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Biomechanical Evaluation of Bone Screw Stability Using Acoustic Modal Analysis and Conventional Pull-out: An Animal Study

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INTRODUCTION

Primary and secondary stabilities are two key elements in achieving osseointegration. Conventional techniques such as pull-out test and insertion torque previously have been utilized to evaluate the screw stability [1,2]. However, they have been found to be non-repeatable and unfeasible for clinical applications. To assess the screw stability in an in-vivo testing condition, the aim of this study was to apply acoustic modal analysis and compare the results with the conventional pull-out test.

METHODS

A titanium self-taped of 1.4 mm outer diameter embedded in right and left proximal tibia of 6 rabbits (Fig.1 a,b,c and e). The conventional pull-out and non-destructive acoustic modal analysis (AMA) [3,4] methods were used to examine and quantify the peak pull-out force (PPF) and natural frequency (NF), respectively (Fig1. D and f). To compare the secondary stability, the NF extracted from the AMA and the pull-out force were compared at 4 and 8-weeks euthanization after implantation. In AMA, the tapping sound was measured and transformed into the frequency domain using the fast Furrier transform (FFT) function and the fundamental frequency results were compared to other test method.

RESULTS AND DISCUSSION

The primary, 4-week and 8-week PPF were calculated 98.4±12.1, 219.8±34.6, 289.4±28.1 N, respectively. Similarly, the primary and secondary NF were obtained 2434±67, 3408±45, 3613±31 Hz, respectively. Significance levels of these data show that the osteointegration was mainly achieved in the 4th week (Fig.1 g).

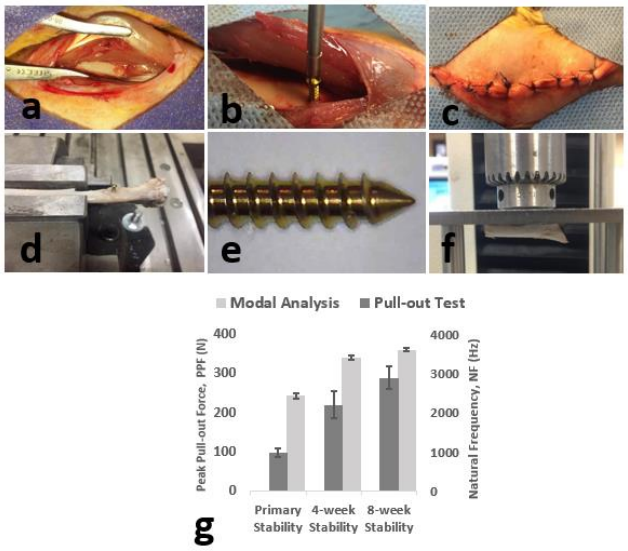

Fig. 1. *a) bone preparation, b) screw insertion, c) site closure, d) modal analysis, e) bone screw, f) pull-out test, g) peak pullout force and natural frequency versus primary and secondary stabilities*

CONCLUSIONS

Significant differences were observed between primary and both secondary stabilities which reveals the fact that the osteointegration was mainly achieved in the 4-week-duration group. AMA could quantify the primary and secondary stability as the pull-out force did. Moreover, the AMA method is a non-destructive method with the potential of using in-vivo [1,2].

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