisci / group)

Mounting of Human meniscus





Adjustable serrated clamp

Biomechanical Test

Cyclic Loading

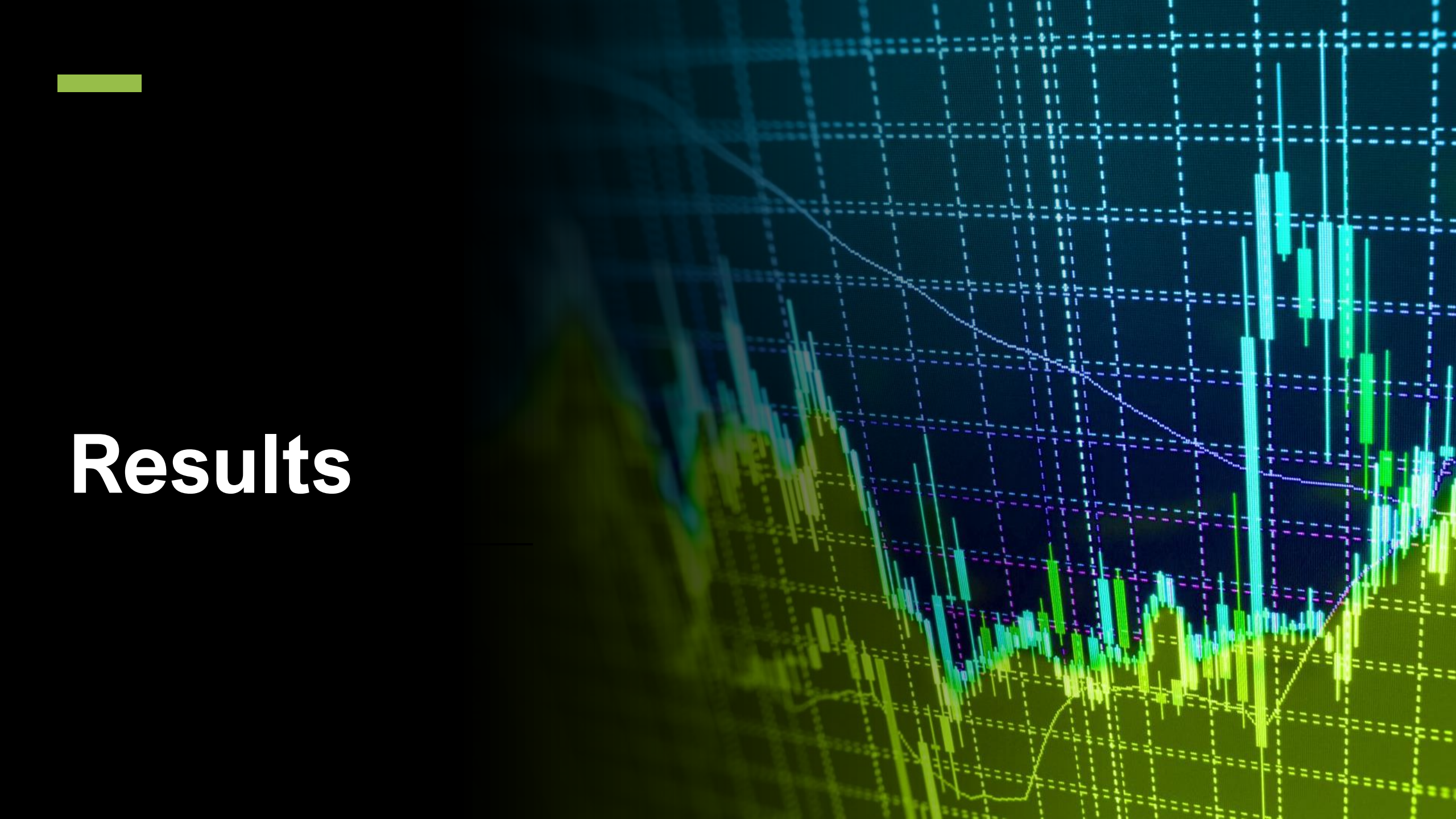
Preload: 2 N for 10 seconds
Force: 5N-20N
Frequency:0.5Hz
Cycle: 1000

