Thickness of simple calcaneal tuberosity avulsion fractures influences the optimal fixation method employed

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Declaration of Interest

I declare that in the past three years I have:

- No shares
- received No royalties
- No consulting work
- Not given paid presentations
- received institutional support from Fu Jen Catholic University Hospital, Imperial College London, Chang Gung University, and National Taiwan University Hospital

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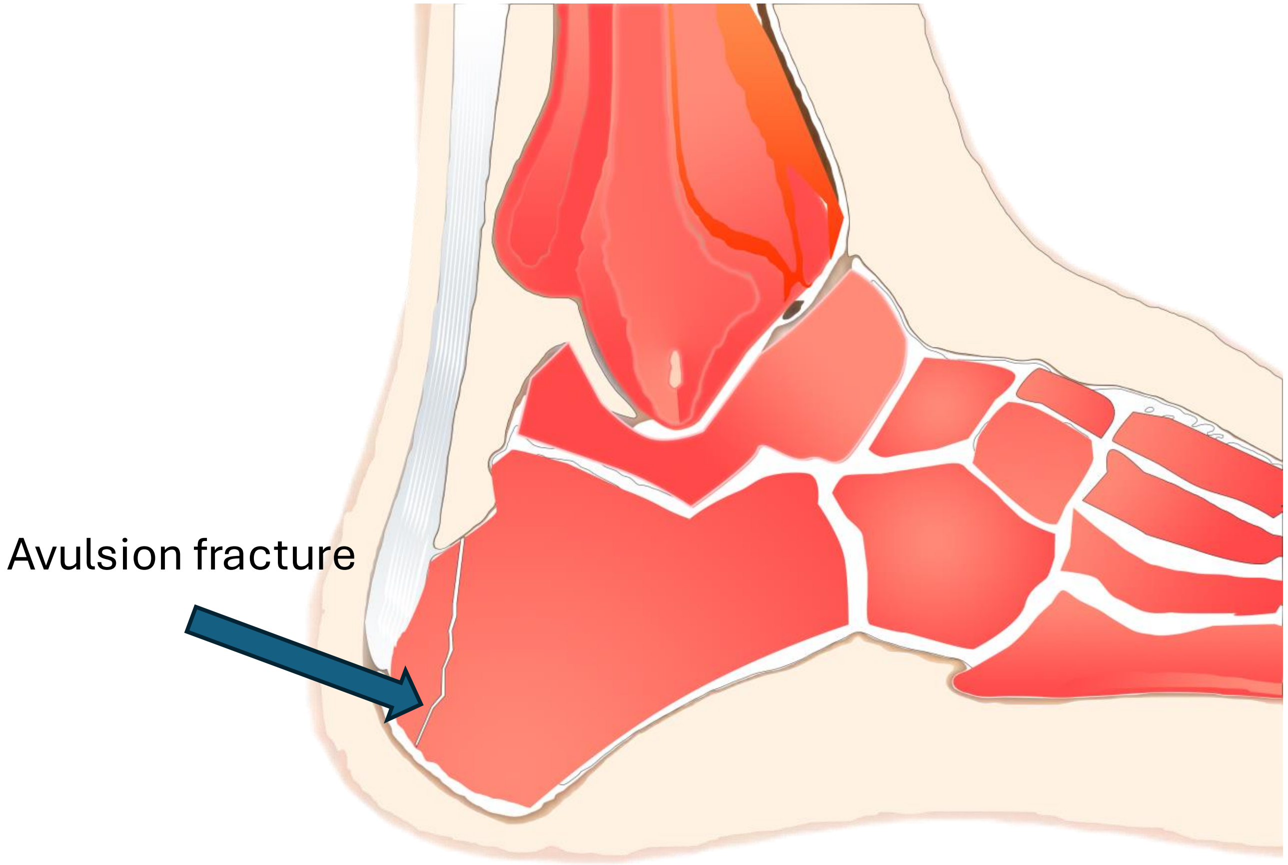
Introduction

Which works better?

