RELATING FRACTURE ENERGY TO CLINICAL OUTCOME IN TIBIAL PILON FRACTURE CASES

Thaddeus Thomas, Donald Anderson, Evan Hermanson, Valerie Muehling, J Lawrence Marsh and Thomas Brown
Department of Orthopaedics and Rehabilitation, The University of Iowa,
email: don-anderson@uiowa.edu, web: poppy.obrl.uiowa.edu

INTRODUCTION

Post-traumatic osteoarthritis (OA), evidenced in part by early radiographic changes, is a frequent outcome following intra-articular fracture. Residual altered articular surface anatomy is believed a primary culprit, subjecting cartilage to chronically aberrant contact stress distributions predisposing to OA. But this dogma has evolved from clinical studies unable to control for the initial mechanical insult to peri-articular tissues, another reasonable factor predisposing to early OA.

We have implemented a CT-based technique to objectively quantify injury severity in complex fractures.[1] The technique exploits the principle that mechanical energy is required to create new free surface area in a brittle solid, and that the amount of energy required is directly related to the amount of *de novo* surface area. In tibial pilon fractures, the fracturing energy is delivered directly through ankle joint cartilage.

In the present study, fracture energy measures were used to quantify injury severity in a series of fracture cases, and these results were compared to the clinical judgment of two experienced orthopaedic surgeons. Cartilage appearance on double contrast CT scans of the healed fractures were graded and correlated with fracture energy measures.

METHODS

Injury severity was quantified in a series of ten tibial pilon fracture cases, utilizing CT studies obtained during standard clinical care. Contralateral limb scans provided intact bone surface areas over a comparable distal segment of the patient's tibia, for taring. Bone free surface area measurements were extracted from CT datasets using validated digital image analyses.[2] The *de novo* surface area liberated during fracture was inferred from the difference between free surface areas measured on fractured and intact tibias of each patient.

In independent grading sessions, the fracture cases were rank ordered by two experienced orthopaedic traumatologists from lowest to highest severity, based on the appearance of A-P and lateral radiographs.[3] One rater participated in two independent sessions. Raters were blinded to the surface energy data. Concordance values were calculated to measure agreement between the two raters and between each rater and the CT-based measure of fracture energy.

At the time the fracture had healed (4-8 months post-op), double-contrast (contrast agent followed by air) CT scans were obtained. Articular cartilage integrity was graded from by one of the orthopaedic traumatologists and by two musculoskeletal radiologists using a scale ranging from 0 (all cartilage apparent) to 4 (no visible cartilage). Mean values of the cartilage gradings were compared to fracture energy data.

RESULTS AND DISCUSSION

Fracture-liberated surface areas ranged from 1765 to 9406 mm^2, reflecting a wide range in fracture severity (Figure 1). There was excellent agreement between all injury severity measures (Figure 2). Concordance between the raters was .912 ($p<0.0001$). The concordance between the first rater's assessment of injury severity and that of the CT-based measure was .844 ($p<0.0001$), and for the second rater it was .800 ($p<0.0006$). The range of graded cartilage integrity did not correlate as well with fracture energy measures, though results are too preliminary to warrant statistical comparisons.

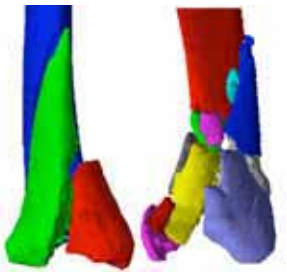

Figure 1. These two cases span the comminution spectrum studied.

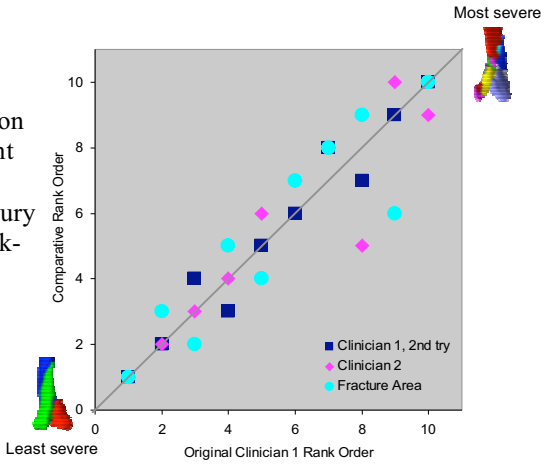

Figure 2: Graphical representation of agreement between different injury severity rank-orderings.

CONCLUSIONS

We have developed estimates of the fracture-liberated bone surface area associated with a series of clinical pilon fractures. Our previous work has shown that this parameter correlates closely with fragmentation energy. The energy measures here calculated agree favorably with the clinical impression of experienced orthopaedic surgeons, in terms of a rank ordering of injury severity. This opens new possibilities in studying the link between initial injury severity and the onset of post-traumatic OA in an actual clinical population.

REFERENCES

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2. Beardsley C, et al. *J Biomech*, **35**, 331-8, 2002.
3. DeCoster T, et al. *Foot & Ankle Int'l*, **20**(1):44-9, 1999.

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