plotted the normalized photoacoustic signal amplitude along a transect crossing the center of each target shown in Fig. 4(b). Again, the FWHM agrees well with the exact target size.

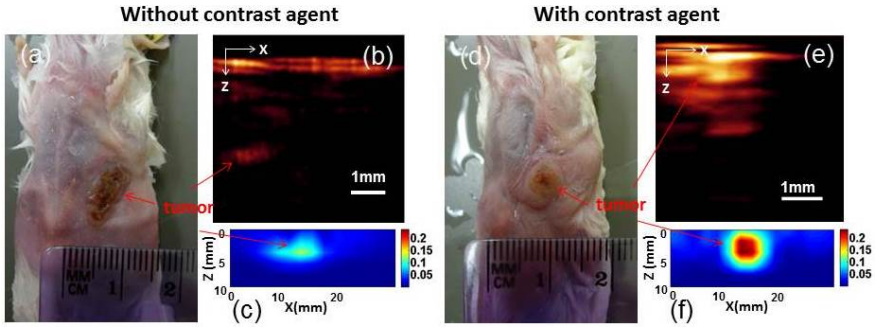

Fig. 5. (a) Photograph of the tumor-bearing mouse without (a) and with contrast agent (100pmole NIR-830-ATF-IONP) (d). A sagittal slice of PAI (b and e) and DOT (μ_a) (c and f).

To demonstrate the in vivo imaging ability of our DOT/PAI probe, tumor-bearing mice without and with the use of targeted contrast agent were imaged. Figure 5 shows the recovered PAI (b) and DOT (c) images for a control tumor-bearing mouse without contrast agent administrated, while Figs. 5(d)-5(f) present the PAI (e) and DOT (f) images for a tumor-bearing mouse systematically injected with 100pmole NIR-830-mATF-IONP, a peptide conjugated molecular probe loaded with both near-infrared dye and iron oxide nanoparticles that can target tumor cell receptors [24]. For the control case, we see that both PAI and DOT detected the tumor with low contrast (Figs. 5(b) and 5(c)). When NIR-830-mATF-IONP was administrated, dramatically improved detection of tumor for PAI and clearly enhanced contrast (tumor-to-tissue) for DOT are obtained (Figs. 5(e) and 5(f)). The artifact seen at the top of the images is due to the strong absorption of blood block existing at the mouse skin. The results clearly show the advantages of this dual modal probe: The tumor margins can be identified by PAI due to its high spatial resolution; meanwhile, the quantitative information of optical properties of tumor can be provided by DOT.

The primary advantage of the combined miniature DOT/PAI probe presented here is its potential for endoscopic imaging. While promising, we are aware of it limitations, such as the long data acquisition time, not-optimized probe size, etc.. We plan to use a laser with 1 kHz repetition rate, making real-time imaging possible. Moreover, we will improve the spatial resolution of PAI by using a transducer with higher central frequency and focal light beam. We will also further miniaturize the probe size with optimized optical/acoustic alignment.

4. Conclusions

We have presented a novel MEMS-based DOT/PAI imaging system and evaluated it with both phantom and animal experiments. It has been demonstrated that this MEMS scanning mirror based miniaturized probe offers a great potential to develop a compact handheld probe for future clinical applications. To our best knowledge, this is the first report of a miniaturized DOT/PAI handheld probe based on a MEMS scanning mirror, which integrates the advantages of two different imaging methods. We plan to apply an improved miniature probe for endoscopic imaging of GI tracks.

Acknowledgment

This research was supported in part by a grant from the National Institutes of Health (R21 CA161384).

#181381 - $15.00 USD Received 7 Dec 2012; revised 19 Jan 2013; accepted 13 Feb 2013; published 15 Feb 2013