Use of a Vibrator for Implant Retrieval at the Time of Hip Revision Surgery

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Abstract :Total hip replacement (THR) is a highly successful orthopaedic procedure and the number of total hip patients have been increasing steadily for many years. The long term failure rates for such surgeries are less than 10% in ten years. The reasons for such long term failures are aseptic loosening, stress shielding and deep infections. As the number of THRs performed each year exceeds half a million, the number of revision surgery for those patients has also increased dramatically. The removal of cemented THA is often difficult, time consuming and sometimes risks fracture of femur. Use of a vibrator for loosening of existing cement layer between bone and the implant may be considered as one of the possible solution for this type of problem. In this study, we investigated the optimum resonance frequencies of such vibrator, for loosening of that cement layer.

Natural frequencies of different sized of implant and made of different metal alloys were computed for relevant boundary condition. For harmonic analysis, CT scan data of a femur was processed in an image processing software MIMICS. Then the geometry of total hip was modeled and was sent to a finite element software ANSYS. Required portion of the femoral part was edited, the implant and the cement layer were introduced in that model and elements were generated in that FEA software. Then elements of femoral part except cement layer and implant were sent to MIMICS software again for assigning of different Young modulus for each element which was proportionate to their densities. Finally the elements were brought back to FEA software. The harmonic analysis was performed for total model in FEA software ANSYS.

For the particular boundary condition, the first three natural frequencies of three types of implant sizes and materials varied upto a maximum of 7 to 9%. Results of the numerical harmonic analysis showed that the response at the bone cement interface, the resonance frequencies were at the range of 4 to 6 Hz ,26 to 29 Hz and 43 to 49 Hz. The vibration response was similar for the three cement bone interface locations examined. This suggests that a vibrator that will produce a resonance frequency response may cause cracks in the bone cement and thus facilitate the removal of failed femoral component.

Retrieval of hip implant may be easier using a vibrator in those band of frequencies with a moderate amplitude. The magnitude of those frequencies will not differ much from implant to implant as the natural frequencies of different types of implant, for that particular boundary conditions, were within the close range. We expect that our results can be used for designing for suitable vibrator for evaluating if such a vibrator could potentially be used for easier removal of cemented total hip implant.