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ASK THE EXPERTS

Part 4: Vertebral body fractures adjacent to an augmented vertebra

Assess PEEK material for use in spinal implant.

Literature review.

Vertebral body fractures adjacent to an augmented vertebra

Titanium and PEEK embedded PMMA

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Vertebral body fractures adjacent to an augmented vertebra

Since the advent of vertebral augmentation techniques for the treatment of vertebral compression fractures and tumors the issue of new fractures close to the originally augmented vertebra has arisen.

The stiffness of the augmented vertebra increases (1) and biomechanical testing has demonstrated that this increased stiffness can decrease load to failure of adjacent vertebrae by 8 to 30% and induce subsequent fractures (2) and FEA calculations confirm the load transfer to adjacent levels (3). Those calculations have been made with sole PMMA augmentation without any metallic implant which will would further exaggerate those stress increase phenomena.

Baroud et al. (4) reported an increased load shift across intervertebral disks resulting in stiffness increase of the intervertebral joint by 17% and of intervertebral pressure by 19%, which may be a cause of new fracture.

A recent meta-analysis on 24 studies showed an increase in the number of subsequent fractures at adjacent levels (5).

Several studies have investigated the predictive factors for subsequent fracture occurrence.

Shin et al. (6) investigated a series of 59 patients having undergone balloon kyphoplasty and in where 9 early adjacent subsequent fractures occurred. The only significant predictive factor was the importance of the original vertebral height loss (not the height restoration). Age, BMI, BMD, kyphotic angles were not found as predictors.

Ahn Y et al. (7) studied 508 consecutive patients treated with vertebroplasty. They looked at subsequent fractures occurring at the 3 consecutive vertebral bodies. They concluded that the mechanisms of adjacent and non-adjacent are different. At adjacent level the fracture is related to a direct pillar effect, the difference in strength caused by the augmentation. At non-adjacent levels it would be a dynamic hammer effect due to the modification of segmental mobility. BMI also influenced the occurrence of non-adjacent fractures.

Hwee Weng DH et al. (8) looked at 93 consecutive who underwent vertebroplasty or kyphoplasty patients with 16 new fractures (half in the adjacent vertebra) and found that level specific T scores and age were predictive of subsequent fracture. Other factors like wedge angle, cement volume and type of procedure were non-significant.

In a recent study Chen Z et al (9) looked at 109 patients treated with vertebroplasty. They found that the highest risk factor for refracture was correlated with higher restoration (and over restoration) of vertebral height.

This seems to confirm previous studies which also concluded that higher heights correction leads to more refractures (10,11).

Likewise, Takahashi S et al. (12), in a series of 116 consecutive patients treated with balloon kyphoplasty that higher correction of wedge angle was predictive of adjacent subsequent fracture.

All this confirms that the higher stiffness of augmented vertebrae contributes to subsequent adjacent fractures, especially in highly osteoporotic patients. Higher height/wedge correction or overcorrection probably contribute to this increased stress.

Titanium and PEEK embedded PMMA

The Young's modulus of elasticity (ME) of PEEK ranges between 1.8 and 3.6 GPa, (13) in average 2.9GPa, this can be modified with different additives (14). The addition of bone marrow or blood during curing can decrease the ME. In vertebral augmentation it appears inevitable that blood and bone marrow will be present during curing. It is thus very close to that of PEEK.

Thus, a PEEK implant will not change much the ME of PMMA when embedded in it.

On the other hand, metallic implants like Ti, will increase that ME and thus stiffness to around that of the metal used. We have mentioned previously that there was little difference in ME between cages made from Ti (50.2 GPa), stainless steel and CrCo stainless steel (51.07 and 53.15 GPA) (15).

This phenomenon compared to that induced by steel bars reinforced concrete. The Young's ME of concrete usually varies between 30 to 50 GPa, while that of the steel bars is around 200 to 210 GPa depending on carbon content. When concrete is steel reinforced, the loads will be mostly transferred to the steels bars and the ME will be that of steel (16).

Likewise, metallic PMMA embedded implant will very strongly reinforce the stiffness of the total construct contrarily to PEEK and, thus, would be more prone to induce an anvil effect on adjacent vertebrae.

Our review clearly demonstrates that PEEK is the material of choice for use in vertebral augmentation.

REFERENCES

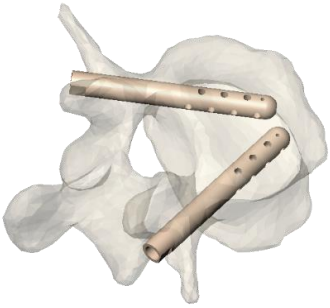
1. Belkoff SM eta al. Spine 2001
2. Berlemann U et al. J Bone Joint Surg Br 2002
3. Polikeit A et al. Spine 2003
4. Baroud G et al. Eur Spine J 2003
5. Sun HB et al. Eur Rev Med Pharma Sci 2021
6. Shin HK et al. J Back Musckuloskeletal Rehab 2021

7. Ahn Y et al. J Neurosurg Spine 2008
8. Hwee Weng DH et al. Spine 2015
9. Chen Z et al. BMC Muskuloskelatal Disord 2021
10. Yoo CM et al. J Korean Neurosurg Soc 2012
11. Kim MH et al. Asian Spine J 2011
12. Takahashi S et al. Spine J 2019
13. Lopez A et al. Bio-Med Mater Engin 2011
14. Arens D et al. J Mech Behav Biomed Mater 2011
15. Heary RF et al. J Spine Surg 2017
16. Assakkaf I. Design of concrete structures, University of Michigan 2004

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.



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