Sternotomy Closure Force Under Cyclic Lateral Distraction: Comparison of Three Closure Techniques

Purpose

To compare the stability of three different sternotomy closure techniques during and after cyclic lateral distraction.

Methods

Anatomical sternum models (Sawbones 20 lb/ft^3 foam, 1025-2) were selected for testing (Trumble 2002). The sternum models were potted, divided along their midline, and fixed with four SuperCable® Iso-Elastic Cables (Kinamed®) in a peristernal configuration, seven No. 5 stainless steel surgical wires (Ethicon®) in a combination peristernal/transsternal configuration, or four stainless steel sternal cables (RTI/Pioneer®) in a figure-of-eight configuration. Each wrapping technique was chosen based on typical clinical usage patterns and the respective product's technique guide. Prior to fixing, a thin-film force sensor was inserted between the sternal halves adjacent to the 3rd intercostal space. Because sneezing has been shown to generate 814 Newtons of lateral distraction force on the sternum (Adams 2014), the sternal halves were laterally distracted with a cyclic force ranging from 0 to >800 N for ten cycles using a Chatillon LRX materials testing system. Throughout the testing, the force sensor recorded the amount of compressive load between the sternal halves, as applied by the cerclage constructs.

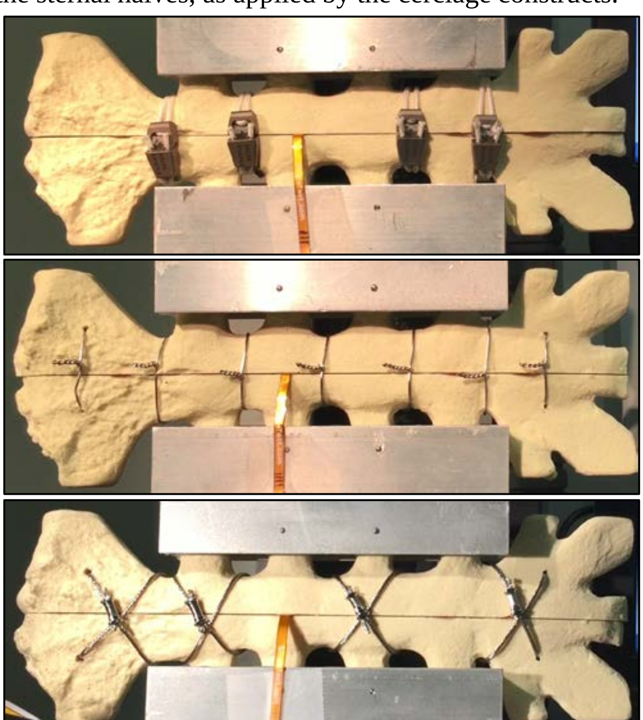

Fig 1. Anatomical sternum models divided and closed with four SuperCables (top), seven No. 5 steel wires (middle), and four steel sternal cables (bottom) and subjected to cyclic lateral distraction. The Wire construct consisted of five peristernal and two trans-sternal wires (Dasika 2003).

Results

All three constructs survived the simulated sneezing regime intact but with differing amounts of residual load. Residual closure force, percent retention of force, and magnitude of recovered force after cyclic loading are summarized in Table 1. Higher force was maintained between the sternal halves and more force was absorbed by the closure construct (based on force recovered) with the SuperCable construct, in contrast to the behavior of the metal wire and cable constructs (Fig. 2).

Parameter	SuperCable (900 N @ 0.9 Hz)	SS wire (824 N @ 0.9 Hz)	SS Cable (830 N @ 0.9 Hz)
Residual closure force (N)	237	18.6	49.4
Percent retention of force	71.0%	17.7%	49.0%
Magnitude of force recovered (N)	221	18.3	53.7

Table 1. Closure force, retention of force, and force recovered for each construct after the sneeze simulation. Force reading taken adjacent to 3rd intercostal space. The cyclic loading parameters (average amplitude and frequency) for each closure type are listed.

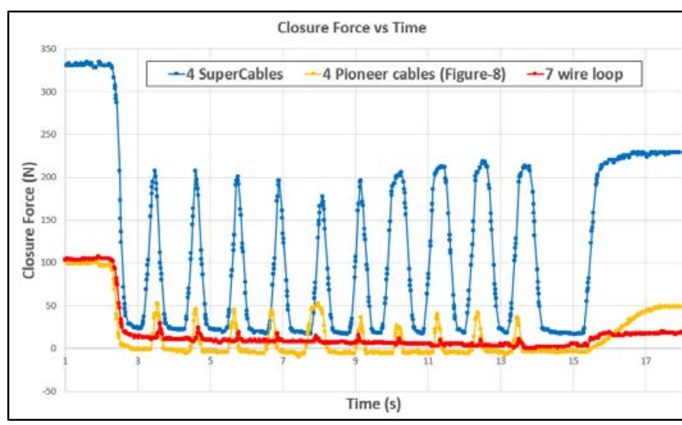

Fig 2. Closure force versus time graph, showing the effect of loosening of the metal wire and cables after anatomic loading.

Conclusions

The SuperCable construct demonstrated superior closure force after the cyclic loading regime and less force transmitted to the bony models during cyclic loading, in comparison to the Steel Wire and Steel Cable constructs. Due to its elastic properties, SuperCable is more effective than Steel Wire or Steel Cable at withstanding cyclic loads associated with sternotomy, by forces generated from sneezing, coughing, lifting, or similar activities.

Click link or scan the code for video of testing and results:

STS 2017