How Does Number of Cerclage Cables Impact Titanium Tapered Stem Stability in Periprosthetic Femoral Fracture: A Biomechanical Cadaveric Study

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INTRODUCTION:

Periprosthetic femoral fractures around total hip arthroplasty stems are commonly treated with femoral component revision using a titanium tapered stem and cerclage fixation. Peri-isthmic periprosthetic fractures are particularly challenging to treat given that the fracture extends through the isthmus and compromises the zone of bone available for stem contact and stability. Limited biomechanical evidence exists to guide fixation strategies. We previously found that a 4-cm cortical contact length between intact bone and stem provided superior stability compared to shorter contact lengths. The objective of this study was to evaluate the difference in tapered stem stability when using 2 versus 3 cerclage cables in the treatment of simulated peri-isthmic fractures with a 4-cm contact length.

METHODS:

Twenty-four fresh frozen cadaveric female femora (12 matched pairs) from donors with an age of 65.4±7.9 years were included. The femoral isthmus was identified using fluoroscopy and the bone proximal to the isthmus was resected. The femoral shaft was over-reamed in a retrograde fashion to create a consistent 4-cm contact length at the isthmus. A simulated oblique fracture was created using a 3D-printed cutting guide, reduced, and fixed using beaded 2.0-mm cerclage cables (2 cables on one femur and 3 on the contralateral femur of each matched pair; Fig.1A). The femur was prepared, and a 195-mm monobloc tapered stem was implanted. The proximal aspect of each stem was loaded axially in a stepwise fashion to up 10000 N using a servohydraulic testing system (Fig.1B). Stem subsidence and fracture displacement were determined at 2600 N (simulating load during gait). Load-to-failure was determined with failure defined as stem subsidence ≥10 mm, the initiations of a new fracture, and/or cable failure (Fig.1C).

RESULTS:

At a 2600 N load, stem subsidence was significantly lower in specimens treated with 3 cables (2.8±4.5 mm) than 2 cables (4.5±2.2 mm; p=0.04; Table 1). Fracture displacement was <2.5 mm in all specimens at a 2600 N load (0.4±0.3 mm for 3 cables; 0.8±0.6 mm for 2 cables; p=0.02). During load-to-failure testing, all constructs failed. The load-to-failure was superior in specimens treated with 3 cables (4223±1168 N) compared to those treated with 2 cables (3504±698 N; p=0.02). The initial failure mode was subsidence ≥ 10 mm in most specimens (3-cable specimens, 11/12; 2-cable specimens, 8/12). New fracture lines were noted in 11/12 3-cable specimens and 12/12 2-cable specimens. Force at which stems subsided ≥ 10 mm was higher in specimens treated with 3 cables (4323±1118 N) compared to those treated with 2 cables (3692±729 N; p=0.02). Force at which new fracture occurred was also higher in specimens treated with 3 cables (5479±1907 N) compared to those with 2 cables (4033±662 N; p=0.01).

DISCUSSION AND CONCLUSION:

In a peri-isthmic periprosthetic fracture model with a 4-cm cortical contact length, titanium tapered stems had improved initial axial stability and reduced stem subsidence in fractures treated with 3 cerclage cables compared to 2 cables. In load-to-failure testing, femora fixed with 3 cables demonstrated superior biomechanical properties to femora with 2 cables as higher loads were required for failure to occur.

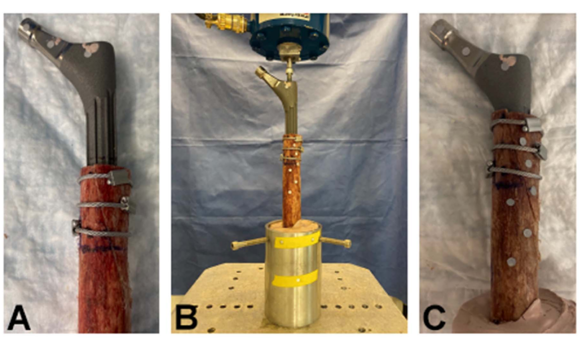

Figure 1

Table 1. The impact of number of cerclage cables on outcome.

Outcome	Construct		P value
	Tapered stem + 3 cables	Tapered stem + 2 cables	
Subsidence at 2600-N (mm)	2.8 ± 4.5	4.5 ± 2.2	0.04*
Fracture displacement at 2600 N (mm)	0.4 ± 0.3	0.8±0.6	0.02*
Load to failure (N)	4223 ± 1168	3504 ± 698	0.02*
Load to subsidence ≥ 5 mm (N)	3175 ± 993	2713 ± 472	0.08
Load to subsidence ≥ 10 mm (N)	4323 ± 1118	3692±729	0.02*
Load to new fracture (N)	5479 ± 1907	4033 ± 662	0.01*
Load to cable failure (N)	6638 ± 1293	4869 ± 1193	0.14