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Intervertebral disc mechanical response to axial rotation: the consequences of a mobile centre of rotation on the anisotropic component

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inferior endplate being rigidly fixed and the lateral face free to swell. As the location of the ICR is a controversial topic, we implemented two different definitions reported in the literature: a static centre of rotation at the IVD barycentre and a mobile one, moving posteriorly in the opposite side of the rotation as described in Schmidt *et al*, 2008. All the numerical simulations were performed on *COMSOL Multiphysics 5.5* on a workstation with an Intel(R) Xeon(R) W-11955M CPU and 64GB of RAM.

3. Results and discussion

The aims of this work were to analyse the consequences of a mobile ICR on the stress tensors associated with the strain energy densities and to quantify the contribution of the anisotropic component of the solid phase during axial rotation. Our results show that the assumption made on the ICR kinematics considerably influences the fibres solicitation. A static ICR at the IVD barycentre creates higher stress (up to 0.21MPa) in the right side of the IVD for a left axial rotation while the simulation with a moving ICR gives higher stress (up to 0.40MPa) in the left posterior side, as illustrated on Figure 2 (a, b). These results are of particular interest as they can bring new insights on the origin of some injuries related to the IVD.

Regarding the contribution of the anisotropic component with respect to the isotropic one, Figure 2 (c, d) displays the ratio of the first anisotropic eigenvalue (i.e. $\max(Sp\{PK_{anis} + PK_{anis}\})$) over the first isotropic eigenvalue ($\max(Sp\{PK_{isotropic}\})$). Although the anisotropic stress is up to two times higher when considering a mobile ICR, its proportion with respect to the isotropic stress stays similar, with the maximal values reached in the inner annulus.

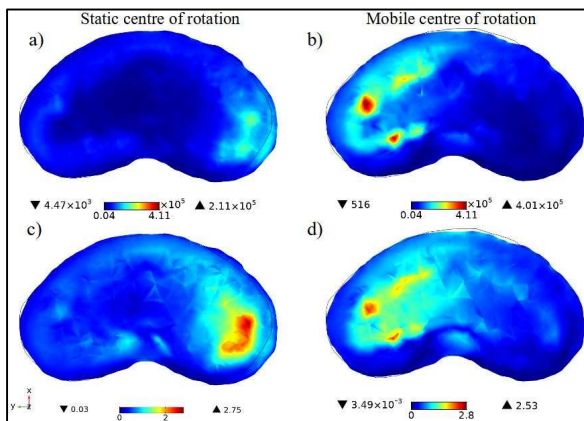


Figure 2: (a, b) First anisotropic eigenvalue (in Pa) in the median transverse plane. (c, d) Ratio of the first anisotropic eigenvalue over the first isotropic eigenvalue in the median transverse plane.

It indicates that in the areas of higher deformation, most of the stress is due to the anisotropic component of the solid phase.

4. Conclusions

ICR mobility is known to increase along with IVD degeneration (Gertzbein *et al*, 1985). Our results can help to precise this relationship as it appears that even though a mobile ICR might globally reduce joint reaction forces (Senteler *et al*, 2018), it also tends to locally put more stress on the fibres which could subsequently fuel the degeneration process or ease the apparition of acute injuries. Future work could focus on how physical therapy or muscle reinforcement might slow down the degeneration by restraining the ICR mobility and reducing the amount of stress put on the fibres.

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