Load to failure

Rate: 0.5 mm/second

EZ-SX; Shimadzu, Japan

Results



Displacement During Cyclic Loading

	Displacement, mm			
Group	After 1 Cycle	After 100 Cycles	After 500 Cycles	After 1000 Cycles
TSS	0.88±0.20	1.57±0.40	1.90±0.56	2.03±0.62
TSK	0.97±0.23(10.5)	1.79±0.44(14.4)	2.19±0.53(15.2)	2.33±0.57(15.1)
TMMA	1.01±0.14(15.2)	1.95±0.68(24.5)	2.58±0.82(35.5)	2.83±0.90(39.7)
TCL	2.45±0.51(180) [a]	4.83±0.72(208) [b]	6.26±1.13(229) [c]	6.78±1.32(234) [d]

Data are shown as mean ± standard deviation (95% confidence interval). TSS, Two Simple Stiches, MMA, modified Mason Allen, SK, Slip Knot, CL, Cinch Loop. Values in parentheses are the percentages of greater displacement compared with the two simple sutures (TSS) technique.

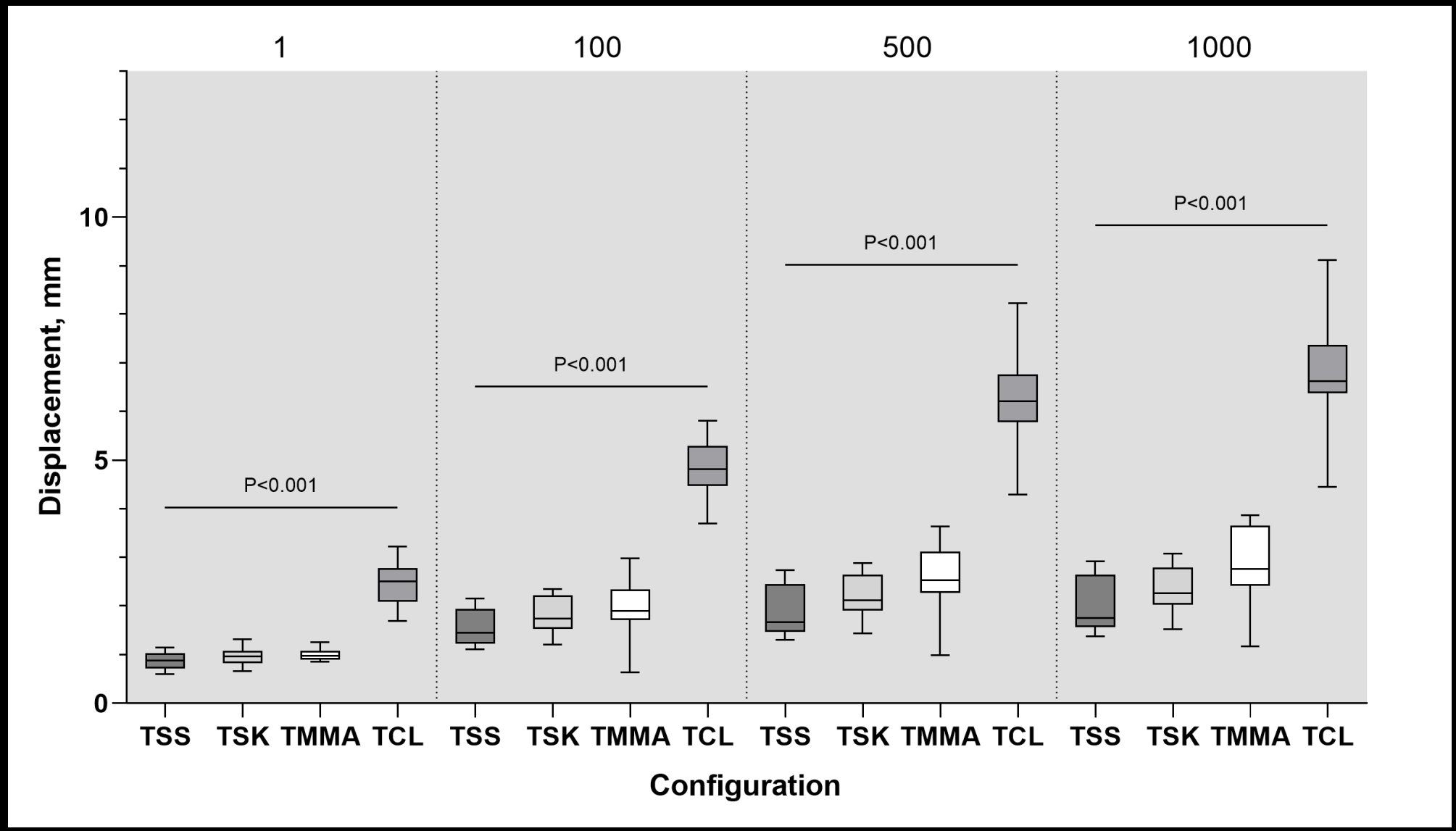
[a] Significant difference compared with TSS after 1 cycle ($p<0.001$ in all comparison)

