SEQUENTIAL LABELLING AND ACOUSTIC EMISSION ANALYSIS OF DAMAGE OCCURRING IN CORTICAL BONE DURING INDENTATION CUTTING

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INTRODUCTION

When a surgeon uses a wedge shaped blade or an osteotome to cut cortical bone during an operative procedure the bone will fail by a process of microcracking and primary crack propagation. It has previously been observed that crack propagation is dependent on the direction of cutting relative to the main axis of the bone [1]. It has also been observed that microcracks occurring during fracture release acoustic signals that facilitate real-time monitoring of a cutting process [2].

In these novel studies, we labelled damage accumulation during cutting of cortical bone using sequential chelating dyes [3] and we correlated recorded AE signals during cutting with load-displacement curves.

METHODS

8mm cubes of cortical bone were located in a chamber and cut using a wedge-shaped blade in longitudinal and transverse directions. Chelating dyes were used at different loading stages. Specimens were sectioned and examined for evidence of damage using UV microscopy post-test.

Similar specimens were also tested using AE monitoring techniques and various AE parameters were recorded and correlated with load curves; number of AE hits, and amplitude of AE signals. A threshold value of 40dB was used to eliminate background noise and low-amplitude signals were amplified by a fixed gain of 40dB with a (0.1-1) MHz band pass filter [4].

RESULTS AND DISCUSSION

The chelating dyes label the progressive damage occurring during different stages of the cutting process and indicate the extent of the damage zone around the cutting area. The zone is different for different cutting directions; extending longitudinally for longitudinal cutting and confined to lateral regions for transverse cutting as shown in Figure 1. For both cutting directions fracture cracks grow along the lamella interfaces.

Figure 2 shows that the number of recorded AE pulses increased prior to main cutting fracture as previously reported for tensile fracture [5]. High amplitude, high duration signals may be associated with the main crack propagation, as they occurred predominantly during this period of loading.

CONCLUSIONS

It is difficult to clearly distinguish different stages in the crack growth from current results however there is clearly labelling of damage (flame effect) by all dyes used, indicating damage occurring at different stages of the loading process, and the labelled zone shows the direction of the damage process occurring relative to cutting. The AE technique is useful for real-time monitoring and prediction of fracture processes, and the increase in AE pulses prior to fracture may be used as an indicator of onset of fracture during bone cutting.

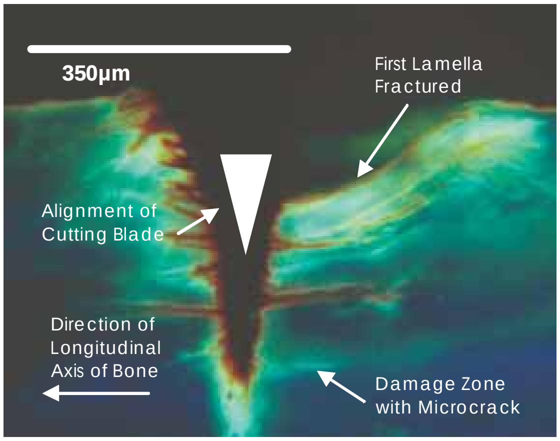

Figure 1: Cutting zone - transverse cutting specimens.

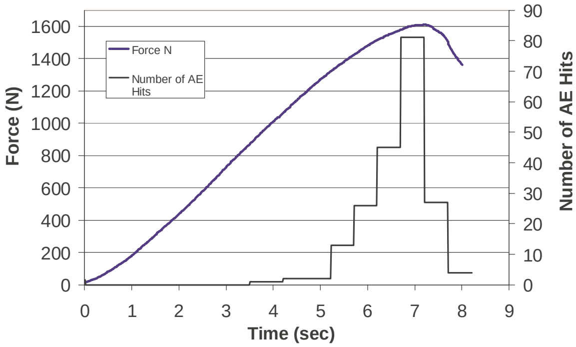

Figure 2: Force and number of AE hits versus time during longitudinal indentation loading.

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