Mechanical Properties of FiberTape® Cerclage for Sternal Closure

Arthrex Orthopedic Research

Introduction

Median sternotomy is the primary approach used in cardiothoracic surgery to gain efficient and unobstructed access to the heart.[1] While these incisions typically heal well, proper approximation and stabilization of the bony sternal halves are necessary to prevent sternal dehiscence and the possibility of subsequent deep sternal wound infection, which carries a mortality rate as high as 47% according to literature.[1,2]

For more than 50 years, it has been a common practice to use metal wires for the closure of these osteotomies, as this technique is considered to be simple, reproducible, and low cost.[1] Nonetheless, the use of metal wires may be problematic, especially in patients with poor bone quality. Physiological loads exerted during normal respiration, or more strongly witnessed during coughing, are concentrated on a small surface area of metal that may cause the wire to cut through the sternum, potentially leading to dehiscence, infection, and a second operation.[1] The FiberTape cerclage system is a 100% nonmetallic, suture-based solution for sternal closure. When compared to metal wires, FiberTape cerclage's flat construct provides broad footprint compression with a larger implant-to-bone contact area, reducing the risk of bone cut-through.

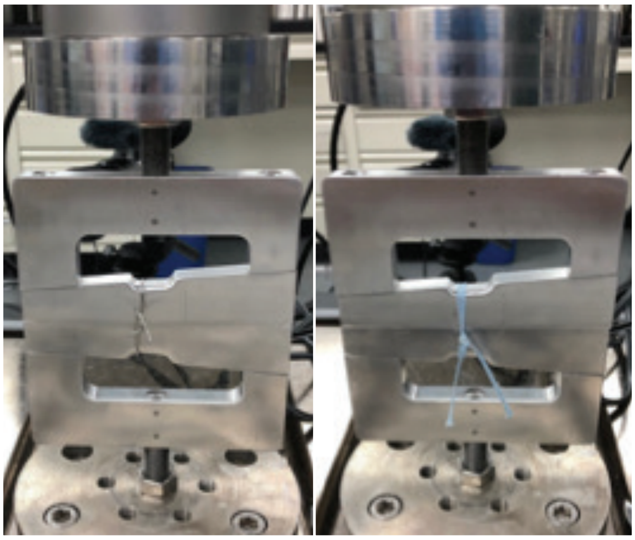
In addition to its broad design, FiberTape cerclage offers other advantages over metal sternal closure devices. It is made from ultra-high-molecular-weight polyethylene (UHMWPE) material. Therefore, it is 100% radiolucent, MR safe, and can be used in patients with metal allergies. Its "soft" construct has no sharp edges to irritate the patient or potentially harm the surgical staff.

This paper compares the mechanical properties of the FiberTape cerclage system to stainless steel wire commonly used for sternal closure.

Methods and Materials

FiberTape cerclage and stainless steel wires were fixed, per surgical technique, to a custom-made metal fixture equivalent to a portion of sternum with respect to geometry and shape (Figure 1) (N = 6). All cerclage constructs were then loaded in static tension with a 10 mm/s loading rate to measure the ultimate load and load at 3 mm gap formation (clinical failure).

Table 1. Test setup



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Results

The mean ultimate loads for stainless steel wire and FiberTape® cerclage constructs were 856.2 ± 168.2 and 1616.5 ± 77.3, respectively (Figure 2). Similarly, the mean loads at 3 mm gap formation for these groups were 518.2 ± 15.5 and 833.6 ± 176.0, respectively (Figure 2). The force displacement curve for an individual sample was captured for additional assessment of mechanical behavior (Figure 3).

