FiberWire® is Superior to Stainless Steel for Tension Band Fixation of Transverse Patella Fractures

1,2Wright, P B; 1Kosmopoulos, V; 1,3Coté, R E; 3Tayag T J; 3,4Nana, A D

1Bone and Joint Research Center, Department of Orthopaedic Surgery, University of North Texas Health Science Center, Fort Worth, TX, 2Department of Orthopaedic Surgery, John Peter Smith Hospital (Tarrant County Hospital District), Fort Worth, TX, 3Department of Engineering, College of Science and Engineering, Texas Christian University, Fort Worth, TX

Senior author anana@hsuunt.edu

Introduction: Internal fixation using metal implants in configurations based on the tension band principle remains the mainstay of treatment for operative transverse patella fractures [1]. Recent investigations [2-6] however, have examined heavy suture as a possible alternative to conventional metal implants. Heavy suture is easier to place accurately in the soft tissue than stainless steel, less likely to fragment over time, and appears to be associated with greater patient satisfaction and decreased re-operation rates. No. 5 Ethibond (Ethicon, Somerville, NJ) and No. 5 Ti-Cron (Davis and Geck, Gosport, Hampshire, UK) sutures have been studied in patella fracture models for this purpose. FiberWire (Arthrex, Naples, FL) suture, having superior load to failure and ultimate tensile strength than Ethibond [7], has not to our knowledge been studied as a possible substrate for tension band fixation of patella fractures. The present study aims to (1) evaluate differences in stiffness and failure strength between No. 5 FiberWire with an without a surgical knot, and 18-gauge stainless steel wire with and without a compression twist; and (2) evaluate the effectiveness of FiberWire as a tension band construct using a three-point-bend model.

Materials and Methods: Repeated samples of No. 5 FiberWire suture and 18-gauge stainless steel wire were tensile tested to failure using a materials testing system (MTS Corp., Eden Prairie, MN). To simulate the conditions after uniting opposite ends of the material to secure a tension band construct, tensile tests were then performed with a knot in the center on a set of new FiberWire samples, and a twist in the center of new 18-gauge stainless steel wires. Stiffness and failure strength were calculated for each sample in both of these protocols.

After these preliminary tests, the two materials were used for tension band fixation of a custom three-point-bend model. The three-point-bend model was machined from stainless steel with a unilateral convex surface designed to mimic a symmetrical patella. To mimic the Lökte figure-of-eight anterior tension band technique, two parallel longitudinal tunnels were drilled in the model to allow the passage of the FiberWire or stainless steel wire [8]. After the suture or wire was secured, the model was loaded in three-point-bending at a rate of 5mm/min using the MTS. The anterior fracture gap of 3mm was defined as construct failure [9]. Failure load was thus evaluated at this critical fracture gap. The four constructs tested were: (1) single stainless steel wire with two (bilateral) compression twists; (2) single strand FiberWire tied with a sliding knot [10]; (3) double strand FiberWire tied with individual sliding knots; and (4) double strand FiberWire tied with a Wagoner’s Hitch [5] (Figure 1).

Unpaired t-tests were employed to compare and identify significant differences between the stainless steel wire and each of the FiberWire constructs. Significance levels were categorized as extremely statistical significant (α = 0.001), highly statistical significant (α = 0.01), and statistically significant (α = 0.05).

Results: The tension tests resulted in a small difference in the maximum tensile force (9%) and a large difference in stiffness between the stainless steel and FiberWire (180%) (Table 1). The introduction of the knot in the tensile tests of the FiberWire resulted in a 32% and 53% decrease in stiffness and maximum tensile load, respectively. The twist in the stainless steel wire resulted in a 64% and 63% reduction in stiffness and load, respectively.

Discussion: This study aimed to evaluate the use of FiberWire in transverse patella fracture fixation. Mechanical tests were performed to compare FiberWire to the current standard of treatment employing stainless steel wire. Initial material testing demonstrated that at higher tensile forces (>250 [N]) the stainless wire was unable to maintain its superiority in stiffness when compared to the FiberWire. In contrast, the FiberWire, even beyond the maximum tensile force of the stainless wire, was able to maintain its initial stiffness until failure. In terms of the three-point-bending protocol, results indicate that the double strand FiberWire requires a similar load as the 18-gauge stainless steel wire for construct failure. The load required for construct failure however, was increased substantially when the FiberWire was tied with a Wagoner’s Hitch. In summary, the results from this study suggest that FiberWire is mechanically superior to stainless steel wire for tension band fixation of patella fractures. Furthermore, clinically, the use of FiberWire may decrease the incidence of implant related pain, decrease re-operation rates, and increase patient satisfaction. This study clearly demonstrates that FiberWire may be a possible alternative to stainless steel wire in patella fracture fixation justifying further study.


Table 1. Average stiffness and maximum tensile force (Fmax).

<table>
<thead>
<tr>
<th>Wire Type</th>
<th>Stiffness [N/mm]</th>
<th>Fmax [N]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel Wire</td>
<td>157.6</td>
<td>494.8</td>
</tr>
<tr>
<td>Fiberwire</td>
<td>8.4</td>
<td>541.5</td>
</tr>
<tr>
<td>Stainless Steel w/Twist</td>
<td>56.6</td>
<td>180.9</td>
</tr>
<tr>
<td>Fiberwire w/Knot</td>
<td>5.7</td>
<td>253.8</td>
</tr>
</tbody>
</table>

The average load needed for construct failure in the three-point-bending protocol for each construct is shown in Figure 2. An extremely statistically significant difference (P<0.0001) was found when the failure load of the stainless steel wire (636.0 [N]) was compared to that for the single strand (343.4 [N]) and Wagoner’s Hitch FiberWire (1337.4 [N]) constructs. No significant differences were found when the failure load of the stainless steel wire was compared to the double strand Fiberwire (636.0 [N] vs 580.7 [N]).

Figure 1. Four anterior tension band constructs tested.

Figure 2. Failure load in three-point-bend for constructs studied.