

ANALYSIS ON THE EFFECT OF HALF ANGLE ON THE DISPLACEMENT OF PEDICLE SCREW DURING AXIAL PULL-OUT TEST IN CANCELLOUS BONE USING 2D AXISYMMETRIC FE MODEL

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ABSTRACT

Pedicle screw fixations are commonly used in the treatment of spinal pathologies. For effective treatment, stable anchorage between the screw and bone is necessary. In this study, the influence of proximal and distal half angle of the screw, on the displacement of fixation and stress transfer are simulated using a 2D axisymmetric finite element model. A parametric study was performed by varying the proximal half-angle between 0° and 60° in steps of 10° and the distal half angles are considered as 30° and 40°. The material properties and boundary conditions are applied based on previous studies. Frictional contact is considered between the bone and screw. Results show that, displacement of fixation is observed to be minimum at a proximal half angle of 0° and maximum at an angle of 60°. High stress concentration is observed in first few threads with highest maximum von Mises stress at an angle of 60°. High stress transfer was obtained for proximal half-angles of 40° and 50°. It is observed that, this method might aid to develop better pedicle screws for treatment of Scoliosis.

Keywords: Finite element analysis, Pedicle screws, Proximal half angle, Cancellous bone, Displacement, Stress concentration

INTRODUCTION

Pedicle screw has been widely used in the treatment of various spinal pathologies like spine degeneration, scoliosis, instability and infections [1]. However, the use of pedicle screws is limited by fixation failures caused by screw loosening. The incidents of failure are reported to be 1 – 15 % for non-osteoporotic subjects and even higher in case of osteoporotic subjects. Insufficient screw grip, screw breakage and screw loosening are few of the most important clinical challenges [2]. A successful pedicle screw fixation is characterized by high pull-out strength, which denotes stable bonding in the screw-bone interface and an adequate stress transfer between bone and the screw. Increased stress transfer has shown to reduce screw loosening and promote bone growth, thereby enhancing peri-implant bone quality [3]–[6].

Several attempts have been made to estimate the efficacy of screw design. Experimental investigations based on pull-out tests have been conducted taking into account factors such as screw design parameters including length, diameter, thread shape (proximal and distal half-angle, pitch, bone mineral density, insertion angle and depth of insertion [5], [7]–[9]. In a recent study, the screws with three different proximal half-angles were analyzed and a 30° angle was found to provide increased fixation strength [10]. However, there is lack of experimental evidence on the appropriate choice of proximal and distal half-angles and testing of all these screw designs could be laborious and time consuming.

Finite element (FE analysis is a commonly used computer-based method for numerically solving a range of problems efficiently. In the field of orthopedic biomechanics, it is used for studying the stress distribution in implant and the surrounding bone for different implant geometries and loading conditions.