INTRODUCTION
Aseptic loosening of the component is an important long-term complication of total hip arthroplasty. Kobayashi et al. found that the factor which affecting aseptic loosening of femoral stem after THRs was affected by an unfavorable geometry of the medullary canal (a so-called stovepipe canal or a large canal). The shape of the femoral canal has high individual difference which is much more variable than most femoral prosthesis would suggest or can accommodate. Furthermore, Noble et al. found that only the female femora displayed significant differences in canal shape or endosteal width as a function of age. Krischak et al. found that femoral prosthesis loosening can be predicted by the mechanical bone quality of the femoral head at the time of implantation. Those studies considered that the femoral canal shape or bone quality may affect the result after THRs. The goal of this study was to evaluate the influences and relationship of proximal canal shape, bone quality and stem flare (shapes) after total hip replacement by finite element analysis.

METHODS
Four two-dimensional finite element models (Figure 1a) were constructed in this study. We used NLF as the symbol for the normal canal femur (N) implanted with low flare (LF) stem, NHF as the symbol for the normal canal femur implanted with high flare (HF) stem, S LF as the symbol for the stovepipe canal femur (S) model implanted with low flare stem, and SHF as the symbol for the normal canal femur implanted with high flare stem. We defined the ratio of the cross-section width of proximal and distal stem as stem flare index (SFI), where the ratio greater than 3 was defined as HF stem and less was LF stem (Figure 1b). All materials were assumed to be isotropic, linearly elastic and homogeneous. In order to evaluate the effect of bone quality in THR, ten elastic modulus values of cancellous bone from 80 to 800 MPa were adopted. The boundary conditions of the models were showed in Figure 1b.

RESULTS AND DISCUSSION
The results in each model were as shown in Figure 2 and Figure 3. The results included the maximum principal stress and von Mises stress at the calcar region of cortical bone. In our results of the S LF model, high principal stress was occurred at stem/cement interface near the stem tip compared with N LF model, whether the bone quality was normal or poor. These results could explain the clinical results of Kobayashi and showed the cement failure at the stem distal was the main factor which would cause the stem loosening after THR. Moreover, the values of the tensile stresses were sensitive to the poor bone quality (the modulus of bone lower than 400 MPa). Surgeons need to concern about the high potential of stem loosening in the old female patients who had poor bone quality or stovepipe canal shape; and a newer design of hip stem for the old female patients should be consider. Several studies have reported that a reduction in the diameter of the distal stem while increasing the cement mantle thickness reduced the maximum principal stress of cement. In present study, the stresses in the cement layer of the N HF and S HF models were decreased obviously as compared with the N LF and S LF models, respectively. However, the high stresses which occurred in the distal end of cement in the N LF or S LF model were transferred to the lateral-middle as the stem change to high flare stem. Overall, the low flare stem seems to be the better one to adopt in the stovepipe canal femur.

In this study, the modulus of bone lower than 400 MPa showed the high stress shielding effect at the calcar region. The stresses would concentrate in the distal region of cement layer because the poor bone quality can’t resist the loading and caused the large deformation of cement. Those results also explained why a stovepipe canal limited the durability of the hip prosthesis. Furthermore, we found the high flare stem increased the stress shielding effect at the calcar region compared with the low flare stem in this study. The reason could be the high stiffness at the proximal of the high flare stem which led to more stress shielding effect.

CONCLUSIONS
We concluded that the poor bone quality has a higher influence on the cement failure and stress shielding effect than femoral canal shapes and stem shapes. The stem flare (high or low flare design) seems not the main factor which could decrease the cement failure or stress shielding effect effectively.

REFERENCES