

A NEW TECHNIQUE FOR EXPEDITED FRACTURE SEVERITY ASSESSMENT

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INTRODUCTION

Intra-articular fractures often portend secondary osteoarthritis, chronic disabling pain, and decreased joint function. Clinical decision-making in treating such complex articular injuries requires assessment of injury severity. Until recently, there has been no means to objectively measure comminution and injury severity, preventing clinicians from compiling a body of literature and collective experience to guide advances in the care of these patients.

A new CT-based methodology has provided objective quantification of injury severity, based upon the amount of interfragmentary surface area [1], and it has been shown to agree with expert subjective opinion [2]. However, translation of these methods to clinical use has been limited by its extended processing time (4-8 hours per case). Thus an expedited technique for fracture severity assessment has been developed based upon textural image analysis.

METHODS

CT studies were obtained from twenty tibial pilon fracture cases. Interfragmentary surface areas (the established fracture severity metric) were calculated as the difference between free bone surface areas on fractured and intact tibias for each patient, using existing methods for accurate segmentation of bone and its fragments [1].

The expedited technique was developed using the same twenty fracture cases. In lieu

of delineating bone margins, the new method quantified disorder in a given CT slice using texture analysis, based on the gray level co-occurrence matrix (GLCM). The GLCM describes the relative spatial organization of pixel intensities within a given image, a textural feature disrupted on CT images of a fracture. GLCMs were constructed on a slice-by-slice basis for both the intact and fractured tibias using MATLAB. The GLCM was reduced to a scalar value reflecting the heterogeneity of each slice, calculated using statistical methods (Figure 1).

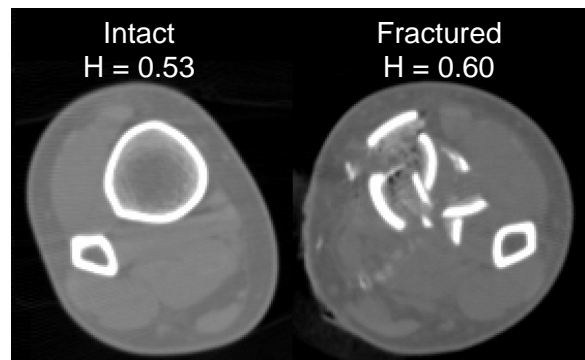


Figure 1: Axial CT slices taken from the same level of a fractured and intact contralateral limb illustrate the degree of disorder following a fracture. Heterogeneity scalars (H) are shown for these two slices.

For a given fracture case, the expedited fracture severity metric was calculated by summing the differences in heterogeneity between the intact and fractured limbs over comparable lengths of the distal tibia. The agreement between this expedited metric and the existing validated fracture severity metric was assessed using linear regression.

RESULTS AND DISCUSSION

The expedited technique reduced the time required to obtain an objective fracture severity assessment to roughly 10 minutes, while maintaining excellent agreement with the existing metric (Figure 2). Linear regression between the heterogeneity measure and interfracture surface area yielded an R^2 value of 0.80 (Figure 3).

In addition, the expedited technique was able to be fully automated, requiring no user intervention once CT scans were obtained.

SUMMARY/CONCLUSIONS

A new CT-based technique was developed to objectively quantify fracture severity in an expedited manner. Areas for future work include the analysis of additional fracture cases and further algorithm refinement.

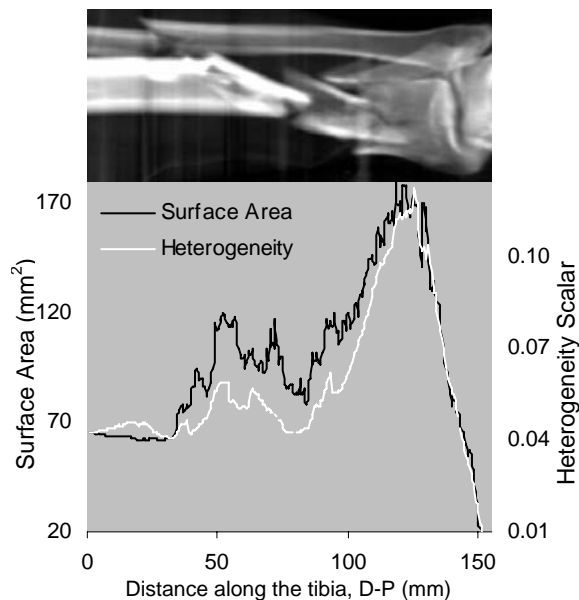


Figure 2: GLCM derived scalars identify discontinuity along the length of the tibia e.g. comminution, displaying similar trends to that of surface area liberation.

Reducing the reliance of present methods upon a CT scan of the intact contralateral limb, not generally available, is a logical next target for refinement. Progressive development of this expedited technique will deliver a practical solution into the clinical setting, providing a new tool to aid in improving patient treatment.

REFERENCES

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ACKNOWLEDGEMENTS

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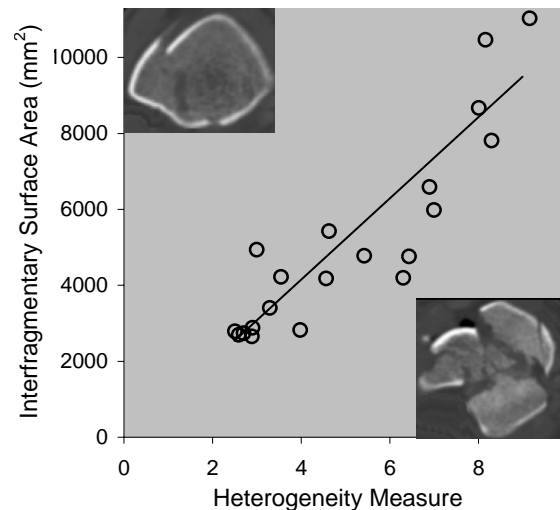


Figure 3: The heterogeneity measure agreed well with the established fracture severity metric. Inset images show slices from the least severe (upper left) and most severe (lower right) fracture cases.