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Reply to the Letter to the Editor

Reply to Losanoff et al.

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We thank Dr Losanoff and associates for their comments. Analysis of bone quality would not include only bone densitometry, but also compressive strength and compressive modulus (elasticity). However, bone is a complex material because of its anisotropic (differing strength and elasticity depending on direction of loading) and viscoelastic (differing strength and elasticity depending on speed of load or applied strain rate) properties and also because of its complex geometric variation in thickness in both cortex and medulla [1]. Also, the bone mineral density is not the same throughout the skeleton. This discordance can be caused by several factors, including differences in bone accretion and loss at various sites, variation in the variations in the accuracy of measuring bone mineral density by different techniques, and differences in the normal ranges for young adults between devices [2]. There is significant variation in the prevalence of osteoporosis with measurements at different peripheral and central sites, suggesting potential for misdiagnosis if the WHO criteria are applied strictly [3,4]. Therefore, analysis of bone quality does not simply mean bone densitometry.

A word on the 'complex statistics' that we applied [5]. The design of the study was such to avoid the influence of sternal bone quality on the results. We used paired bone samples from adjacent parts of the same sternum and therefore of presumably identical bone quality. Each type of closure was compared to standard steel wire closure as a control using these paired bone samples. This permitted the use of a statistical test that used paired results (due to the skewed distribution of the data, logarithmic transformation of the raw data was required to perform the paired *t*-test). Therefore, any variability in the sheep's bone densitometry status affected both the test specimen and the control, and there would not be any error resulting from this. The design study is such as to eliminate differing material properties of the bone samples.

As regards Puc's report of reduced tissue damage with polyester tapes [6], we note that in this report both stainless steel wires and Mersilene ribbon were used. Sternal cortical bone behaves rather like femoral trabecular bone since it fails by yielding; and the rate of yield (or rate of wire cutting through bone) is proportional to the force and inversely proportional to the area of contact:

$$\text{rate of yield} \propto \text{force/area of contact}$$

Therefore, one would expect that polyester tape would cut through bone less quickly than polyester suture because of the greater area of contact. However, we tested polyester no. 5 suture which cut through quicker than steel no. 5 suture because polyester stretches when a load is applied to it; and therefore the effective diameter decreases from its nominal 0.787 mm. However, tape closure results in increased suture mass and therefore an increased risk of tissue irritation/infection [7]. The ribbon shape alone does not give immunity to dehiscence, e.g. the failed nylon band closure [8].

Synthetic material closures have been used mostly in a paediatric setting, e.g. polydiaxone (PDS Ethicon) reported by Kreitmann in 1992 [9], Schwab in 1994 [10] and Keceligil in 2000 [11]. Our mathematical model, $T = rlP$, predicts that in such a population the forces generated on coughing would be low due to the small thorax size, and that these forces diminish as a square of the linear dimensions.

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Letter to the Editor

A biological model for biomechanical testing of median sternotomy closure

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We read with interest the recent article by Casha et al. [1] on fatigue testing median sternotomy closures. Their model is based on 2.5-cm cut samples of sheep sternal bones, wired in the standard trans-sternal, figure-eight, and peristernal fashion; additionally, no. 5 gauge polyester and stainless steel bands were used. The authors conclude that use of polyester and figure-eight closures requires caution because they cut through bone faster than the wire closure [1]. Casha et al. illuminated a largely unresolved issue-superiority of one sternotomy closure technique over the other. The adequacy of their model is an open question, however. The human sternum's anatomy is complex; thickness varies considerably from the manubrium to the structure's most distal part. Strength consequently varies at different points, with direct effect on closure stability. Casha's model investigated the closure properties of single sternal fragments, but not the complex properties of the entire sternotomy closure, which consists of several loops of closing material placed at variable distances from one another, and overlying bone of varying thickness and strength.

Casha's group tried to avoid bias in applying complex statistics, including measurement of bone thickness and cortex/medulla ratio [1], but their study did not include analysis of the specimens' bone quality, which is important for successful osteosynthesis. Published studies indicate that, as in humans, sheep suffer from osteoporosis and osteodystrophy. These can be diagnosed reliably using X-ray densitometry [2]. Did Casha's group note the possibility of error in their results associated with the sheep's osteodensitometry status variability?

The authors comment that polyester produces a less rigid closure than stainless steel, a major limitation. Other clinical research articles have reported improved closure and reduced tissue damage associated with polyester tapes [3]. Literature from experimental [4] and clinical [5] settings confirm that less rigid sternotomy closure, using resorbable synthetic materials such as polydioxanone, (PDS, Ethicon) are most successful. It remains for Casha's modeling techniques to be compared with overlapping figure-eight and combined parasternal–peristernal (Robicsek) wiring methods, augmented closures claiming optimal sternal stability and reliability.

Despite some questions about study design and its relationship to earlier reports, Casha's study represents an important step that should be followed by comparison with analogous experiments utilizing whole human cadaveric sterna.

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