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ASK THE EXPERTS

Part 2: Stress distribution in vertebra

How can transpedicular PEEK implant balance stress distribution in a vertebra?

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In a healthy lumbar spine, weight-bearing loading columns is distributed approximately to a force ratio of 60% and 40% applied respectively for anterior and the posterior column. However, with aging and the consequences of related osteoporosis disease, the ratio shifts to a value of about 80% and 20% (1,2,3). In addition, aging causes a decrease of the bone density and its resistance to fracture. As a result, vertebral body is at risk of fracture. Vertebral compression fractures are the most common sequelae of osteoporosis, comprising approximately 700,000 out of a total 1.5 million osteoporotic fractures annually in the USA (4). Approximately 25% of all postmenopausal women in the US gets a compression fracture during their lifetime (4). The prevalence of this condition increases with age, reaching 40% by age 80 (5).

In order to investigate the performance of transpedicular PEEK polymer implant (V-STRUT© Vertebral Implant – Hyprevention) to re-distribute the applied stress on a treated vertebra. An enhanced numerical model was used consisting in a spinal segment composed by a bloc of 3 vertebral levels generated from a CT scan of an osteoporotic patient treated with PEEK implant due to a vertebral fracture.

The modeling approach consists in two steps: (i) Perform image processing to generate the Finite Element models from the DICOM scans of the spine, (ii) Simulate the responses of the spine/implant combination under an applied compressive stress.

The model is composed by three consecutive vertebrae (T12, L1 and L2) and three intervertebral discs. Two models were created: with and without implant for comparison. The middle vertebra is loaded via two intervertebral discs; thereby transferring load as would happen under in vivo conditions. Each Finite Element model is composed by about 350 000 tetraedric elements (9). Heterogeneous mechanical properties, such as Elastic modulus and Poisson coefficient, were assigned to the bone using the grey scale level obtained from the scans (6), A hyperelastic behavior was retained for the discs (7) and PEEK material properties is applied to the implant (8). During the compressive load, the vertebra/disc contact is modeled without friction between the contacting surfaces (9). Compressive load is applied on the upper surface of the model: P = 0.5 – 1.1 MPa (9). Inferior endplate of the lower vertebra is encastered.

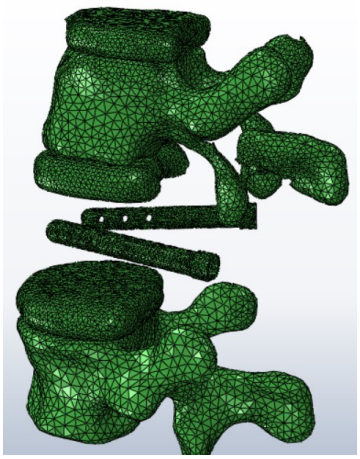
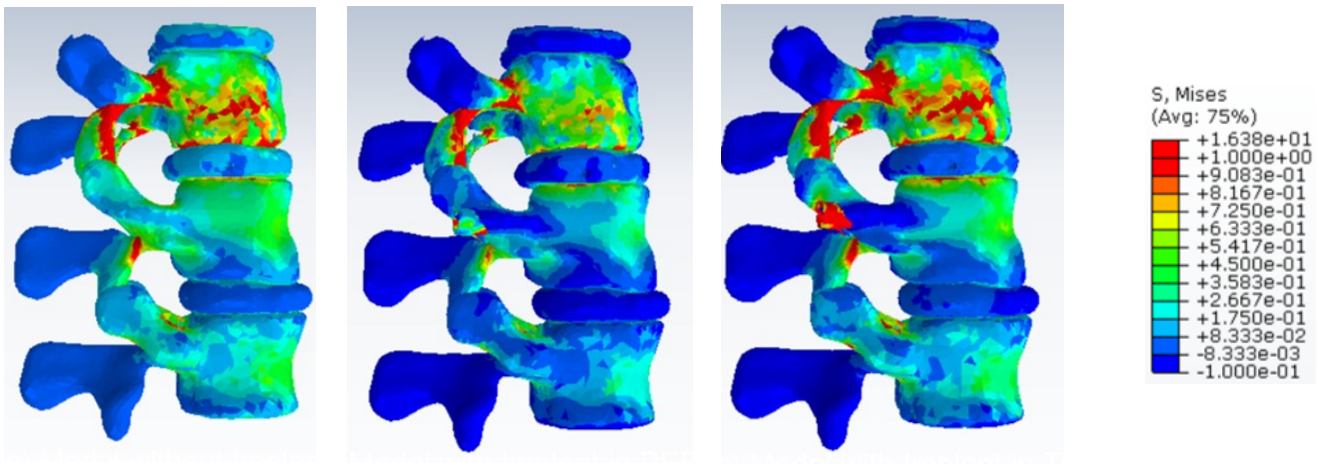


Fig 1: Finite Element model - The middle vertebra is removed to show the implant



a) Without implant *b) With V-STRUT© PEEK Implant* *c) Titanium Implant*

Fig 2: Distribution of the equivalent stress

Transpedicular PEEK polymer implant reduces the stress in the vertebra because a part of the applied stress is transferred to the implant and posteriorly to the pedicle. When the implant rigidity is greater than the healthy bone one (ex: implant made of Titanium), the stress is transferred to the upper vertebrae that may lead to adjacent fracture on osteoporotic bone.

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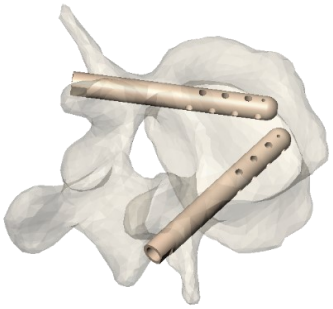
About V-STRUT© Vertebral Implant

Hyprevention has developed V-STRUT© Vertebral Implant indicated to treat vertebral fracture due to osteoporosis or bone metastasis.

The medical device reinforces the full vertebrae thanks to a PEEK implant providing a unique pedicle anchorage and allowing to share loading between the anterior and posterior column to limit subsequent and adjacent fracture.



COMING SOON
ASK THE EXPERTS Part 3: PEEK Material in Spine