

INVESTIGATING FULL FIELD DEFORMATION OF SOFT TISSUE UNDER SIMPLE SHEAR TESTS BY THE FOURIER TRANSFORM MOIRÉ METHOD

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INTRODUCTION

Soft tissues usually exhibit anisotropic and nonlinear material responses. In order to understand the mechanical properties of soft tissues, well controlled mechanical tests are required. Uniaxial tensile tests are the most common mechanical tests for soft tissues since soft tissues mainly sustain tensile load. However the shear deformation of soft tissue could affect the load transfer mechanism of soft tissues when soft tissues are subjected to complex deformations. Finite simple shear is a uniform deformation that can provide information (in addition to what tensile tests provide) about the mechanical properties of planar soft tissues. However test configurations like specimen geometry and the boundary condition can affect the deformation homogeneity during finite simple shear test. In order to ensure that the parameters of constitutive equations obtained from finite simple shear tests are appropriate, the deformation homogeneity of specimens during simple shear tests should be investigated.

The finite element method was used to study finite simple shear deformation of parallel-fibered planar soft tissues [1]. The purpose of this study is to use the Fourier transform moiré method to examine the deformation uniformity of porcine skin during finite simple shear tests. The effects of a different aspect ratio and clamping prestrain of the porcine skin specimen were examined.

METHODS

The Fourier transform moiré (FTM) method was used to investigate the in-plane full-field deformation of porcine skin specimen under simple shear tests (Figure 1). The FTM method, developed by Morimoto [2,3], is a useful tool for in-plane full-field displacement and strain measurements because the setup is simple, sensitivity and resolution can be varied if necessary and the signal-to-noise ratio is high. The main steps of the FTM method include calculating the Fourier spectrum of the image, obtaining one harmonic of the spectrum, shifting the harmonic toward the origin of the spatial frequency axis and computing the complex moiré fringe pattern. Displacement and strain of the specimen can be obtained from the phase of complex moiré fringe pattern. FTM is an objective method as all computation steps can be done by computer once the image of the deformed specimen is obtained so human error can be minimized.

The procedures for preparing specimen grids on soft tissue specimens and for analyzing deformation in a series of images by using FTM method are detailed in ref [4]. Three aspect ratios (sample dimensions of 5x5, 5x3.75, 5x2.5 cm) were examined. They allowed the effect of different aspect ratios on the strain fields during simple shear tests to be investigated. The deformations of samples due to clamping prestrains were also investigated.

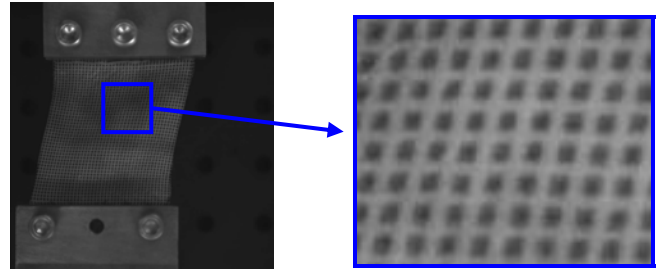


Figure 1: Schematic of in-plane full-field deformation measurement by the FTM method.

RESULTS AND DISCUSSION

Strain fields, computed from FTM complex moiré fringe patterns (figure 2), were used to examine the in-plane deformation uniformity of samples with different aspect ratios at different shear angles during simple shear tests. The FTM method can be used to validate the soft tissue constitutive model used by the finite element method.

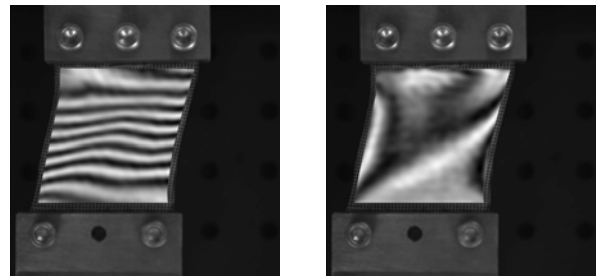


Figure 2: u and v field complex moiré fringe patterns of a 5x5 cm specimen at 10° shear angle.

If no pre-tension is applied to planar soft tissue sample prior to simple shear test, the out-of-plane deformation of samples under simple shear test can be significant when the shear angle is large. Future work will include out-of-plane deformation measurement and finite element simulations of soft tissues during simple shear tests.

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