[b] Significant difference compared with TSS after 100 cycle ($p<0.001$ in all comparison)

[c] Significant difference compared with TSS after 500 cycle ($p<0.001$ in all comparison)

[d] Significant difference compared with TSS after 500 cycle ($p<0.001$ in all comparison)

Cyclic Loading



Yield Load, Displacement at Yield Load, Ultimate Failure Load, Displacement at failure, and Stiffness

	TSS	TSK	TMMA	TCL
Yield load, N	73.64±22.12 [c,d]	102.90±28.42(39.7) [d]	133.90±21.08(81.8) [a]	164.04±65.05(122) [a,b]
Displacement at yield load, mm	2.30±0.94 [d]	3.30±0.92(43.7) [d]	4.74±0.83(106) [d]	8.57±4.26(273) [a,b,c]
Ultimate failure load, N	94.65±25.33 [c,d]	123.48±27.24(30.5)	168.38±23.24(77.9) [a]	170.54±57.32(80.2) [a]
Displacement at ultimate failure, mm	5.67±2.19 [c,d]	 5.53±1.25(-2.4) [c,d]	9.53±2.18(68.1) [a,b]	11.82±4.25(108) [a,b]
Stiffness, N/mm	23.84±10.65	 24.95±4.01(4.64)	23.15±2.98(-2.9)	19.61±13.33(-18)

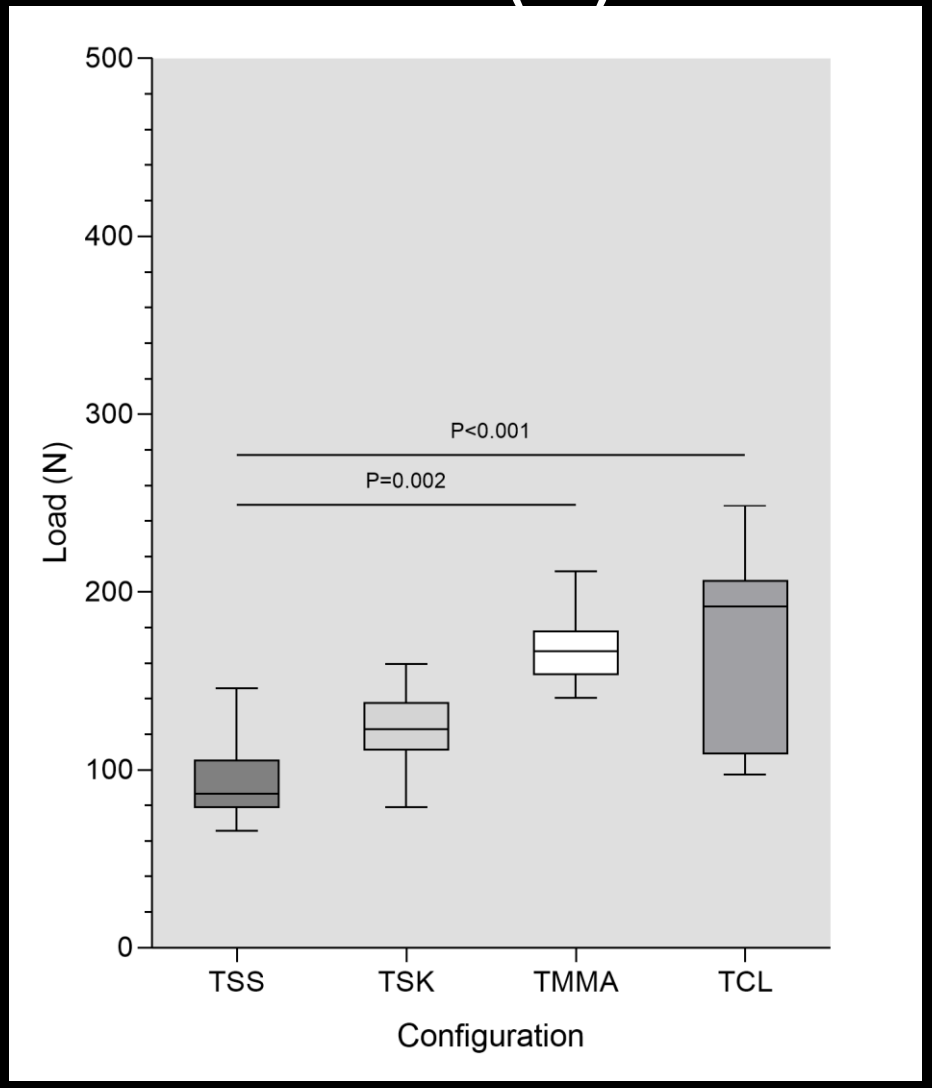
No significant difference: TSK *vs.* TMMA *vs.* TCL

