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Finite element analysis of hard coated surface on UHMWPE based cervical spine implant

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Performances and longevity of various biological implants such as hip implants and knee implants heavily depends on the wear resistance behaviour of the UHMPE component. Coatings now a days being increasingly used to improve the tribological performance of biological implants. A tribological contact with two loaded surfaces in relative motion is a very complex system that is not easy to understand nor simulate or predict. The system becomes even more complex when coatings are deposited on the surfaces. UHMWPE wear debris has been linked to complications including tissue inflammation, bone loss osteolysis and implant loosening. Reduction of debris has been addressed by investigating new polyethylene formulations, manufacturing and finishing processes, including surface treatments and coatings both on plastic and metallic components. There have been many studies on the effect of surface treatments and hard coatings on cobalt chromium and titanium alloys for prosthetic applications. However, most of them have used laboratory tribo-testers without much correlation to articulating movements in human joints. The current study is an attempt to perform a finite element analysis of the artificial intervertebral disc along with entire cervical spine in natural loading conditions having various thickness of DLC coating on the disc.

A 3D model of cervical spine was generated based on the Computed tomography (CT) scan data of 50years old male subject in the DICOM (0.208×0208×2.0) format maintaining the accuracy as much as possible. Using a commercially available CAD package, artificial intervertebral disc was design and inserted inside the vertebra model. Artificial implant has a provision for ball and socket joint (titanium alloy on UHMWPE) having a hard coating layer between the contacts. The entire model was meshed with 10 noded tetrahedral element and the coating with shell element with varying thickness. F.E analysis were conducted on three different spine movements i.e. Flexion/extension, lateral bending and axial rotation subjected to 0.5Nm moment.

The result show that the thickening of the coating layer lowers the stress on UHMWPE layer. The stress simulations showed how a thicker hard coating on a soft substrate has a better load-carrying capacity that a thinner one.