Initial Stiffness of Bicortical Locked Screw Versus Unicortical Locked Screw and Graft-Cable Fixation of Comminuted Vancouver C Periprosthetic Fractures: A Biomechanical Study

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Background/Purpose: Periprosthetic fractures are estimated to occur in 1% to 6% of patients who have undergone total or hemiarthroplasty of the hip. The treatment that is considered by many to be the "gold standard" for Vancouver C periprosthetic fractures is fixation with a locked plate using unicortical screws and cables with or without an allograft strut. With the recent advances in polyaxial locking technology; we sought to determine the stiffness of this construct in comparison to bicortical locked-screw fixation around the implant stem in an osteoporotic, biomechanical model.

Methods: 20 synthetic osteoporotic femoral models were implanted with a noncollared, press-fit hip stem. After the stem was seated through traditional impaction, the stem was further subsided by 100 cycles of 1000 N at 1 Hz on a uniaxial servohydraulic testing machine. A 5-cm section of femoral diaphyseal bone was then removed 2 cm distal to the hip stem to simulate a Vancouver C periprosthetic fracture with severe comminution. An anatomic, proximal femoral, locking plate was then applied to each model with four bicortical, locked screws in the distal segment and 3-mm spacers between the plate and bone to simulate soft-tissue interposition. Specimens were then divided into four groups of five depending on the proximal segment fixation: (A) three polyaxial, locked bicortical screws anterior to the hip stem; (B) three polyaxial, locked bicortical screws posterior to the hip stem; (C) three alternating polyaxial, locked bicortical screws with two posterior and one anterior to the hip stem; and (D) three unicortical locked screws with a femoral allograft strut held in place by two proximal and two distal circumferential, braided-steel cables. Each specimen was then placed at 25° of adduction in a mounting fixture under a uniaxial servohydraulic testing machine. A preload of 50 N was applied followed by application of a 250-N load at 50 N per second. The process was then repeated with the specimen at 10° from the horizontal, in the coronal plane, using a load of 50 N at 10 N per second to simulate torsion during standing. This process was repeated in triplicate for each specimen. Load was assessed using the uniaxial servohydraulic testing machine and medial cortical displacement was assessed at the fracture gap using an optical tracking device.

Results: The highest axial stiffness was documented in group D, which was significantly higher than groups A through C ($P < 0.0001$ for all) (Table 1). The axial stiffness of groups B and C were not significantly different ($P = 0.1197$), but both were significantly greater than group A (Group B: $P = 0.0227$; Group C $P = 0.0014$). The highest torsional stiffness was also documented in group D, which was significantly higher than groups A through C ($P < 0.001$ for all) (Table 1). The torsional stiffness of group C was also significantly higher than both group A ($P = 0.0208$) and group B ($P = 0.0003$).

See pages 47 - 108 for financial disclosure information.

Conclusion: In a comminuted Vancouver C fracture model, proximal fixation with unicortical screws, cables, and a femoral strut graft provided the highest initial stiffness in both axial and torsional stiffness, despite greater variation between specimens. If locked plate fixation is used, placement of bicortical screws both anterior and posterior to the stem should be utilized to provide maximum torsional and axial stiffness.

Table 1. Initial Construct Stiffness in Axial and Torsional Testing

Method	Construct	n	Mean	St. Dev.	Min	Max
Axial	Anterior (A)	5	440.39	35.68	388.81	480.23
	Posterior (B)	5	591.48	22.28	558.23	632.84
	Alternating (C)	5	596.67	52.84	516.99	657.11
	Cable-Graft (D)	5	829.09	71.72	713.51	939.26
Torsion	Anterior (A)	5	46.31	4.71	37.03	53.06
	Posterior (B)	5	44.44	3.35	40.13	49.24
	Alternating (C)	5	53.51	4.03	48.41	62.44
	Cable-Graft (D)	5	82.11	15.76	56.67	100.94