Prophylactic Cerclage With Braided Polyblend Suture During Femoral Broaching

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abstract

Femur fractures occur during broaching and impaction of the implant during hip arthroplasty. Prophylactic cerclage of the proximal femur with braided cable and steel wire has been shown to decrease hoop stresses and has been posited as a way to decrease the incidence of intraoperative fracture. In this biomechanical study, the authors investigated the strain across the proximal femur during broaching after the application of stainless steel wire, comparing it with that for braided polyblend suture. Nine femur models were prepared, and strain gauges were applied to each of 3 groups. The control group received no cerclage, the second group received a double loop of suture, and the third group received a single loop of steel wire. A broach was firmly seated in each femur and sequentially increasing axial loads were applied at 1000 N, 2000 N, 3000 N, 4000 N, 5000 N, and 6000 N and to failure. Strain at all loads was lower in both cerclage groups than in the control group. Strain was 28.6%±12.4% lower in the suture group than in the control group (P=.0003). Strain was 30.8%±10.7% lower in the steel wire group than in the control group (P=.0011). There was no statistically significant difference between suture cerclage and steel wire cerclage (P=.7367). When used for prophylactic cerclage of the proximal femur, braided polyblend suture increases hoop stress resistance, decreases strain, and may play a clinically useful role in decreasing intraoperative proximal femur fractures during hip arthroplasty. [Orthopedics. 2016; 39(6):e1183-e1187.]

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the proximal femur with 2-mm cobalt-chrome cable significantly increases the hoop stress resistance, and surmised that this would decrease the incidence of intraoperative femur fractures.

A single loop of braided composite suture has been shown to have mechanical properties close to those of 18-gauge stainless steel wire. The utility of suture material in prophylactic cerclage of the proximal femur during hip arthroplasty has not been studied, and this may even confer advantages over the more traditionally used wires and cables. The authors conducted a biomechanical study comparing 18-gauge stainless steel wire with a double loop of commercially available braided polyblend composite suture to investigate the ability of each to withstand an increasing axial load to the proximal femur, as occurs during the broaching and impaction of a cementless femoral implant. They hypothesized that the suture material would significantly decrease strain at the proximal femur when used for prophylactic cerclage.

**Materials and Methods**

**Specimen Preparation and Study Groups**

The test samples used in this study were small, left, fourth-generation, composite femurs (Model 3414; Pacific Research Laboratories, Vashon Island, Washington). Femurs were cut normal to the long axis of the diaphysis, 20 cm distal to the lesser trochanter. Two wood screws were placed in the distal end of each specimen, and these ends were potted in 5 cm of epoxy resin. A standardized 45° oblique osteotomy was then made through each femur, 0.5 cm above the proximal edge of the lesser trochanter. The angled osteotomy stopped at the medial edge of the greater trochanter and then followed the border of the greater trochanter to its proximal edge. A 1-mm groove was cut on the lateral aspect of each femur, immediately proximal to the lesser trochanter, to standardize cerclage placement.

In 3 specimens that served as a control, no cerclage material was used. In 3 other specimens, the suture cerclage group, a double loop of #5 FiberWire braided polyblend suture (AR-7210; Arthrex Inc, North Naples, Florida) was tightly wound around the proximal femur, just above the lesser trochanter, and secured with at least 4 square knots. In the final 3 specimens, the wire cerclage group, a single loop of Babcock 18-gauge stainless steel wire (SN 1020-001; Carefusion Corp, San Diego, California) was applied and tensioned in the typical fashion. A strain gauge was applied on the posterior-medial aspect of the femur, immediately distal to the lesser trochanter, and secured with at least 4 square knots. In the final 3 specimens, the wire cerclage group, a single loop of Babcock 18-gauge stainless steel wire (SN 1020-001; Carefusion Corp, San Diego, California) was applied and tensioned in the typical fashion. A strain gauge was applied on the posterior-medial aspect of the femur, immediately distal to the lesser trochanter, in all specimens (Figure 1). Each femur was initially hand reamed. Then, a CORAIL broach (DePuy, Warsaw, Indiana) was seated into each femur in a standardized fashion. After the broach
was adequately seated, anteroposterior radiographs were obtained to ensure that the broach was in neutral alignment and not in excessive varus or valgus angulation.