Simple avulsion fracture
Screw vs Suturing



Hypothesis:
Fragment thickness is the leading factor?
How thick of the fragment is appropriate to use the screw fixation

Material & methods

Suture bridge Headless screw

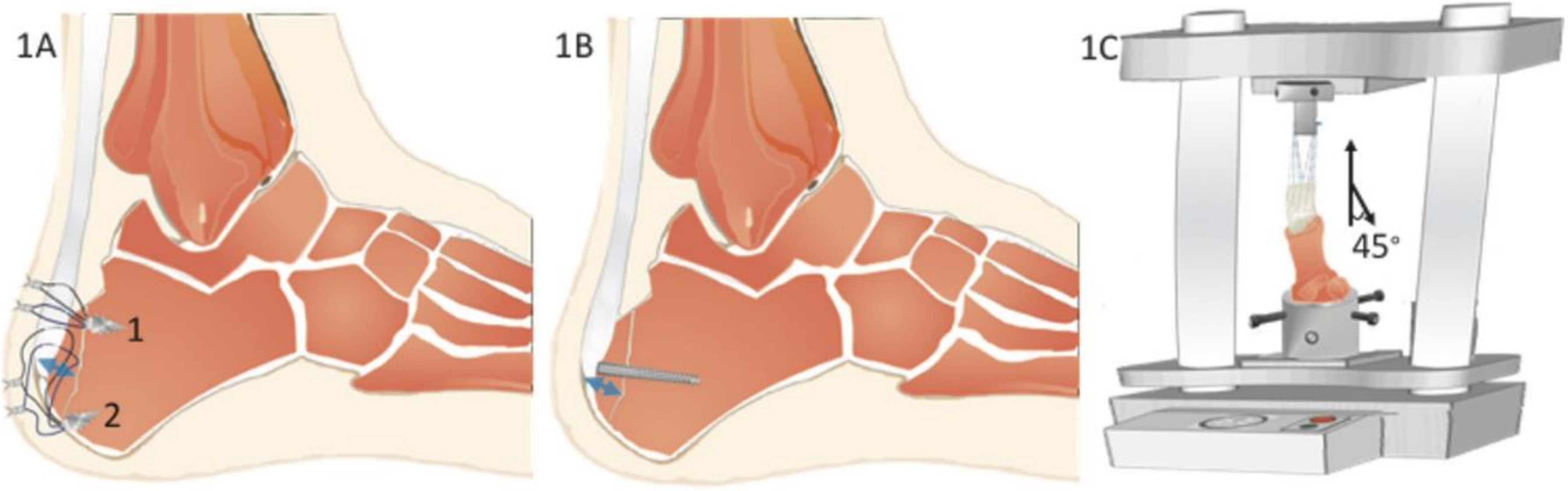
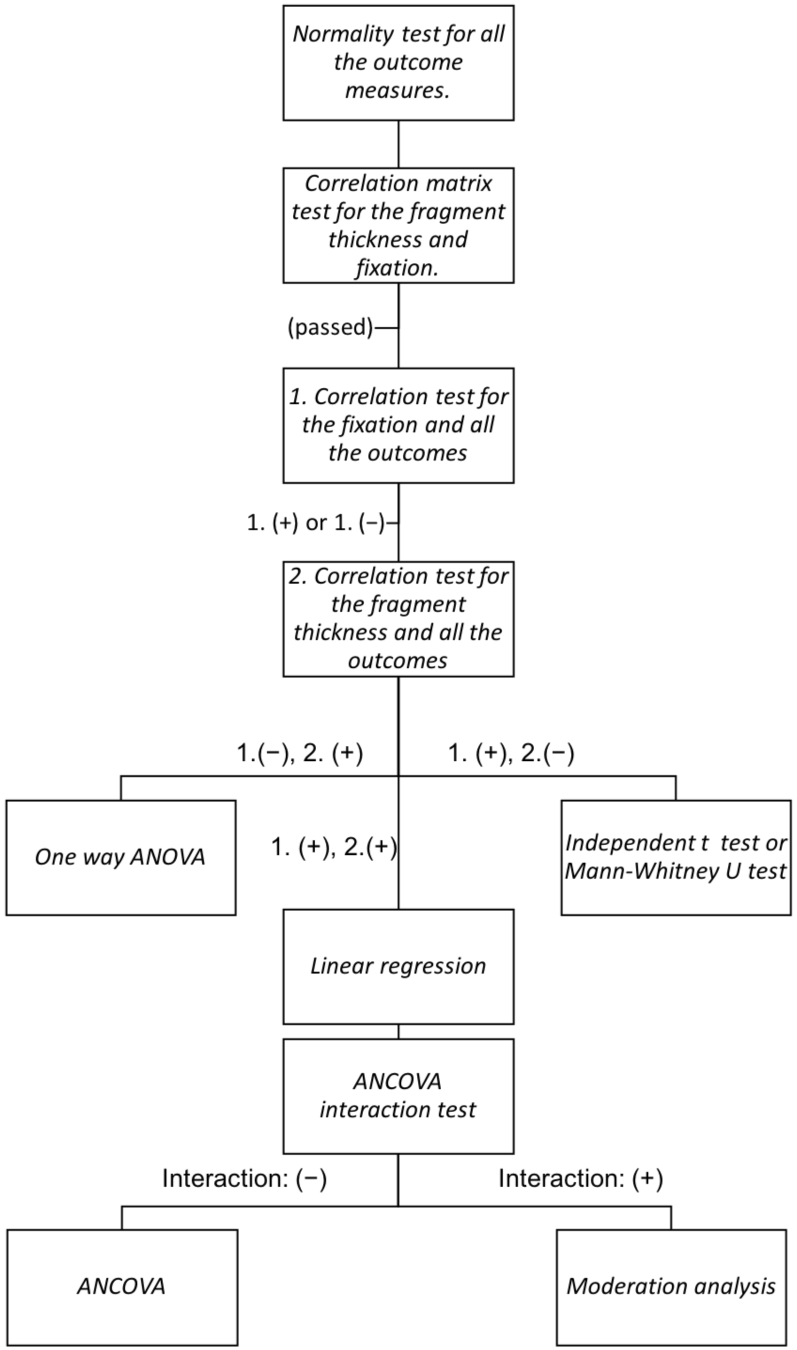


