MONITORING BONE FRACTURE USING VIBRATION ANALYSIS

P. Varley, J. Hession, L. Creedon, G. Muir
Department of Mechanical and Electronic Engineering, Institute of Technology Sligo

ABSTRACT

Radiographic techniques are regularly employed to image fractures however patients are exposed to ionising radiation as a consequence. Vibration analysis provides a non-ionising method to monitor bone fracture. This study has found that the resonant frequency of a "healthy" sheep tibia decreased by 47.13% (S.D. 11.63%) following the creation of a 9mm deep fracture in the mid diaphysis. This study was confined to *in vitro* testing therefore future work will focus on monitoring fracture *in vivo*.

INTRODUCTION

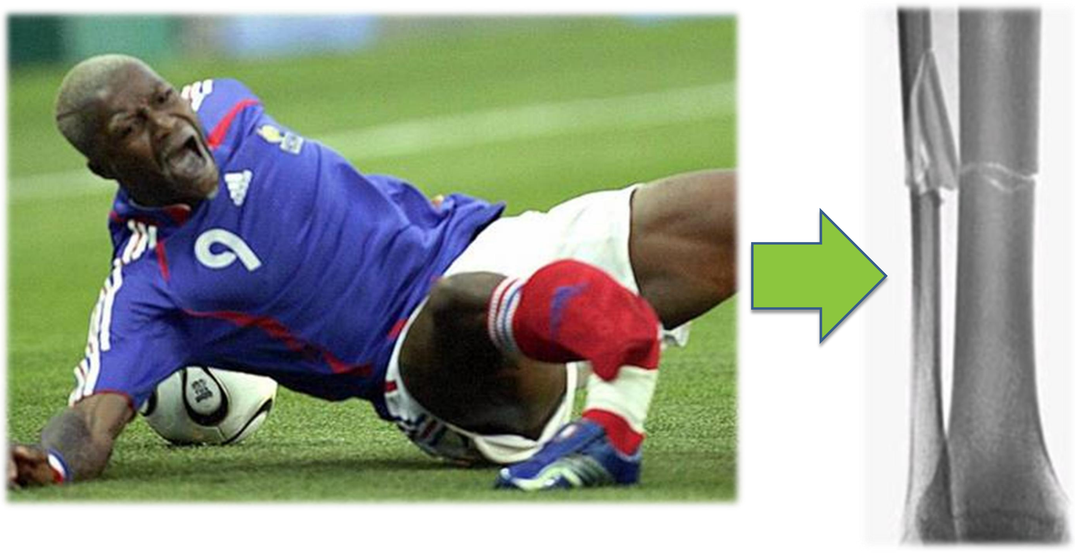

Figure 1: Tibial fractures regularly occur in sports. Djibril Cisse exited the 2006 World Cup after this awkward fall. A typical radiographic image of a simple transverse tibial fracture is shown on the left.

Background:

The inpatient cost of fall related hospitalisations among older persons was estimated at €59 million in 2008. Current radiographic imaging techniques expose patients to harmful radiation. Vibration analysis is used extensively in industrial applications to monitor machine condition however the first reported use of this technique in orthopaedics was in 1932. Since then it has been employed in a variety of studies ranging from diagnosis of; implant loosening, bone integrity and fracture healing.

Aim:

This study aims to investigate the ability of vibration analysis to detect damage in bone.

METHODOLOGY

1. Sheep tibiae were obtained from a local abattoir and soft tissues were removed before testing.
2. The resonant frequencies of "healthy" (undamaged) tibiae were measured by exciting the tibiae with an electrodynamic shaker and measuring the response of the bones (Figure 2).
3. A fracture in the mid-diaphysis was simulated by cutting the bones normal to the axial direction of the tibiae (Figure 3), again the resonant frequencies were measured in the same way as above.
4. The depth of the fracture was incrementally increased and resonant frequencies were measured subsequent to each increase in depth.

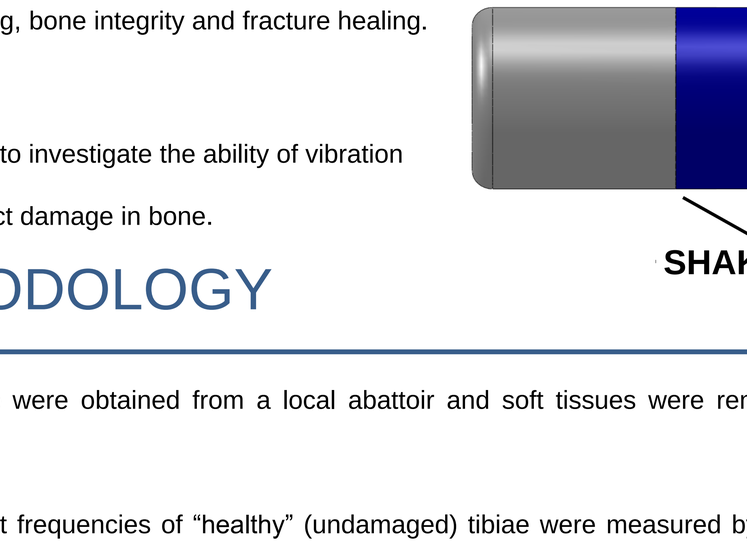

Figure 3: A fracture is simulated by cutting the tibia at the mid-diaphysis using a low speed saw.

