

CAN BONE MINERAL DENSITY PREDICT FIXATION STRENGTH OF LAG SCREWS FOR PERTROCHANTERIC FRACTURE FIXATION?

Larry W. Ehmke¹, Benjamin C. Kam², Mark B. Sommers¹, and Michael Bottlang¹

¹Legacy Clinical Research & Technology Center, Portland, OR; *email: mbottlan@lhs.org*

²Oregon Health Sciences University, Portland, OR

INTRODUCTION

Fixation strength of pertrochanteric fractures treated with sliding hip screws highly depends on the bone quality in the proximal femur. The surgeon's perception of fixation strength determines the need for supplemental fixation by means of additional hardware or cement augmentation, and by the time-course of post-operative weight-bearing and patient mobilization (Bartucci, 1985). Bone mineral density (BMD) measurements from dual energy x-ray absorptiometry (DEXA) scans of the proximal femur are commonly used to estimate the quality of cancellous bone within the femoral head and neck (Lenchik, 1998). However, controversy remains regarding the value of BMD as a predictor for lag screw fixation strength (Stenström, 2000; Lin, 1999).

This biomechanical study investigated the relationship of BMD with lag screw insertion energy and fixation strength of a commonly used sliding hip screw. Results of this study depict the value of BMD as a quantitative tool to aid a surgeon's perception of lag screw fixation strength.

METHODS

Specimens: Eleven proximal femora from 6 female and 5 male fresh-frozen human cadavera with an average donor age of 77 ± 6 years were obtained. The femoral heads were sectioned at the neck and potted into a steel shell ($\varnothing 50\text{mm}$) with low melting alloy.

BMD measurements: Prior to potting, DEXA scans were performed on all

specimens to determine the BMD of the proximal femur using a fan beam x-ray bone densitometer (QDR 4500, Hologic, Waltham, MA). To ensure accurate BMD measurements, repeat recordings on one specimen were obtained in addition to measurements on contra-lateral specimens.

Insertion energy measurements: To determine the relationship between BMD of the proximal femur and the energy required to insert a lag screw, the insertion forces of a common lag screw (DHS, Synthes) were measured (fig. 1a).

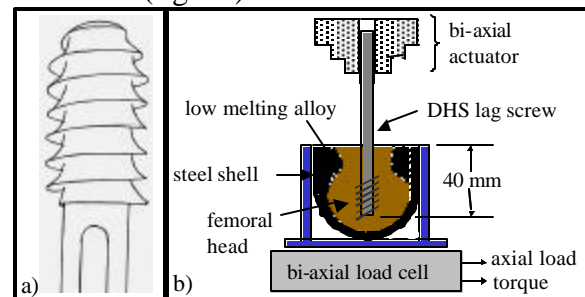


Figure 1: a) DHS lag screw, b) implant insertion setup

Specimens were mounted on a bi-axial load cell and implants were fixed to the bi-axial actuator of a material test system (Instron 8874, Canton, MA) (fig. 1b). Lag screws were advanced in concurrent linear and angular displacement to precisely reflect the pitch of its thread. Each lag screw was inserted to a depth of 40 mm, according to the manufacturer's insertion technique. The total amount of energy expended during lag screw insertion was computed as the area under the force-displacement curve (axial energy), plus the area under the torque-angle curve (torsional energy) (Heiner, 2001).

Fixation strength assessment: All specimens were subjected to a 3 Hz sinusoidal loading of 2 kN in a servohydraulic material test system (fig. 2a) (Sommers, 2001).

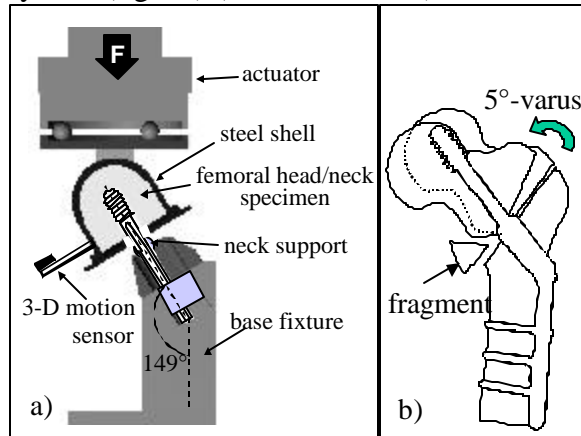


Figure 2: a) fixation strength test setup and b) varus collapse of specimen

An electromagnetic motion tracking system (PcBird, Ascension Tech., Burlington, VT) was used to record specimen migration into varus with respect to the lag screw. Loss of lag screw fixation was defined as 5°-varus collapse of the specimen (fig. 2b). Fixation strength under dynamic loading was quantified as the number of load cycles sustained at 5°-varus collapse ($NC_{5^\circ\text{-varus}}$).

RESULTS

Specimens spanned the range from severely osteoporotic (0.25 g/cm^2) to normal bone (0.95 g/cm^2). As BMD increased so did the insertion energy required for DHS lag screws, although a considerable amount of variation was observed (fig. 3).

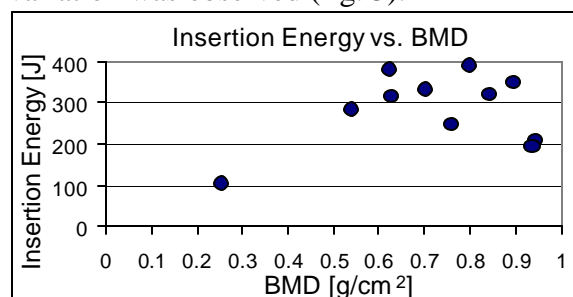


Figure 3: Insertion energy vs. BMD

BMD was a poor predictor for fixation strength. Although statistical evaluation did reveal a positive relationship between BMD and $NC_{5^\circ\text{-varus}}$, a large amount of variation was observed (fig. 4).

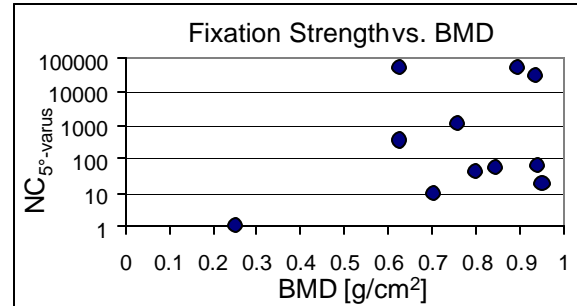


Figure 4: Prediction of $NC_{5^\circ\text{-varus}}$ from BMD

Repeat BMD measurements on the same specimen were not significantly different and yielded a standard deviation of $\pm 0.01 \text{ g/cm}^2$. BMD measurements on 11 contralateral specimens yielded an average difference of $0.05 \pm 0.03 \text{ g/cm}^2$, which was not significantly different ($p=0.66$).

DISCUSSION

Results of this study suggest that BMD does not closely correlate with either lag screw insertion energy or fixation strength.

The findings of this study may be in part explained since BMD is a measurement of mineral content and does not account for trabecular bone structure or mechanical properties.

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