Fig. 1

a) The suture spanning technique with two suture anchors. The blue arrow marks the thickness of the fragment. b) Headless screw fixation for the calcaneal tuberosity fracture. c) The setting of the porcine heel on the material testing machine. To simulate the ankle joint in the postoperative protective condition, the tested angle between the tendon and the long axis of the calcaneal body was set at 45°.

Materials & methods



Results

Table I. All outcome measures in the six subgroups.

Outcome measure	Suture anchor, mean (95% CI)	Headless screw, mean (95% CI)
Load-to-failure test		
Peak failure load, N		
5 mm	428.39 (301.47 to 555.32)	267.20 (206.88 to 327.52)
10 mm	358.43 (216.80 to 500.05)	315.75 (282.96 to 348.55)
15 mm	446.58 (361.61 to 531.55)	432.55 (370.30 to 494.80)
Stiffness, N/mm		
5 mm	63.99 (42.88 to 85.10)	73.60 (70.79 to 76.41)
10 mm	52.35 (23.83 to 80.87)	82.67 (68.72 to 96.61)
15 mm	46.23 (35.53 to 56.93)	73.18 (66.66 to 80.36)
Cyclic loading test		
Peak failure load, N		
5 mm	387.54 (224.49 to 550.59)	224.01 (188.41 to 259.61)
10 mm	354.27 (202.17 to 506.37)	324.30 (288.13 to 360.47)
15 mm	390.76 (356.59 to 424.93)	402.57 (363.82 to 441.33)
Mean stiffness, N/mm		
5 mm	38.17 (24.76 to 51.58)	N/A
10 mm	41.61 (27.17 to 56.06)	42.32 (31.30 to 53.33)
15 mm	35.85 (34.14 to 37.56)	63.43 (46.55 to 80.30)
Creep, mm		
5 mm	10.51 (5.67 to 15.35)	N/A
10 mm	10.10 (6.09 to 14.11)	6.20 (4.87 to 7.54)
15 mm	8.68 (6.84 to 10.53)	3.94 (2.18 to 5.70)

