ACOUSTIC MODAL ANALYSIS CAN QUANTIFY BONE SCREW STABILITY IN AN IN-VIVO ANIMAL STUDY

Mohammadjavad Einafshar (1), Farshid Bastami (2), Ali Kiapour (3), Ata Hashemi (4)

1. Department of Material and Production, Aalborg University, Aalborg, Denmark.
2. Department of Dentistry, Shahid Beheshti University of Tehran, Tehran, Iran.
3. Department of Neurosurgery, Massachusetts General Hospital, Harvard, Medical School, Boston, MA, USA.
4. Biomechanics Group, Biomedical Engineering Faculty, Amirkabir University of Technology, Tehran, Iran.

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).

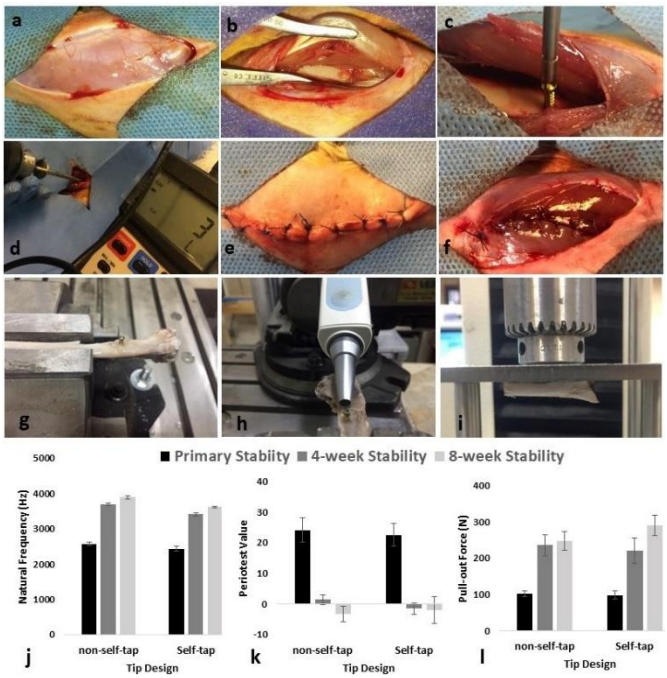

Figure 1: *a) skin dissection b) bone preparation, c, d) screw preparation and insertion e, f) site closure, j) acoustic modal test, h) Periotest, i) pull-out test, g) natural frequency, k) Periotest values and l) peak pull-out force versus primary and secondary stabilities.*

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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