Bone Block Graft Fixation for Glenoid Bone Loss: A Comparative Study of Construct Tensioning Protocols Using FiberTape® Cerclage

Arthrex Orthopedic Research

Objective

Recurring anterior shoulder instability is frequently associated with bone loss of the glenoid.[1] Different techniques using autogenic or allogeneic bone block grafts have been established over the past years to address the glenoidal bone defect.[2] The suture-based bone block cerclage, using two interconnected FiberTape and TigerTape™ cerclage sutures, offers a metal-free fixation method, thereby avoiding screw-related complications.[3] To achieve sufficient stable graft fixation and minimize the risk of graft fracture, nonunion, or failure, repeatable procedures need to be established. The purpose of this white paper is to compare different knot-tensioning protocols using a cerclage tensioner for an all-suture bone block cerclage and analyze them regarding the load applied during tensioning and the initial fixation achieved after tensioning. Three different protocols were tested (n = 5 in each group):

- 3x tensioning up to the 80 mark on the tensioner,
- 3x tensioning up to the 30 mark, and
- 2x tensioning of the hitching suture up to the 30 mark, after tying one knot.

Methods and Material

For this purpose, two 40/20 pcf Sawbones blocks, representing the glenoid (30 mm x 30 mm x 40 mm) and the bone block graft (10 mm x 10 mm x 20 mm), were prepared. Two drill holes were predrilled 10 mm apart with a diameter of 3 mm in each block. The glenoid Sawbones block was mounted to the testing machine, enclosed in a sample holding fixture, with the drill holes axially aligned along the actuator axis. The small bone block was placed on a custom aluminum plate with corresponding drill holes, which was secured to the actuator of the testing machine. This allowed for the measurement of the load applied onto the small bone block by tensioning the bone block cerclage construct. The two blocks were positioned a few millimeters apart, with the drill tunnels aligning axially (see Figure 1A).

Figure 1A. Test setup with bone blocks and cerclage.

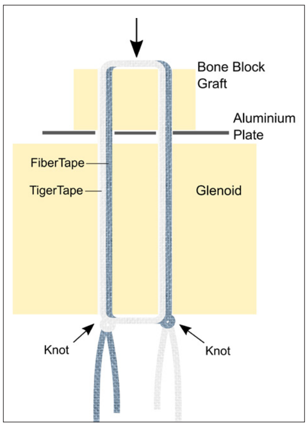

Figure 1B. Schematic representation of FiberTape cerclage construct with two interconnected sutures.

For the FiberTape cerclage, two different colored cerclage tapes, FiberTape and TigerTape, were shuttled from the bottom to the top through the glenoid and bone block graft, and then vice versa back through the second tunnel, to press the bone block graft to the plate above the glenoid (see Figure 1B). To interconnect both cerclage sutures, the FiberTape cerclage suture tail was loaded through the pre-tied racking hitch knot from the TigerTape cerclage suture, and consequently, the TigerTape cerclage suture tail was loaded through the pre-tied racking hitch knot from the FiberTape cerclage suture. The cerclage loop was then shortened by pulling alternately on the suture tails until the two knots were seated against the Sawbones block, thus reducing the slack in the construct. Afterwards, five samples were tested for each tensioning protocol.

Tensioning Protocol 1

The first group was tensioned three times in total. One of the cerclage sutures was loaded into the FiberTape cerclage tensioner and tensioned up to the 80 mark on the tensioner. The second cerclage suture was then tensioned in the same way up to the 80 mark, followed by another tensioning step of the first suture up to 80. The suture's ends were cut to separate the two tails of the FiberTape and TigerTape sutures. Two consecutive half hitches followed by two alternating half hitches were made on each cerclage suture to finalize the construct.

Tensioning Protocol 2

Tensioning protocol 1 was adapted by tensioning three times up to the 30 mark on the tensionier instead of 80. Based on pretesting, 30 was identified as the ideal value for further investigations.

Tensioning Protocol 3

For the third tensioning protocol, the suture's ends were cut and a half hitch was applied to the first cerclage. The hitching suture tail was loaded into the FiberTape® cerclage tensioner and tensioned up to the 30 mark, while holding the other suture tail aside. One successive and two alternating half hitches were applied. The procedure was repeated for the second cerclage suture. The loads acting on the bone block were recorded during tensioning. The maximum load during tensioning and the load retained after the last tensioning (initial fixation after tensioning) were evaluated as depicted in Figure 2. The groups were tested for equal variances and normality using the Brown–Forsythe and Shapiro–Wilk tests, respectively. To analyze the effect of the tensioning protocol on the maximum load during tensioning and the load retained after tensioning, a test was performed, followed by a Tukey/Steel Dwass post-hoc test (depending on the normality of the data). Statistical analysis was performed using JMP and statistically significant difference determined for $P \leq .05$

