Introduction

Compression staples have gained increasing popularity in orthopedic/podiatric surgical applications.[3] Internal fixation is designed to secure tissue (i.e. bone) easily and effectively, to impart reduction, stabilization, and compression across a fracture/osteotomy site. Early staple designs commonly had a tendency to loosen, lack compression, and provide an inconsistent degree of fixation.[1] Nitinol heat activated compression staples are a type of shape memory alloy (SMA), which have the ability to impart dynamic compression by returning to a previously defined shape at appropriate thermal levels and shown to be non-cytotoxic in vitro[2]. Our study illustrates the potential differences in compression of 5 major staple manufacturers when staples normalize to 98.6 degrees Fahrenheit.

Methods

Seven Nitinol compression staples with varying actuation temperatures, were evaluated including BME OsStaple 18X18mm & 20X20mm (San Antonio, Tx), Integra Aeon 20X20mm (Plainsboro, NJ), DePuy 20X20 (Warsaw, IN), Memodyne 15X15mm (Telos Medical Fallston, MD), and BioPro Memory Staple 18X18mm & 20X20mm (Port Huron, MI). Each staple was submerged in a heated bath (Fisher Scientific Waltham, MA) of distilled water and attached to a force gauge (HGF 45 Transducer Techniques Temecula, CA). Temperature in the water bath was gradually increased in order to compare force (pounds) of actuated compression and post actuation values.

Figure 1. Hand held force gauge apparatus with submerged Nitinol staple in heated water bath.
Results

The BME staples lost 2.72 lbs and 3.745 lbs of compression, respectively. The Memodyn staple lost 3.14 lbs of compression after actuation. The Integra staple showed a loss of only 0.87 lbs of compression after actuation. In contrast, the DePuy and both BioPro staples were shown to lose no compression from the time of actuation and submergence at 98.6 degrees. Peak compression values were greatest with the Depuy staple, followed by Memodyne, and subsequently the BioPro memory staple.

![Graph of peak compression forces at 98.6 degrees Fahrenheit]

![Graph of degree of compression loss of the five staple manufacturers]

Figure 2. Summary of the peak compression forces at 98.6 degrees Fahrenheit. Figure 3. Summary of degree of compression loss of the five staple manufacturers compared in the study.

Conclusions

This study demonstrates that upon actuation, it is possible to lose compression as staples normalize to 98.6 degrees Fahrenheit. Of note, staples were shown to gradually initiate compression below published actuation temperatures. For its size, the Memodyn 15X15mm staple appears to be the most efficient with respect to size and degree of compression.
98.6 degrees. The DePuy and BioPro staples were the only staples with no loss of their compression at temperatures consistent with core homeostatic temperature regulation.

References