Biomechanical Testing

Biomechanical testing was conducted on an 8521 machine (SN C1921; Instron, Canton, Massachusetts). Each femur was placed on the table of the test frame such that the actuator motion was parallel to the axis of the bone. The broach handle was fixed rigidly to the actuator, but the distal end of the femur was free to translate or rotate on the table. A preload of 100 N was applied to each broach. The strain gauge output at 100 N was recorded and used as the initial strain gauge reading. The broach was then driven into the femur under load-control at a rate of approximately 200 N/sec until the load reached 1000 N. The load was held at 1000 N for approximately 5 seconds. The load was sequentially increased to 2000 N, 3000 N, 4000 N, 5000 N, and 6000 N at a rate of approximately 200 N/sec. Photographs and anteroposterior radiographs were obtained after biomechanical testing to aid in mode of failure analysis (Figure 2).

Data Evaluation and Statistical Analysis

The outcome measure was the amount of strain recorded at each loading step (1000 N, 2000 N, 3000 N, and so on). An initial comparison of strain values between each test group at all loading steps was performed using a Student’s t test method with the level of statistical significance set at \( P \leq 0.05 \). A post hoc power analysis indicated under-powered results. To mitigate against a Type II error at each loading step (1000 N, 2000 N, 3000 N, and so on), a sample size of 13 would be required. Additionally, a comparison of strain values between the test groups at all loading steps was performed using a least squares multivariable fit model using load applied and test group as the predictors for strain.

RESULTS

In the axial loading tests, strain at all measured loads was lower in each of the 2 cerclage groups than in the control group (Figure 3). Using the Student’s \( t \) test method, there was no statistically significant difference between the test groups; however, the measured difference in strain between each cerclage group and the control group exceeded 25%. Strain was 28.6\%±12.4\% lower in the FiberWire cerclage group than in the control group. Strain was 30.8\%±10.7\% lower in the stainless steel wire cerclage group than in the control group. When a least squares multivariable fit model using load applied and test group as the predictors for strain was employed, there was a statistically significant difference in the strain measured between the FiberWire group and the control group (\( P=0.0003 \)) and between the steel wire group and the control group (\( P=0.0011 \)). There was no statistically significant difference between suture cerclage and steel wire cerclage (\( P=0.7367 \)).

DISCUSSION

Creating an exact fill of the proximal femoral canal that allows for maximal initial stability and bony ingrowth is the goal of noncemented arthroplasty. However, doing so predisposes the patient to intraoperative proximal femoral fractures, especially in osteoporotic bone or when minimally invasive methods are used. Prophylactic cerclage of the proximal femur with cerclage cables and steel wires has been proposed as one method by which to decrease the incidence of these fractures. In the current study, prophylactic cerclage of the proximal femur with #5 FiberWire was comparable to using stainless steel wire, and a statistically significant reduction in the strain experienced at the proximal femur of more than 25% was achieved.
The #5 FiberWire is a flexible, high-strength, polyblend-polyethylene suture with biomechanical properties approximating those of stainless steel wire. It may offer advantages over wires or cables, including better adaptation to the bone surface, decreased soft tissue irritation from the crimp, no risk of metallosis in the case of metal-on-metal contact, potentially easier handling and application, less risk for injury to the surgical team, and being radiolucent. Ting et al studied 29 patients who received nonmetallic periprosthetic cables. They did not observe complications directly related to the cables at a mean follow-up of 21 months, suggesting that these biomaterials can be used safely and effectively in hip arthroplasty.

This study had several important limitations. To minimize variability among the study specimens, the authors used synthetic bone models, which may differ from the in vivo environment. Another potential limitation was that they did not measure or control for the amount of tension placed by the cerclage sutures or wires across the proximal femur, as all the tensioning was done by hand. Third, and perhaps most important, this study had a small sample. This likely contributed to the lack of significance found with the Student’s t test. However, the authors were able to show significance when multivariate linear regression analysis was employed, as this was better able to compensate for the small sample. Despite these limitations, the use of fourth-generation composite models allowed for a more reliable test bed than cadaveric specimens and lower variability in testing for all loading regimens. This study sets the stage for future investigations.

**Conclusion**

A proximal femoral fracture during hip arthroplasty compromises the stability of the implant and, if unrecognized, can lead to failure. For patients who are at particular risk for this complication, such as elderly female patients with diminished bone density and small femoral canals, prophylactic cerclage, in addition to careful surgical technique and meticulous pre-operative templating, may be of benefit. This may be even more important when an anterior approach to the hip is used. This pilot study suggests that braided polyblend suture, when used for prophylactic cerclage of the proximal femur, decreases strain, may be biomechanically equivalent to stainless steel wire, and may serve a clinically useful role in decreasing the incidence of intraoperative proximal femur fractures. Further biomechanical testing with cadaveric femurs will contribute to understanding regarding prophylactic cerclage at the proximal femur and further guide clinical practice.

**References**

7. Davidson D, Pike J, Garbaz D, Duncan CP, Masri BA. Intraoperative periprosthetic fractures during total hip arthroplasty: evalua-


