BMD patterns of S1 using quantitative CT and biomechanical strategy for SI fixation

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INTRODUCTION:

Fixation of the sacroiliac (SI) joint with percutaneously placed screws and open plating of the pubic symphysis is the method of choice for treatment of many vertically unstable pelvic injuries. Identification of regions of relative high BMD in the sacrum and pubic symphysis would aid in the placement of screws for more rigid pelvic fixation. Quantitative CT has been shown to be highly accurate in assessing vertebral BMD. Although the variability of screw placement is somewhat limited by the pedicle geometry, it may be possible to make small adjustments in screw trajectory to aim for more dense bone.

Placement of a second SI screw is technically challenging. The S1 pedicle is just large enough in some large patients to accommodate two screws.[1] The S2 pedicle has approximately 30% less surface area[2], it is difficult to visualize intra-operatively with fluoroscopy, and generally has poorer bone stock and BMD. Previous tests of screw fixation in cancellous bone of the femoral head showed that a screw with a larger thread and shaft diameter can achieve stronger and more rigid fixation.[3]

METHODS:

Six fresh frozen human pelves, ages 44 - 63, 4 male and 2 female were CT scanned . A series of measurements were taken from each axial slice. Nine regions of interest (ROIs) spanning the cross-section of the S1 body relating to the trajectory of sacroiliac screws were identified and marked. [FIGURE 1]

To investigate the stiffness and motion in six degrees of freedom (DOF) of a vertically and rotationally unstable pelvic construct under cyclic loading conditions, 5 sawbones pelves were cut to simulate bilateral Tile C1 fractures in Zone 1 and were fixed with two screw types: standard cannulated cancellous SI lag screws, 7.9 mm thread, and a prototype SI screw, 12.3 mm thread. Then the pelves were mechanically loaded with a vertical compressive force through the sacrum with the hip joint positioned to simulate a single leg stance. 6 DOF of motions of the sacrum and the ilium were measured with 3D video analysis.