Data are shown as mean ± standard deviation (95% confidence interval). TSS, Two Simple Stiches MMA, modified Mason Allen, SK, Slip Knot, CL, Cinch Loop. Values in parentheses are the percentages compared with the two simple sutures (TSS) technique.

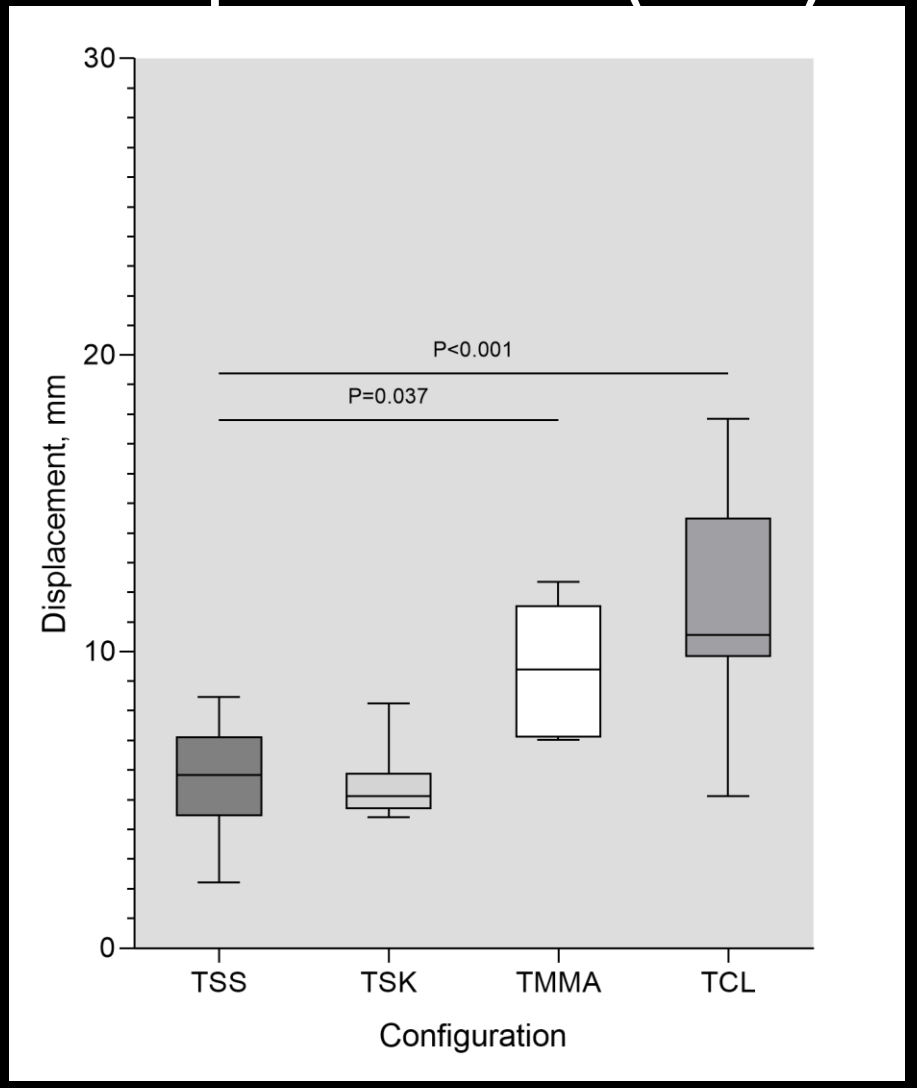
[a] Significant difference compared with Two simple Stiches
[b] Significant difference compared with Slip knot
[c] Significant difference compared with Mason Allen
[d] Significant difference compared with Cinch Loop