Results

The maximum loads during tension and the loads retained after tensioning are shown in Figures 3 and 4. Tensioning three times up to the 80 mark on the tensioner resulted in the highest loads during tensioning (475.1 ± 78.2 N) and loads retained after tensioning (172.6 ± 73.4 N). Those loads were significantly higher compared to tensioning protocol 2, tensioning only up to the 30 mark (232.8 ± 13.6 N, $P < .0001$; 77.5 ± 17.0 N, $P = .0326$). Protocol 3 revealed significantly lower maximal loads (243.8 ± 21.6 N, $P < .0001$) on the construct while tensioning, but similar initial fixation loads (115.0 ± 11.8 N, $P = .5488$) compared to protocol 1. Compared to protocol 2, loads retained after tensioning were significantly higher ($P = .0326$) without increasing the maximal load on the construct ($P = .9298$). An analysis of the variances of the loads retained after tensioning revealed significantly higher variances when tensioning up to the 80 mark compared to tensioning up to 30 after tying one knot ($P = .0483$). All other pairwise comparisons of variances showed no significant differences.

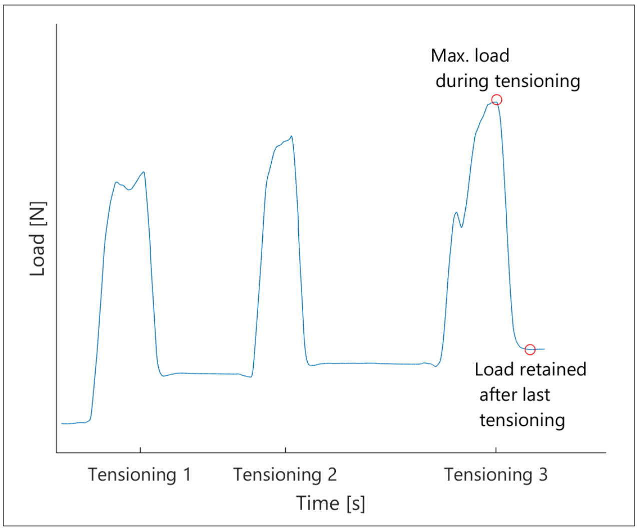

Figure 2. Schematic load-time graph time for a construct tensioned three times. The maximum load during tensioning and the load retained after the last tensioning are marked.

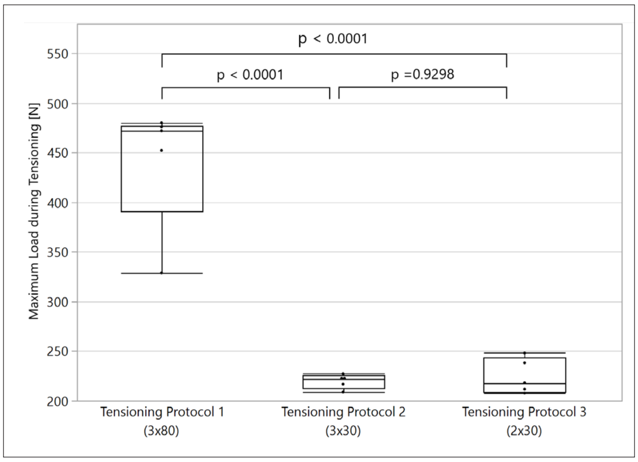

Figure 3. Maximum load during tensioning with corresponding P values for pairwise comparison; n = 5.

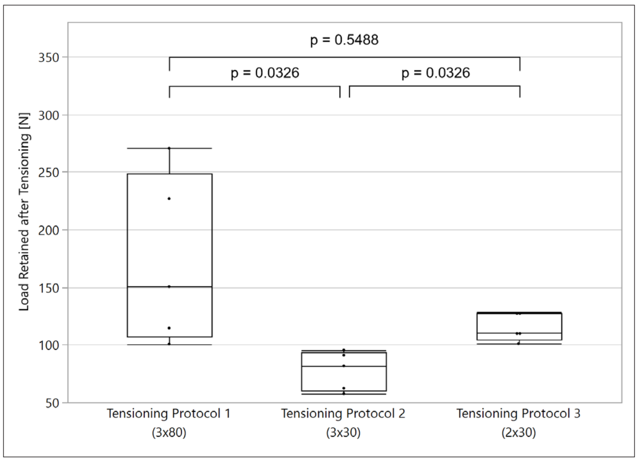

Figure 4. Load retained after tensioning with corresponding P values for pairwise comparison; n = 5.

Conclusions

Tensioning only up to the 30 mark on the tensioner instead of up to 80 resulted in significantly decreased loads on the construct during tensioning but also significantly lower initial fixation after tensioning for protocol 2. Tensioning the hitching sutures up to 30 after tying one knot down (tensioning protocol 3) also resulted in significantly lower loads on the construct during tensioning compared to tensioning up to 80. However, the initial fixation achieved after tensioning was comparable to the stability achieved for tensioning up to the 80 mark. Additionally, this procedure resulted in significantly decreased variances, therefore achieving higher repeatability.

The tensioning protocol involving the tensioning of the hitching sutures up to 30 after tying a knot down resulted in a repeatable and stable initial fixation while decreasing loads on the construct during tensioning.

References

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