MAJOR IMPROVEMENT IN INSERTION TORQUE OF SELF-TAPPING CORTICAL BONE SCREWS IN HUMAN CADAVERIC BONE USING AMORPHOUS DIAMOND COATINGS

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INTRODUCTION
Bone screws are the most common implant in orthopaedic surgery. However, many biological and biomechanical factors affect the stability of the fracture fixation [1]. The problems with the screws include poor bone-implant interaction due to different kinds of corrosion at the bone-implant interface. Also the damage to tissues is considerable when installing the screws. These problems can be prevented by using biocompatible and well-designed implants. In fact, the use of modified materials can stimulate bone growth and decrease healing time [1,2].

The purpose of this study was to study the effect of amorphous diamond (AD) coatings on the insertion torque of cortical bone screws. Furthermore, bone mineral density (BMD) of the human cadaveric bone samples was measured, and the relationship between insertion torque and BMD was studied.

MATERIALS AND METHODS
The whole insertion torque curve can be recorded with custom-built equipment shown in Fig. 1, which allows precise inspection of the insertion torque as discussed in our previous article [3].

BMD of the bone samples was measured using a peripheral quantitative CT (pQCT) scanner XCT2000 (Stratec, Pforzheim, Germany) with a resolution of 0.2 x 0.2 mm² and slice thickness 2 mm. Therefore, the BMD could be detected exactly at the screw insertion site. The bone samples were divided into two groups with mean ages of 33.5 years (range 25 – 41 years, N = 4) and 75 years (range 73 – 77 years, N = 4), respectively.

RESULTS
The results can be categorized in three groups based on the factors affecting the insertion torque. Firstly, insertion torque was affected by the surface condition of the screws. As shown in Fig. 2, insertion torque can be decreased dramatically using AD-coated polished screws. In some applications a better attachment is required and this can also be achieved with rough AD coatings. Values of maximum insertion torque (±SD) with different surface conditions were 0.57 (0.11) Nm, 0.40 (0.11) Nm and 0.25 (0.08) Nm for as-delivered (normal), AD-coated and AD-coated polished screw, respectively. In the case of insertion torque in the first cortex, the values were 0.19 (0.09) Nm, 0.21 (0.06) Nm and 0.10 (0.02) Nm, respectively. In both cases, the differences between the values of normal and AD-coated polished screws were significant (p<0.01).

Secondly, insertion torque was affected by the BMD: the higher BMD of the bone, the higher was the insertion torque. According to this study, linear correlation coefficient between maximum torque and BMD was R=0.519 (p<0.01) and between insertion torque in first cortex and BMD R=0.488 (p<0.01). Also the difference of the maximum torque values 0.29 (0.08) Nm and 0.39 (0.13) Nm was significant (p<0.01) in the bone samples from old and young persons. The BMDs of the groups were 1134 ± 19 mg/cm² and 1196 ± 39 mg/cm², respectively.

Thirdly, screw diameter had an effect on insertion torque. The increase in torque value increased roughly as a square of the screw diameter; this agrees with the simple rule based on the size of the screw.

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