Design and analysis of interbody fusion cage materials based on finite element analysis

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***Abstract*—This study investigates the effect of the Posterior Lumbar Interbody Fusion (PLIF) cage's material on the strength and stability of the cage. The lumbar vertebrae L2-L3 unit finite element model was developed from computed tomography (CT) scan images in 3D Slicer software. The PLIF cage model was constructed using Solidworks software. The models were assigned with polyetheretherketone (PEEK) and polylactic acid (PLA) materials. The models were implanted and analyzed in Ansys Workbench Software by applying external preload, compression load and other load conditions to mimic the spine physiological motions under static and dynamic analysis. The von Mises stress and maximum principal stress were observed and analyzed to evaluate their strength and stability. In addition, the percentage differences between the von Mises stress and yield strength of the material and between the maximum principal stress and critical strength of the material were calculated. The PEEK cage produced higher von Mises stresses than the PLA cage for the static analysis. However, the PEEK cage exhibited lower percentage differences than the PLA cage. This result indicates that the PEEK cage has the superior structural integrity to the PLA interbody cage. The results from the dynamic analysis showed that both cages exhibited extremely low von Mises stresses and similar curve patterns. These results indicate that both cages are stable and do not pose harmful health implications. Thus, PLA can be considered an alternative material for the cage because it is more cost-effective than the PEEK material, and stresses generated were far lower than the ultimate tensile strength and yield strength of the material.**

Keywords—Finite Element Analysis, PLIF cage, PEEK, PLA, Von Mises Stress

I. INTRODUCTION

The human spine or the vertebral column may be described as a stack of small ring-like bones, known as vertebrae, extending from the skull to the tailbone. It consists of the cervical region, thoracic region, lumbar region and sacral region. This vertebral column provides the primary support for the body, allowing us to stand upright, bend and twist while protecting the spinal cord from injury. The intervertebral disc acts as a flexible spacer between adjacent vertebrae and carries significant gravitational and muscular force loads. The disc consists of the inner nucleus pulposus and the outer annulus fibrosus [1]. Certain diseases, disorders, or injuries can affect the structure and function of the vertebral column and intervertebral disc space. To name a few, degenerative disc disease, lumbar degenerative disorder, disc herniation, spondylosis, and lumbar spinal stenosis.

Lumbar degenerative disorders are typically divided between those that cause mechanical back pain and those that cause radiating leg pain [2]. Intervertebral disc degeneration, one of the examples of degenerative disc disease, is the main contributor to low back pain, which is the leading cause of disability worldwide [3]. The disc degeneration usually occurs as a progression of time and age. In time, they will wear out and no longer offer as much protection as before. However, other factors can speed up the process of degeneration, such as obesity, smoking, extreme physical work, and injury.

This study aims to evaluate the effect of material used for interbody cage implant by assessing the stress and strain distributions under static and dynamic loads. By doing that, the structural integrity of the interbody cage, as well as the risk factor exposure to whole-body vibration (WBV) after interbody cage implantation, can be evaluated