CI, confidence interval; N/A, not applicable.

The failure modes

Table II. The failure modes of the suture anchor and headless screw fixation in the load-to-failure and cyclic loading tests.

Test	Headless screw			Suture anchor		
	Fracture fragment pullout	**Broken screw**	**Fracture fragment and screw pullout**	**Broken sutures**	**Broken eyelet**	**Anchor pullout**
Load-to-failure	6	0	3	9	0	0
Cyclic loading	9	0	0	9	0	0

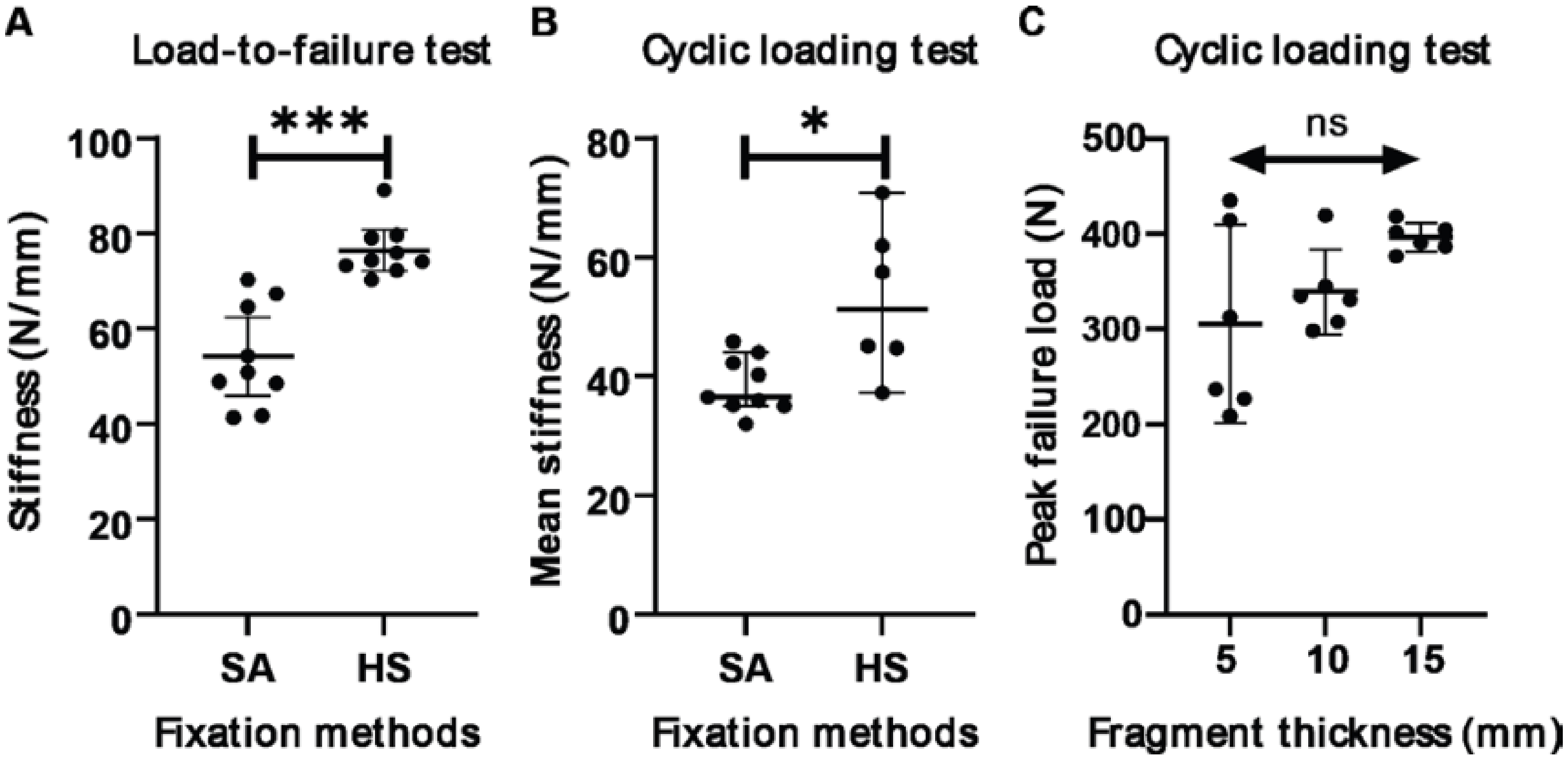
Regression analysis

Table III. The correlation between all the outcome measures and the two independent variables in terms of fixation method and fragment thickness.

Outcome measure	Fx/FT	R^2	Correlation coefficient	p-value
Load-to-failure test				
Peak failure load, N	Fx	0.245	-0.495	0.037*†
	FT	0.261	0.511	0.030*
Stiffness, N/mm	Fx	0.653	0.808	< 0.001*†
	FT	0.269	-0.269	0.280*
Cyclic loading test				
Peak failure load, N	Fx	0.195	-0.441	0.067*†
	FT	0.292	0.541	0.021*
Mean stiffness, N/mm	Fx	0.431	0.661	0.007†‡
	FT	0.177	0.276	0.320‡
Creep, mm	Fx	0.734	-0.857	< 0.001*†
	FT	0.331	-0.575	0.025*

*Pearson correlation test
†Point biserial correlation.
‡Spearman correlation test.
FT, fragment thickness; Fx, fixation method.

Results



A
Load-to-failure test
***
Stiffness (N/mm)
100
80
60
40
20
0
SA
HS
Fixation methods
B
Cyclic loading test
*
Mean stiffness (N/mm)
80
60
40
20
0
SA
HS
Fixation methods
C
Cyclic loading test
ns
Peak failure load (N)
500
400
300
200
100
0
5
10
15
Fragment thickness (mm)

