Hip arthroplasty when reconstructed are significantly less effective for osteoporotic than for healthy bone

The number of primary hip replacements has increased substantially in the United States and each year, as many as 200,000 total hip replacements (THR) are performed annually.

Total hip arthroplasty is generally performed with cementless components for the femur and the acetabulum. In the elderly osteoporotic patient, bone deficiency may preclude cementless fixation and the surgeon may opt for a cemented construct. Total hip replacement is a successful and cost effective procedure that offers immediate relief of pain and considerable improvement of life daily function to patients suffering with osteoarthritis of the hip. However, osteoporosis is a problem specific to the patient and surgeons performing primary hip arthroplasty need to evaluate the procedures needed for a successful THA. Although uncemented and cemented designs of femoral prostheses have been used successfully, there is a higher rate of periprosthetic fracture associated with the use of uncemented stems in patients with osteoporosis. An enlarged femoral canal as well as poor metaphyseal bone may make cementless fixation impossible.

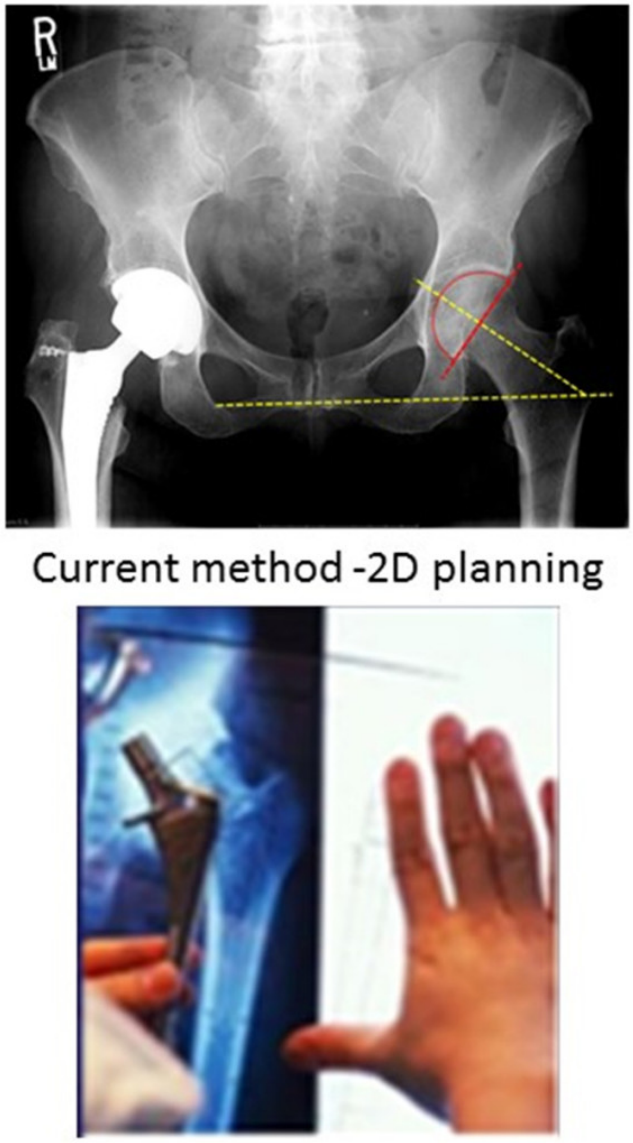


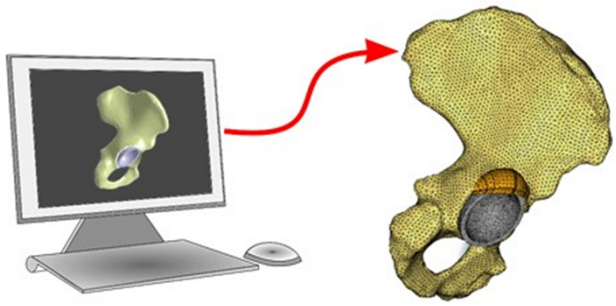
Fig. 1. Initial Planning stages performed on x-rays radiographs