Ultimate Failure Load

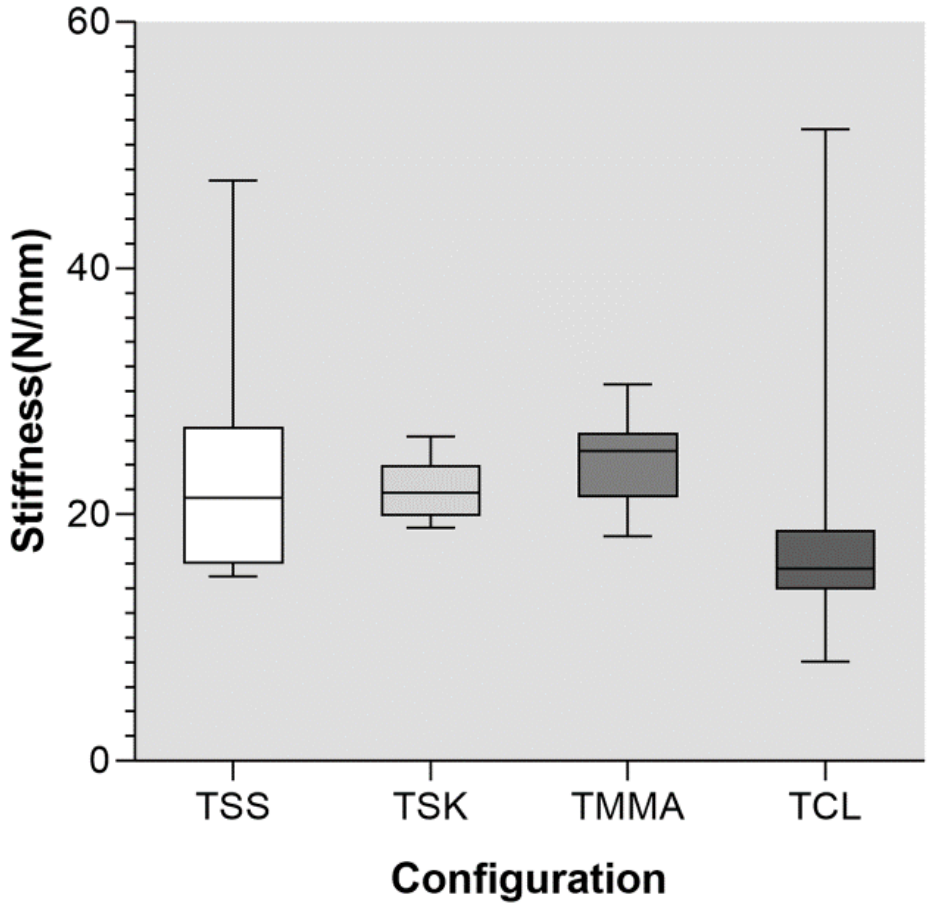
Load(N)



Displacement(mm)



Stiffness



No statistically significant difference in stiffness among the four constructs

Discussion

The 3 Pillars of an Excellent Suture Construct

Low Displacement during Various Forces

High Load Bearing Capacity

Ease of Implementation

Low Displacement during various Forces

Meniscal function could be compromised if the suture elongation exceeded a threshold of 3mm*

Multiple piercing of the meniscus may render the meniscus vulnerable

*Starke C, Kopf S, Lippisch R, Lohmann CH, Becker R. Tensile forces on repaired medial meniscal root tears. Arthroscopy. 2013;29(2):205-212.