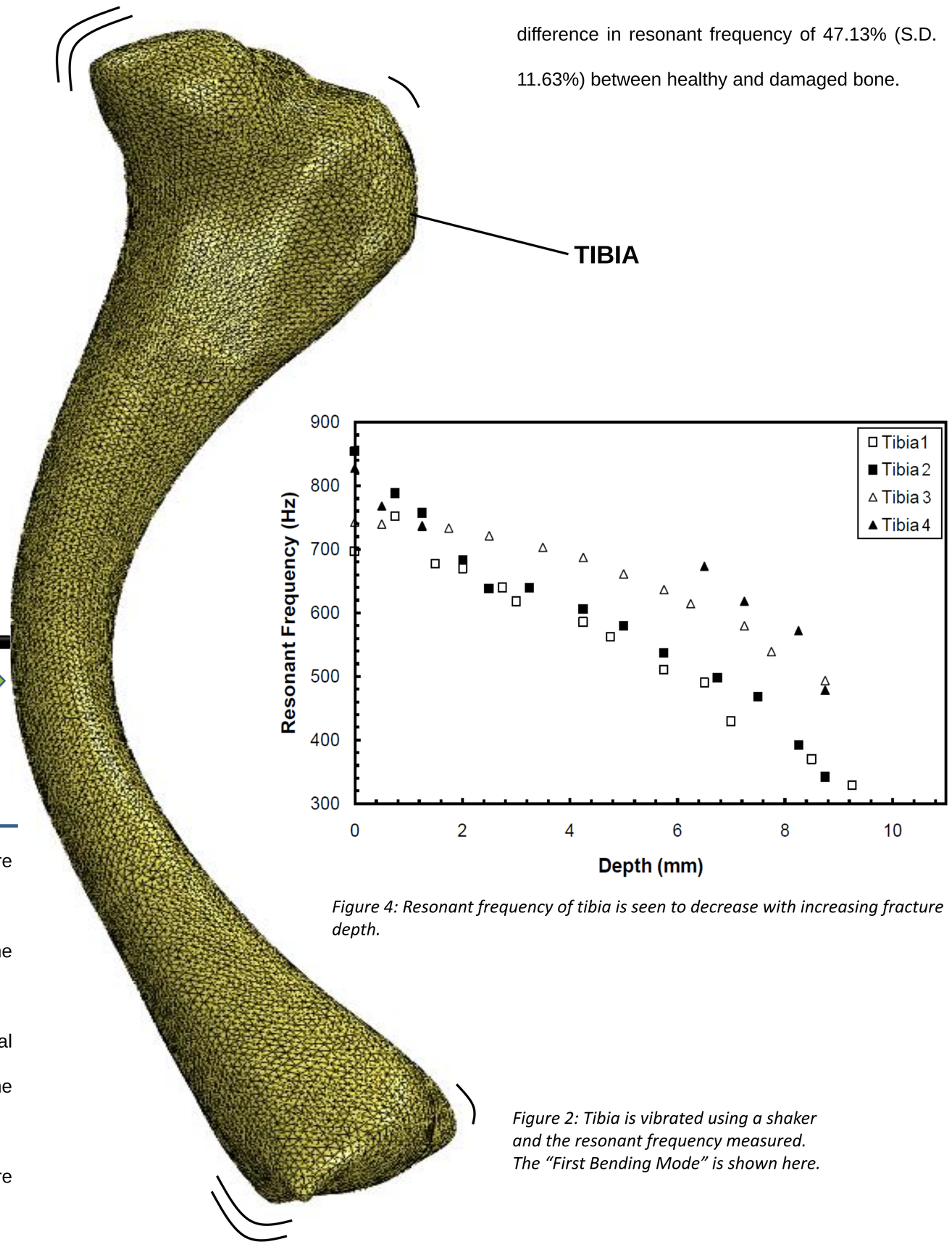

Figure 2: Tibia is vibrated using a shaker and the resonant frequency measured. The "First Bending Mode" is shown here.

Figure 4: Resonant frequency of tibia is seen to decrease with increasing fracture depth.

RESULTS

- As the depth of the fracture was increased, the resonant frequency monotonically decreased with an approximately linear relationship as seen in Figure 4.
- Tibiae showed similar responses with an overall difference in resonant frequency of 47.13% (S.D. 11.63%) between healthy and damaged bone.

CONCLUSION

- This study has shown that vibration analysis can detect damage in bone.
- However as yet only *in vitro* testing has been carried out therefore *in vivo* tests will need to be conducted if the technique is to be applied in a clinical setting.
- If vibration analysis can reliably detect damage *in vivo* it could be an alternative to current diagnostic techniques. This would eliminate patient exposure to harmful radiation and it is envisaged that the cost of instrumentation will be more affordable than existing instruments, thereby reducing hospital operating costs.

Ireland's EU Structural Funds Programmes 2007 - 2013
Co-funded by the Irish Government and the European Union
EUROPEAN REGIONAL DEVELOPMENT FUND
AN ROINN OIDEACHAIS AGUS EOLAIOCHTA | DEPARTMENT OF EDUCATION AND SCIENCE
HEA
Higher Education Authority
An tÚdarás um Ard-Oideachas

This project was funded by a PRTLI, TSR, Strand 3 grant.

CONTACT DETAILS

EMAIL: varley.padraig@itsligo.ie PHONE: +353 71 9155445