

Monitoring Femoral Component Insertion in Total Hip Arthroplasty

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According to the American Academy of Orthopaedic Surgeons, there were nearly 1.4 million total hip arthroplasties (hip replacements) during the period from 1991 to 2000. Due to the less invasive trend in surgery today, incision lengths have reduced from 10 inches to 2-3 inches. There has been an anecdotal increase in the incidence of femoral fracture due to the surgeon's diminished visualization. Due to the surgeon's inability to visually perceive proper insertion of the femoral component, there is an increased reliance on the tactile and auditory senses.

This study attempts to identify a means to quantify proper seating of the femoral component through the novel application of damage identification techniques normally used in structural health monitoring of civil structures to biomedical structures. Due to stringent requirements on what materials can be used in the human body, vibration measurements can not be taken on the bone directly, so measurements must be taken on the femoral component directly.

For this study, bone was substituted with a PVC pipe, filled with vacuum-cast polyurethane, test bed. A surgically accurate hole was created using a lathe to create a pilot hole then finished with the actual surgical tools. The femoral component was inserted loosely into the test bed, and a modal test was performed. The femoral component was inserted further in steps until full insertion was achieved, with a modal test performed at each step, as shown in Figure 1. The frequency response function (FRF) was exported to MATLAB for analysis to identify features in the data.



Figure 1. The femoral component inserted into the test bed with attached accelerometer.

Results show that using the global Holder exponent as a measure of stability of the FRF tends to show conclusive evidence of the onset of seating, but that differentiating between nearly-seated and fully-seated states could prove difficult, as the two may not be different enough to distinguish using the above method. Additionally, nonlinearities were noticed in the FRF's as the femoral component was inserted, and further study is needed to determine if this is an artifact of the PVC test bed used.