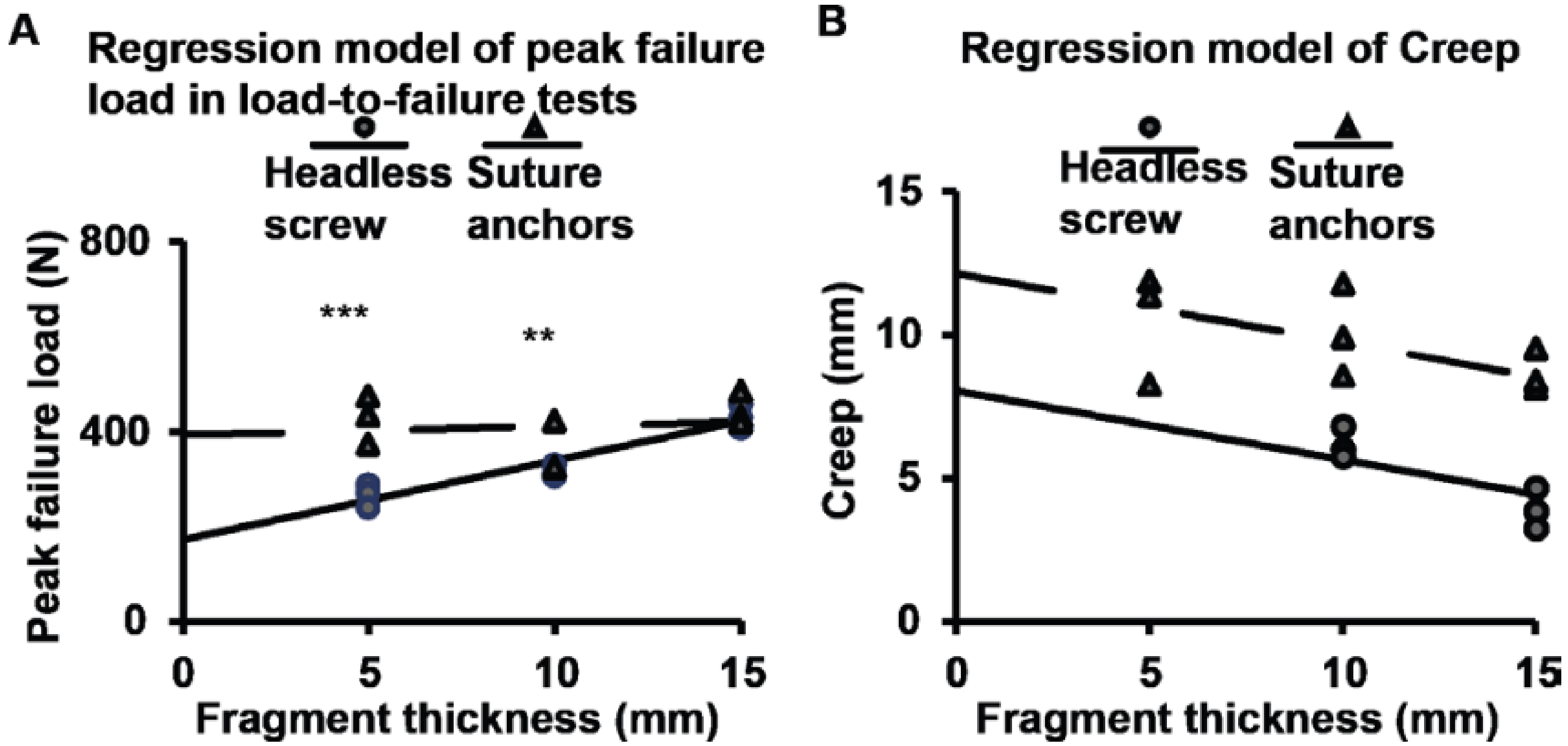
The regression equation

Table IV. The results of multiple regression analysis and regression models for the creep and peak failure load in the load-to-failure test.

Outcome variable	R^2	Intercept	B (fixation)	B (thickness)	B (combined effect of fixation and thickness)	p-value
Creep	0.83	12.13	-4.10*	-0.24	N/A	< 0.001†
Peak failure load (load-to-failure test)	0.67	173.15	219.79	16.53	-14.72	0.001‡

*The reference fixation method was headless screw fixation for the dummy variables (headless screw = 1; suture anchor = 0).
†Analysis of covariance.
‡Moderation analysis.
B, beta coefficient; N/A, not applicable.

The regression models



Key messages

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BIOMECHANICS

Thickness of simple calcaneal tuberosity avulsion fractures influences the optimal fixation method employed

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Aims

This study aimed to establish the optimal fixation methods for calcaneal tuberosity avulsion fractures with different fragment thicknesses in a porcine model.

Methods

A total of 36 porcine calcanea were sawed to create simple avulsion fractures with three different fragment thicknesses (5, 10, and 15 mm). They were randomly fixed with either two suture anchors or one headless screw. Load-to-failure and cyclic loading tension tests were performed for the biomechanical analysis.

- Fragment thickness affects the pullout strength of headless screw fixation more than suture anchor fixation.
- The pullout strength of headless screw fixation is comparable to suture anchor
- fixation when the fragment thickness is
- above 15 mm.
- Preoperative or intraoperative measure-
- ment of avulsed fragment thickness could help to decide the optimal fixation method to use.

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