Cement flow behaviour in artificial cancellous bone structures.

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Background: Vertebroplasty is currently the most established clinical cement application in spine. Bone cement leakage and the associated risks represent the main complication for this type of surgical procedure. These risks can possibly be minimized if cement flow is pre-operatively planned. In order to accomplish this, cement flow behaviour needs to be further investigated.

Aim: To allocate bone cement distribution in artificial cancellous bone structures.

Material and methods: Four differently coloured bone cement portions were injected in 1ml steps into initially CT-scanned six open porous aluminum foam models, mimicking vertebral osteoporotic cancellous bone. Each model was characterised by an explicit leakage path simulating blood vessels. After cement hardening the models were re-scanned and finally sectioned along their mid-plane. Cement allocation was then evaluated in two and three dimensions. Initially, each sectioned surface was macroscopically analysed by evaluating the surface area of each cement portion (Fig. 1a) and by calculating the summed lengths of the coloured sections lying on a virtually applied 10deg beam grid (Fig. 1b). For the three-dimensional analysis, virtual common volumes of the six cement clouds were calculated.

Results: Stepwise injected cement portions did not intermix, although the colour transitions were diffuse. The first injected cement portion, which was distributed at the border of the cement cloud, revealed the lowest surface area, whereas the surface area of the last injected cement portion, widely spread in the centre, was the biggest. Standard deviations of the averaged summed section lengths (Fig. 1c) revealed highest cement flow irregularities along the leakage paths. Finally, the common volume of all six cement clouds was 1.74ml, corresponding to 44% of totally injected 4ml bone cement.

Conclusions and clinical implication:

Bone cement does not flow arbitrarily, despite irregularities along leakage paths. Future work will focus on finding an in-silico algorithm for simulation in accordance to the experimental cement distribution.

References:

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