RELIABILITY OF WAVEFRONT SHAPING IN DEEP TISSUE FOCUSING

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1. ABSTRACT

Wavefront shaping can compensate the wavefront distortions in deep tissue focusing, leading to an improved penetration depth [1]. However, when using the backscattered signals as the feedback, unexpected compensation bias may be introduced, resulting in focusing position deviations or even no focus in the illumination focal plane. Here we investigated the reliability of wavefront shaping in deep tissue focusing by measuring the position deviations between the foci in the illumination focal plane and the epi-detection plane [2]. The results indicate that when the penetration depth reaches 150 μm, feedback based on backscattered signals will make wavefront shaping lose its reliability.

2. EXPERIMENTAL RESULTS

The experimental results show that when the penetration depth reaches 150 μm in mouse brain tissue (with scattering coefficient ~22.42 mm^{-1}) using a 488 nm laser and an objective lens with 0.75 numerical aperture, the center of the real focus will deviate out of one radius range of the Airy disk while the optimized focus in the epi-detection plane maintained basically at the center. With the penetration depth increases, the peak to background ratio (PBR) of the focus in the illumination focal plane decreases faster than that in the epi-detection plane. Specifically, the PBR in the illumination focal plane drops to ~59.5% of that in the epi-detection plane at the thickness of 150 μm, showing a dramatically degradation of the focus quality.

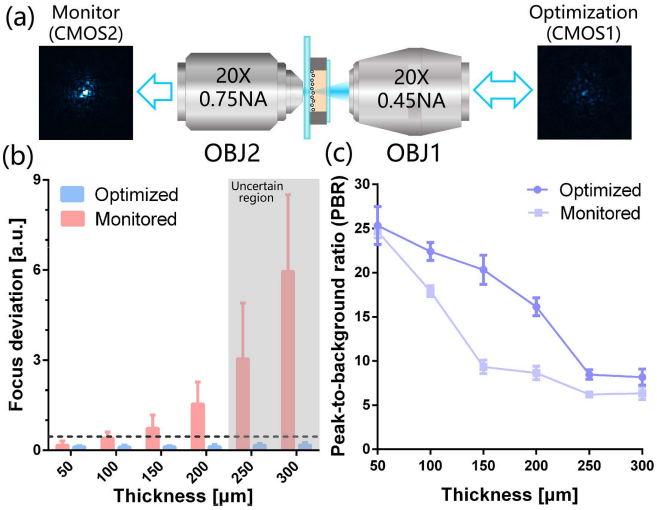

Figure 1: (a) Illustration of focusing deviation measurement. The patterns above two objective lenses refer to the intensity distributions in the illumination focal plane (CMOS1) and epi-detection plane (CMOS2); (b) Averaged focusing deviations in the epi-detection plane (optimized) and the illumination focal plane (monitored) after compensation. The unit of the ordinate is one Airy disk diameter. Black dashed line represents one Airy disk radius. Bars represent the SE of each measurement set; (c) Trends of the foci peak-to-background ratios in the epi-detection plane and the illumination focal plane after compensation as the thickness of brain sections increases. Bars represent the SE of each measurement set.

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