Off the shelf cementless prosthesis assume a rather narrow femoral canal with a larger metaphyseal area. With osteoporosis the femoral canal relatively enlarges creating a size mismatch that cannot be addressed with a standard prosthesis. Surgeons often will opt for cemented fixation in this scenario. Similar bone deficiency in the acetabulum may make fixation with a standard cementless cup difficult. Successful replacement requires knowledge of the acetabular bone stock as well as the geometry of any bone defects, particularly in the rim. In acetabulum with bone deficiency due to osteoporosis, trauma or previous surgery, A CT scan may be useful to assess the degree of bone deficiency and acetabular geometry. The results of cemented acetabular cups historically have not paralleled those of cemented stems. In cases of

osteoporosis some surgeons perform hybrid fixation with a cemented stem and a cementless cup. A cementless cup requires bone ingrowth to create durable fixation. The key to attaining cup ingrowth is initial stability between the cup and the underlying acetabulum. Micromotion between the cup and the bone can preclude bone ingrowth.

Defects of the acetabular wall can also negatively impact on cup fixation. A cementless cup is generally placed in an underreamed acetabulum. The insertion of the cup in the underreamed acetabulum creates hoop stress that fosters immediate cup fixation. Defects in the acetabular wall can significantly decrease this fixation.

A number of corrective methods for stabilizing the wall prior to cup implantation are currently in use, such as bone grafting or screw fixation. A number of studies supported by clinical follow-ups of patients suggested that if the structural graft supports more than 50% of the acetabular component, a reconstruction cage device spanning ilium to ischium should be used to protect the graft and provide structural stability. It has also been suggested that cementless components be used to treat major acetabular bone loss. Because defects may also occur in conjunction with various levels of osteoporosis characterized by reduced bone density we hypothesized that moderate acetabular defects (Paprosky type I or II) when reconstructed with bone screws supported by bioabsorbable calcified triglyceride bone cement are significantly less effective for osteoporotic than for healthy bone.



Novel method -3D computer aided planning

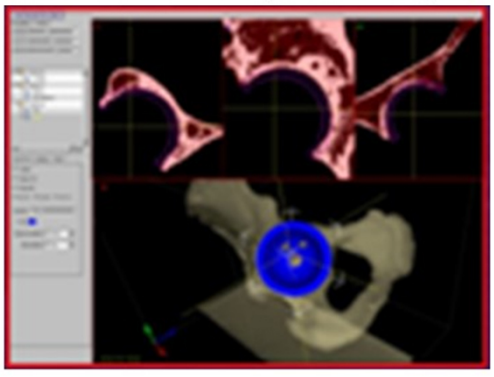


Fig. 2. Novel method, CT bases that accounts for acetabula strength using Finite Element Analysis

This hypothesis was tested using a validated Finite Element Model simulated with different bone apparent densities. We developed the 3D Finite Element Models from Computer tomography of a specimen selected from on six cadaveric subjects with age of 79.4±7.8. An artificial defect with length of 41.5 mm and depth of 12.5 mm was created on the posterior acetabular wall. The resulted acetabular wall defect was less than 50% and was considered as reconstructed with bone screws supported by bioabsorbable calcified triglyceride bone cement. The reconstruction was reinforced by three Zimmer 2.7 mm Cortical Screws (Zimmer, Inc. Warsaw, IN) with length of 22 mm and hex size of 2.5 mm located equidistant from one another within the defect. After the defect reconstruction a 54 mm DePuy Pinnacle acetabular cup (DePuy Orthopaedics, Inc., Warsaw, IN) was press-fit with 1 mm of under-reaming.

The model was validated testing the cadaveric pelvi modeled using an Instron electromechanical tensile-testing machine to apply a compressive load calculated considering the peak load recorded by Bergman et al. for fast walking. The maximal displacement for a healthy bone at 1500N is 78 µm and is 33 µm (43%) and 99 µm (128%) higher for moderate and severe osteoporosis. The relative displacement of the cup for both Moderate and Severe osteoporosis are significantly different from the displacement calculated for the healthy bone. The corresponding stresses ranging from 25 MPa to 226 MPa, are strongly affected by the grade of osteoporosis, noted primarily on the cortical bone near the peripheral rim of the acetabular cup.

In conclusion Reconstruction of moderate acetabular defects with bone screws supported by bioabsorbable calcified triglyceride bone cement during THA are less effective in osteoporotic bone and a **different technique** for defect reconstruction is recommended.

Publication

Primary cup stability in THA with augmentation of acetabular defect. A comparison of healthy and osteoporotic bone.
Amirouche F, Solitro G, Broviak S, Goldstein W, Gonzalez M, Barmada R
Orthop Traumatol Surg Res. 2015 Oct