Slip knot	Mason Allen	Cinch Loop
15.1%	39.7%	234%

More cyclic displacement comparing to clinical standard TSS

Cinch Loop : Exceeded the 3mm threshold (4.83mm) after just 100 cycles !!

Stiffness

= The ability of a construct to resist deformation when a force is applied

	TSS	TSK	TMMA	TCL
Stiffness, N/mm	23.84±10.65	24.95±4.01(4.64)	23.15±2.98(-2.9)	19.61±13.33(-18)
VS.	---	**+ 4.6%**	- 2.9%	**- 18%**

High Load Bearing Capacity

Two Slip-Knot technique *vs.* TMMA *vs.* TCL

- No significant difference in ultimate failure
- Significantly least displacement at ultimate failure load (P=0.03, P<0.001, respectively)

- More complex suture construct would provide higher ultimate failure load, but would elongate more as it fails

Anz et al. AJSM 2014

Feucht et al. AJSM 2013

LaPrade et al. AJSM 2015

Vertullo et al. OJSM 2021

30N

threshold force for early post-operative rehabilitation

(Mitchell et al. Arthroscopy 2013)

Simple Suture
73.6N

<

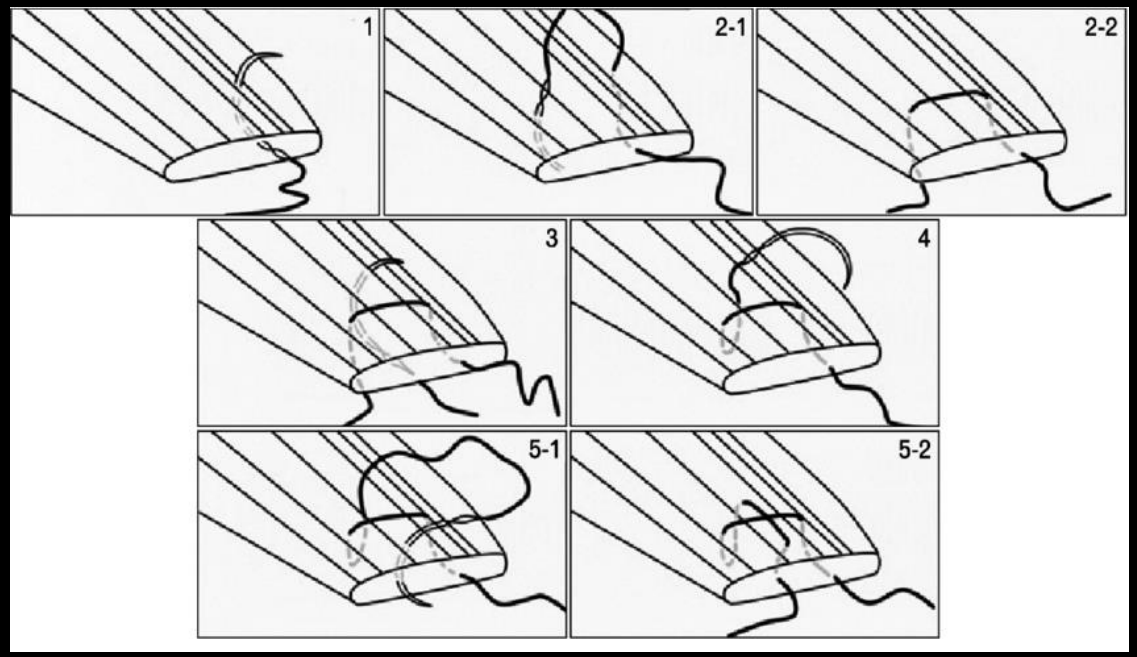
Slip Knot
102.9N

Yield Load

Ease of implementation with minimal meniscal injury

Modified Mason Allen *vs.* Simple-suture, Slip-Knot, Cinch-Loop

4 piercings > 1 piercing



Fast, Easy

Less damage to meniscus

Conclusion

The Slip-Knot Technique

Strength	Stronger than clinical standard two simple-suture technique
Displacement	Least displacement among the four suture constructs
Ease of Implantation	Simple, fast, with minimal meniscal damage

Thanks for Your Attention