Viscoelastic characterizations of acellular dermal matrix (ADM) preparations for use as injectable implants

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Abstract

Viscoelastic characteristics of acellular dermal matrix (ADM) preparations with various additives were analyzed with creep curves, stress-strain relationships, and the storage modulus with reference to those of ADM preparations crosslinked with glutaraldehyde. Creep curves for all ADM preparations were determined to comply with the Kelvin-Voigt model. The stress-strain plots of all ADM preparations compared were described as linear. The storage modulus of all ADM preparations was maintained at a nearly constant level throughout the range of oscillating frequencies applied. ADM preparations crosslinked with glutaraldehyde showed that both Young's modulus (E) for the spring part and retardation time (tau) in the Kelvin-Voigt model, and hence viscosity (eta) for the liquid part, increased with an increasing concentration of glutaraldehyde. Higher Young's modulus and viscosity and a greater extent of the "solid" response of ADM preparations crosslinked with glutaraldehyde might have been responsible for the longer persistence that was demonstrated after implantation. The increase in ADM concentration and the addition of various additives to ADM preparations, including alpha-hydroxy acid (citric acid, lactic acid, and glycolic acid) and hyaluronic acid, resulted in similar effects on the viscoelastic characteristics of the ADM preparations, but they were less efficacious than those crosslinked with glutaraldehyde. Among them, increasing ADM concentration to >200 mg/mL and addition of glycolic acid at a concentration of >2% improved the viscoelastic characteristics of the resulting ADM preparations so that their level of persistence was closer to that of material crosslinked with glutaraldehyde. On the contrary, the influence on viscoelastic characteristics of adding PVP greatly differed from that of hyaluronic acid and was only apparent when adding concentrations of PVP of >10%. Similarly, viscoelastic characteristics of the ADM preparations examined were also so sensitive to temperature that the persistence of ADM preparations after implantation at body temperature would deteriorate.