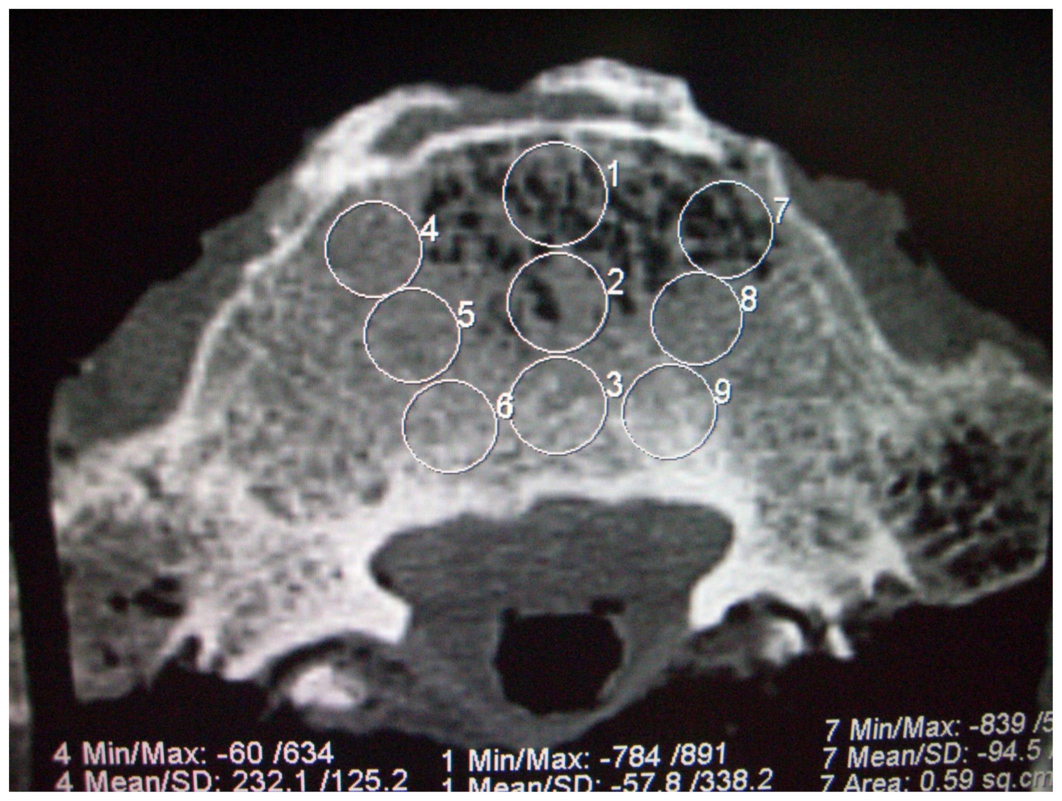

FIGURE 1 – Location of 9 Regions of Interest

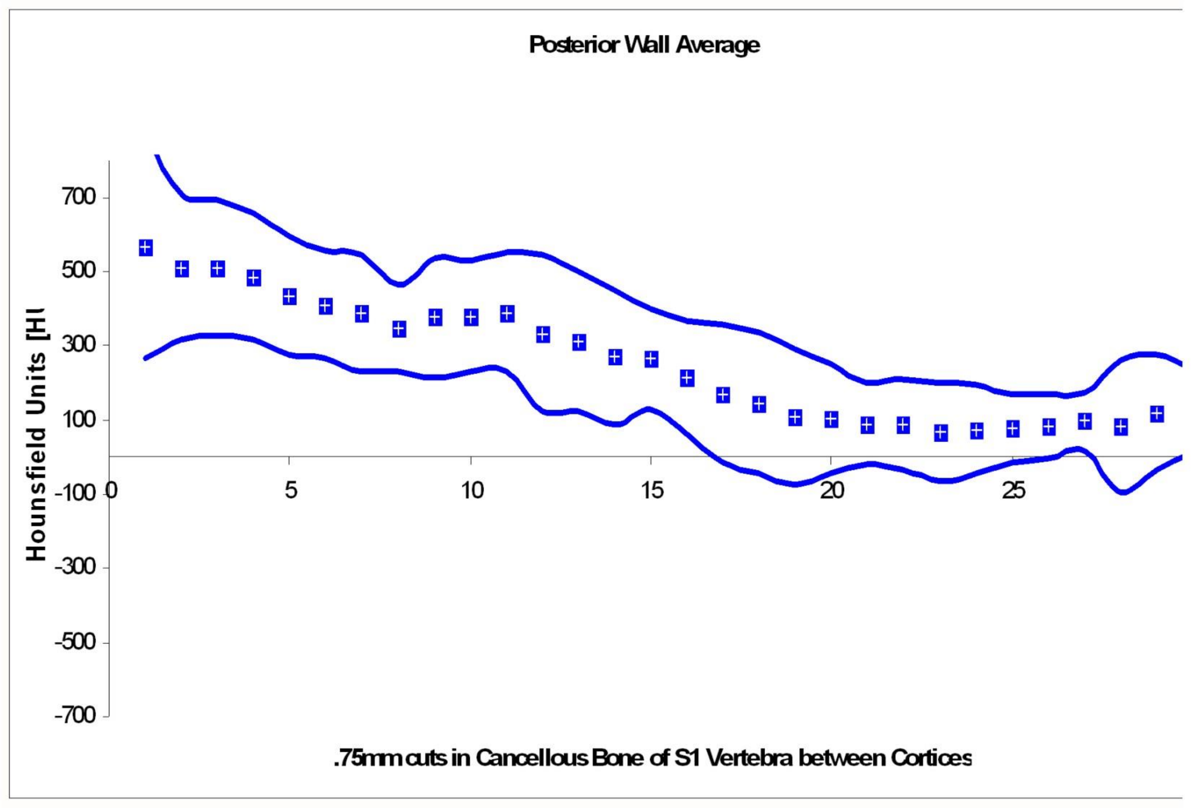

FIGURE 2 – Change in density along the posterior wall

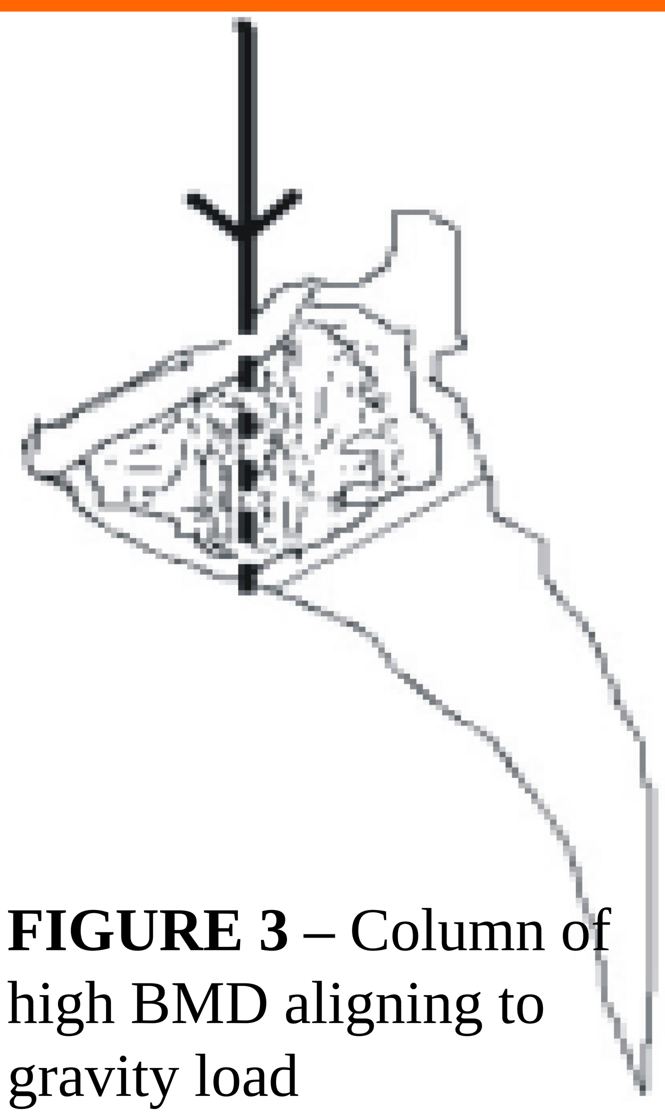

FIGURE 3 – Column of high BMD aligning to gravity load

RESULTS:

There was a decrease in the relative density from superior to inferior through the S1 vertebral body. The posterior wall region showed greater density than the middle and the anterior wall regions in the superior half of cancellous bone of the S1 vertebral body.

There was a slight increase in density along the anterior wall region over the middle horizontal region, and posterior wall region in the inferior half of cancellous bone of S1 body. [FIGURE 2]

The standard screw fixation allowed significantly more vertical motion and lateral rotation between the bone fragments. There was significantly more motion across the fracture for the standard fixation (with and with out symphyseal plating) in the vertical translations 3.86 ± 0.51, 0.97 ± 0.42 ($P = 0.00006$) and lateral rotation 0.85 ± 0.18, 0.04 ± 0.02 ($P= 0.00005$).

DISCUSSION:

The BMD measures showed a column of highest density from posterior-superior to anterior-inferior in S1. This column is approximately vertical in S1 and may align to the gravity loading on S1. [FIGURE 3]

The larger, prototype screw allowed significantly less motion across the fracture plane in simulated single leg stance loading.

REFERENCES:

1) Ebraheim, NA, et al, Spine, 22:841, 1997
2) Lu, J, et al, Amer. J. Orthop., 29:376, 2000;
3) Milne, EL, et al, Contemp Orthop. 17-5:79-83, 1988.

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