BONE STIFFNESS DURING BONE TRANSPORT: DEVICE DESIGN

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Introduction

Distraction osteogenesis is a technique to generate new bone tissue from the gradual separation of two bone fragments. There are many experimental studies about the distraction process [Ilizarov, 1989, Aronson 1989]. Methods have been developed to assess callus stiffness using instrumented external fixators [Windhagen, 1999, Richardson, 1994]. However these methods exhibit some drawbacks: they do not measure the rigidity with real load motion conditions and do not allow continuous monitoring. Therefore, the aim of this work is to provide a tool to know callus stiffness at any time.

Materials and Methods

To measure bone stiffness, an Ilizarov distractor previously used in bone transport experiments [Claes, 2000], was optimized (Fig. 1). In order to obtain *in vivo* force values within the bone, a data acquisition system was designed together with an analytical model of the bone–fixator system.

Experiments have been performed in sheep metatarsus to validate the device (Fig 1). Known stiffness springs are located at the site of the distraction callus with values between 0.5N/mm to 4000N/mm according to the literature [Leong, 2008]. The bone-fixator system is loaded up to 500N [Claes, 1999] by means of a servohidraulic machine.

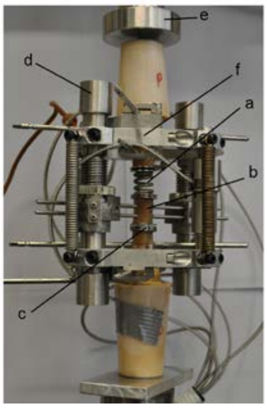

Figure 1: Bone – distractor system during testing. a)Spring (distraction callus site), b)Bone transport segment, c)Docking site, d)Force transducer, e)Servohidraulic machine actuator, f)Distractor.

Results and discussion

The accuracy of the compression stiffness measurements during the bone transport experiments with this device presented an average error lower than 15% for stiffness values between 4N/mm and 1900N/mm (Fig. 2). Results demonstrate advantages over previous methods: maintenance of bone axial transverse alignment, it measures stiffness with real load motion conditions, and allows continuous monitoring of forces. So, it permits identifying viscoelastic behavior in the callus tissue.

Very interesting applications could be performed with this device. For example, in animal experiments, it allows characterizing mechanically the process of bone transport. Also, it may provide a more comprehensive control of the bone transport process because it allows determining the moment to retire the fixator.

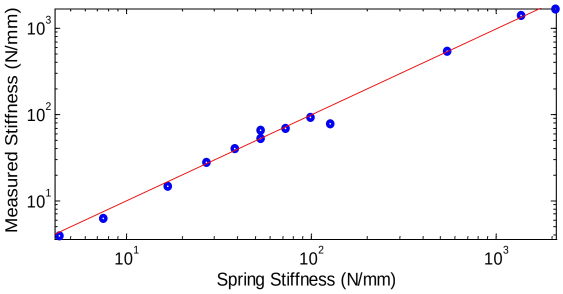

Figure 2: Stiffness value of distraction callus obtained for each known stiffness spring.

References

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