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ACOUSTIC MODAL ANALYSIS CAN QUANTIFY BONE SCREW STABILITY IN AN IN-VIVO 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 destructive pull-out and conventional non-destructive Periotest tests. Periotest is a well-known modal analysis method in stability assessment of dental implants. To investigate the discernability of methods to slight changes, the tip design of screws was selected as a self-tapped and non-self-tapped types.

Methods

Two types of titanium self-tapped and non-self-tapped of 1.4 mm outer diameter embedded in right and left proximal tibia of 6 rabbits (Fig.1 a,b,c,d,e and f). The pull-out, Periotest and acoustic modal analysis (AMA) [3,4] methods were used to quantify the peak pull-out force (PPF), Periotest value and natural frequency (NF), respectively (Fig1. i, g and h). To compare the primary and secondary stability, PPF, Periotest value and NF were compared within 3 durations: immediately after implantation (primary stability), euthanization after 4 and 8 weeks (secondary stability). In AMA, the tapping sound was recorded and transformed into the frequency domain using the fast Furrier transform (FFT) function; very similar to our previous studies [2,4] and first fundamental frequency results were compared to the other test methods.

Results

No significant differences were observed in primary stability in terms of the pull-out force (98±12 and 102±8 N), the Periotest value (22.6±3.6 and 24.2±4.1) and the NF (2434±67 and 2572±43 Hz) between the self-tapping and non-self-tapping screws (Fig1. l, j and k). For the secondary stabilities (4-week and 8-week), the values were 228±32 vs. 268±26 N for the pull-out force -0.05±1.70 vs. -2.60±3.40 for Periotest, 3547±40 vs. 3751±35 Hz for the AMA natural frequency in the self-tapping and non-self-tapping groups respectively (Fig1. l, j and k).

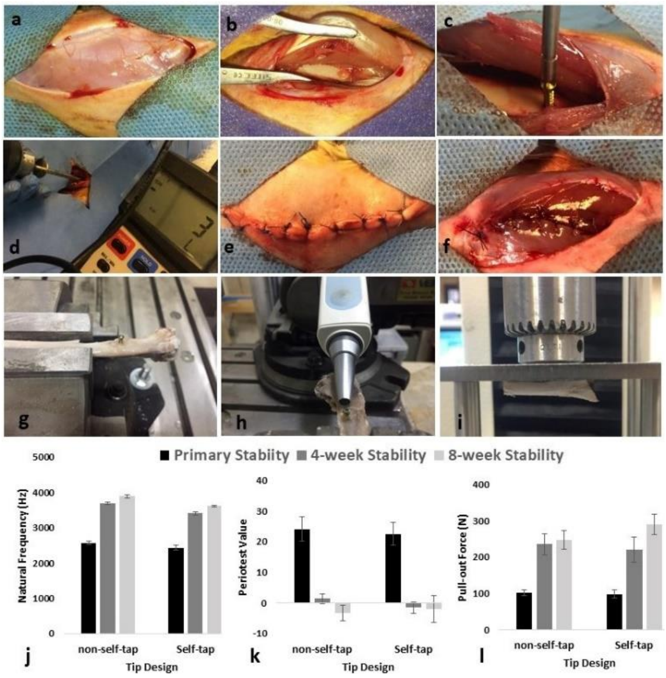

Figure 1: *a) skin dissection b) bone preparation, c, d) screw preparation and insertion e, f) site closure, j) acoustic modal test, h) Periotest, i) pull-out test, g) natural frequency, k) Periotest values and l) peak pull-out force versus primary and secondary stabilities.*

Discussion

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]. The Periotest values could quantify primary and secondary stabilities, but it is not accurate enough to discern between secondary stabilities. AMA and pull-out tests could quantify the secondary stability in both 4 and 8-week durations.

References

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