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Research paper

## Low coherence interferometry of the cochlear partition

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### 14 Abstract

15 Interferometric measurement of the vibration of the organ of Corti in the isolated guinea pig cochlea was conducted using low-coher-  
16 ence light ( $1310 \pm 47$  nm wavelength) from a superluminescent diode. The short coherence length of the light source localized measure-  
17 ments along the axial direction to within a  $\sim 10$ - $\mu$ m window (in tissue), even when using a low numerical-aperture lens. The ability to  
18 accomplish this is important because measurement of the vibration of the basal-turn organ of Corti is generally done via a small hole  
19 in the bone of the cochlea, which effectively limits the numerical aperture. The axial localization, combined with the inherent sensitivity of  
20 the method, allowed distinct measurements of the basilar membrane (BM) and the putative reticular lamina (RL) vibration using only  
21 the native tissue reflectance, that is without requiring the use of reflective particles. The system was first operated in a scanning mode as  
22 an optical coherence tomography (OCT) system to yield an image of the organ of Corti. The reflectance of intensity from the BM and RL  
23 was  $8 \cdot 10^{-5}$  and  $8 \cdot 10^{-6}$ , respectively. The internal structure between the BM and RL presented a variable reflectivity of about  $10^{-7}$ . A  
24 mirror would define a reflectance of 1.00. Then the instrument was operated as a homodyne interferometer to measure the displacement  
25 of either the BM or RL. Vibration at 16 kHz was induced by a piezoelectric actuator, causing whole movement of a dissected cochlea.  
26 After calibration of the system, we demonstrated clear measurement of mechanically driven vibration for both the BM and RL of  
27 0.30 nm above a noise floor equivalent to 0.03 nm. OCT interferometry, when adapted for in vivo organ of Corti measurements, appears  
28 suitable to determine the micromechanical vibration of cells and tissue elements of the organ.

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### 32 1. Introduction

33 Direct measurement of the vibration parameters from  
34 different locations within the organ of Corti is crucial to  
35 the understanding of the mechanical workings of the inner  
36 ear. In the basal turn of the guinea pig cochlea, interfero-  
37 metric measurements face technical difficulties. Interferom-

etry uses a focused laser beam that must pass through a 38  
small hole in the bony wall of the scala tympani. The small 39  
size of the hole (typically about 0.3 mm in diameter) 40  
imposes a low optical numerical aperture on the measure- 41  
ment. Hence, the axial extent of the laser beam focus is 42  
increased and both axial and lateral resolution is reduced. 43  
Reflectance from many tissue surfaces that fall within the 44  
length off focus can contribute to the interference signal, 45  
yielding a signal of compromised interpretability. Potential 46  
difficulties interpreting the measurements of localized tissue 47  
vibration from the organ of Corti have been raised in pre- 48  
vious reports (e.g., Khanna, 1986; Dalhoff et al., 2001; Ren 49  
and Nuttall, 2001b; de la Rochefoucauld et al., 2005 ). To 50  
enhance the signal of interest, a common technique is to 51

Abbreviations: BM, Basilar membrane; RL, Reticular lamina; OCT, Optical coherence tomography

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