$$k = k_0 \left(\frac{J - \varphi_f^0}{1 - \varphi_f^0} \right)^2 e^{-M(I_3-1)/2} \tag{3}$$

464

465 where k_0 is the reference permeability, M is the non-linearity parameter, and I_3 is the 3rd strain invariant,

466 defined as $I_3 = \det\mathbf{C}$ where $\mathbf{C}$ is the right Cauchy-Green deformation tensor. The osmotic pressure was

467 calculated as a function of the tissue's fixed charge density and bath osmolarity (Cortes and Elliott, 2012).

468   The elastic (E, v, β) and permeability (k_0, M) properties were obtained by curve-fitting the full

469 experimental load curves to the biphasic-swelling model using FEBio's built-in Levenberg-Marquardt

470 algorithm (Cortes et al., 2014a). Briefly, the full confined compression experiment in PBS was simulated

471 generating a reaction force curve that was compared to the experimental load curve. The material

472 properties were solved iteratively by minimizing the difference between the FE-generated and

473 experimental load curves. Pilot testing for a previous study demonstrated that the optimization procedure

474 produced a unique set of parameters (Cortes et al., 2014a). The quality of the curve fits was analyzed by

475 calculating the coefficient of determination, R^2.

476 **Appendix: Supplemental Tables**

477 **Supplemental Table 1: Summary of sample set by degeneration grade. Some discs only had 1 usable**
478 **CEP from levels L1L2 or L2L3 and were labeled as "unpaired".**

Degeneration Type	Non-Degenerate (Grade 1 and 2)	Degenerate (Grade 3)	**Total**
Number of Paired CEP	14	12	**26**
Number of Unpaired CEP	1	3	**4**
Total CEP	**15**	**15**	**30**

479

480

Supplemental Table 2: Correlations between parameters and NP T2 Time, a continuous measure of degeneration. Data was first analyzed in groups by disc level before ultimately all data analyzed together.

Correlations with NP T2 Time					
Permeability		Fixed Charge Density		Modulus	
Inferior	Superior	Inferior	Superior	Inferior	Superior
$p < 0.05$*	$p < 0.1$#	$p < 0.1$#	ns	ns	ns
$p < 0.05$*		$p < 0.05$*		ns	

Supplemental Table 3: Correlations between parameters and age. Data was first analyzed in groups by disc level before ultimately all data analyzed together.

Correlations with Age					
Permeability		Fixed Charge Density		Modulus	
Inferior	Superior	Inferior	Superior	Inferior	Superior
$p < 0.1$#	ns	ns	ns	ns	ns
$p < 0.05$*		ns		ns	

References

Antoniou, J., N. Goudsouzian, T. Heathfield, N. Winterbottom, T. Steffen, A. Poole, M. Aebi, and M. Alini. 1996. The Human Lumbar Endplate. *Spine (Phila Pa 1976)*. 21:1153-1161.

Armstrong, C.G., and V.C. Mow. 1982. Variations in the intrinsic mechanical properties of human articular cartilage with age, degeneration, and water content. *Journal of Bone and Joint Surgery*. 64:88-94.