Figure 2. Mean ultimate load and load at 3 mm gap formation along with statistical significance

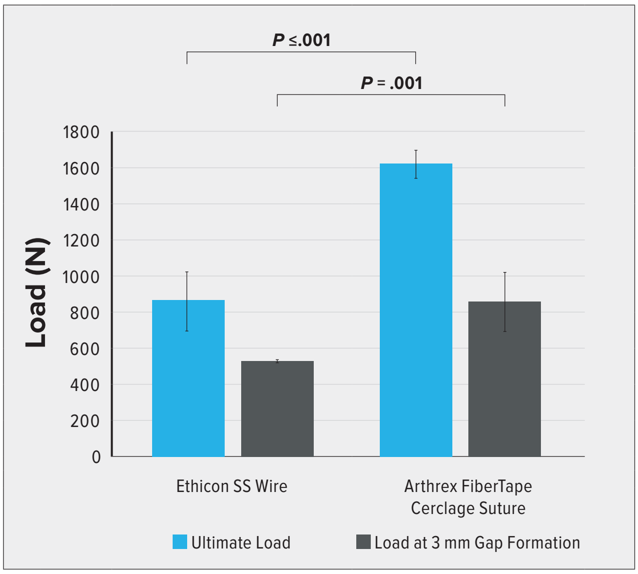
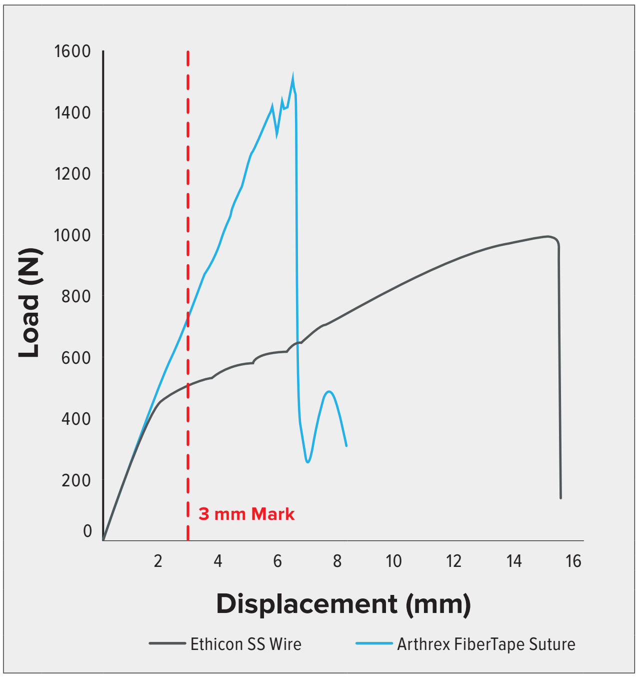


Figure 3. Exemplary load-displacement curve for stainless steel wire and FiberTape cerclage constructs



Discussion

Mean ultimate load and load at 3 mm gap formation for FiberTape cerclage were statistically higher than the stainless steel wire, $P \leq .001$ and $P = .001$, respectively (Figure 2). Therefore, FiberTape cerclage exhibited higher mechanical strength compared to stainless steel wire.[3] In addition, stainless steel wire underwent plastic deformation and/or stiffness loss around/before the defined clinical failure point (Figure 3). Mechanical behavior of stainless steel wire, as expected, was more ductile in nature, which involved elongation and low modulus of resilience. However, FiberTape cerclage exhibited brittle-like mechanical behavior with less stretching and a high modulus of resilience.

References

1. Grapow MT, Melly LF, Eckstein FS, Reuthebuch OT. A new cable-tie based sternal closure system: description of the device, technique of implantation and first clinical evaluation. *J Cardiothorac Surg*. 2012;7:59. doi:10.1186/1749-8090-7-59
2. Schimmer C, Sommer SP, Bensch M, Bohrer T, Aleksic I, Leyh R. Sternal closure techniques and postoperative sternal wound complications in elderly patients. *Eur J Cardiothorac Surg*. 2008;34(1):132-138. doi:10.1016/j.ejcts.2008.04.006
3. Arthrex Inc. Data on file (APT-06653). Naples, FL; 2024.

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