INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Lumbar spine complications rank among the most prominent reasons for medical attention, especially for elderly subjects. Spinal fusion surgery is a common procedure to address some operative cases. Pedicle screw fixation is popular amongst the extensive range of spinal fusion developed. However, issues such as aseptic loosening, screw pullout, screw breakage, disposition of screws and pedicle fracture often lead to revision surgery. To reduce these problems, the concept of expandable pedicle screws came by with improved anchorage owing primarily to greater screw-bone interface. Clinically, they showed improved biomechanical fixation by facilitating bone growth around the fins, reducing strain shielding and promoting favourable bone remodelling. In this study, anatomically viable finite element (FE) models of a functional spinal unit (FSU) of intact L4-L5 vertebra were used to estimate stress-strain fields and the same were compared with FSUs instrumented with normal and expandable pedicle screws under different physiological loading conditions. The expandable pedicle screws predicted marginally improved anchorage with more contact area with the bone indicating improved stability. Greater area with peak stresses at the bone-screw interface indicated lesser stress shielding. Further, a strain energy density-based bone remodelling algorithm was employed on patient-specific lumbar FSU to investigate the bone density changes around the screws. Bone apposition was predicted near screw insertion region in L4 and L5 vertebra (for normal pedicle screws) and central anterior screw insertion region for both vertebra (for expandable pedicle screws). Bone resorption was predicted in posterior region, near screw length in L4, central anterior right side and posteriorly in L5 vertebra for normal pedicle screws. In context to bone remodelling, overall result favoured expandable pedicle screws over normal pedicle ones. Further, pullout tests were performed on three novel designs of expandable pedicle screws and thereafter, validated numerically. Next, two FE mechanoregulation based tissue differentiation algorithms were implemented to assess osseointegration for the three types of expandable pedicle screws. Six weeks post-surgery bone growth of 12-29% (load case 2) and 11-21% (load case 1), respectively, was predicted for the three types of screws. Type 3 (proximally coarse pitch screw) was estimated to have highest maximum pullout force (POF) and greater ossification among expandable pedicle screws with dual-threads.