Superior Approach for Measuring Vocal Cord Tissue Tension at High Frequencies for Tissue Engineering/ Regenerative Medicine (Case 1651)

Published date: June 11, 2012

Technology description

Brief Description:
During normal speech, human vocal folds sustain more than 100 high impact collisions each second. Vocal tissues may be become damaged by voice overuse and/or disease (e.g., cancer), which in the first case may generate nodules on the outer layer of the vocal folds, known as the superficial lamina propria or SLP, and in the second cancerous tissue. In either case, both typically require an invasive procedure/surgery resulting in scar tissue that lacks the pliability of the original tissue, and voice quality is often seriously reduced. Tissue engineering approaches have been trying to regenerate vocal fold vibratory tissue that responds to normal SLP by better understanding the mechanical properties of the natural tissue in order to create replacement materials at frequencies of human phonation - approximately 100-900 Hz.
Current techniques to study viscoelastic properties at the high frequencies of human vocal folds have their limitations. Standard rheometers/rheometric methods are constrained in terms of the viscoelastic property data of human SLP obtained being below the human phonation frequency range, while electromagnetic torsion methods, electromechanical tensile test methods, and stress-controlled rheometer methods at low audio frequencies neglect wave propagation in the sample and thus have frequency limitations. An alternative approach based on analysis of longitudinal waves in viscoelastic cylindrical rods can measure properties in the frequency range of human phonation, but LP geometry, not allowing the preparation of slender cylindrical specimens, interferes with its use. Therefore, a new, improved method and apparatus are needed to address the existing limitations and accurately assess the viscoelastic properties of human vocal fold tissues, and with practical available tissue sample geometries and dimensions, in the frequency range of human phonation. In addition, better methods for growing human vocal fold tissues in artificial environments similar to natural environments is required for successful tissue engineering of human vocal folds and subsequent reconstruction.
The invention consists of a method and apparatus, which most broadly measures mechanical properties of soft materials, with thin disc-like geometry, across a frequency regime. An innovative artificial growth environment is also achieved. In particular, this novel system uses small amplitude torsional waves (and 1-dimensional wave theory) to measure the mechanical properties – the viscoelastic response – at human phonation frequencies of both human vocal fold tissue, including the

LP, and candidate scaffold materials for use in human vocal fold reconstruction. This method is free of complications such as geometric dispersion, i.e., any practical tissue sample geometry can be used, and lateral inertia effects that encumber longitudinal wave propagation in rods.
Sample material is mounted between two vertically aligned plates with faceted sides. The bottom surface of one plate is attached to the drive shaft of a galvanometer for twisting both plates and the sample, back and forth through angles of up to ±6° at frequencies of up to 2500 Hz. The rotations of the top and bottom plates are monitored by an optical lever technique in which laser beams, reflected off the faceted plate faces, are captured by photodiode detectors. The experimentally determined amplification factor is obtained as the ratio of the rotation amplitude of the top plate divided by the corresponding amplitude of the bottom plate. The shear modulus and loss angle, which describe the mechanical properties of the sample, are then obtained from the experimental data gathered by the apparatus. Advantageously, the innovative apparatus/assembly may be enclosed in an environmental chamber to reproduce and maintain typical conditions (temperature, pressure, relative humidity) experienced by vocal folds in the throat of a living human/animal for growth of vocal fold tissue from a similar vibrational perspective as that experienced by natural tissueinsitu.
d/or tissue engineering, regenerative medicine, biophysics, material sciences, among others.

Application area

include vocal fold tissue repair/regeneration/reconstruction as a result of: voice overuse - common with professional singers, announcers, and the like; disease such as cancer; trauma caused by surgery scarring or other injury; congenital birth or genetic defects/abnormalities, among other potential medical scenarios. Further applications are for use in regenerative medicine and tissue engineering R&D, among other research endeavors in cell/molecular biology, biomedical engineering, biophysics, material sciences, etc., as a research tool. Markets include: medical device – therapeutic implants (market niche); scientific R&D research tools in the market segments of biomedical an

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