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Commentary

A New Approach for *In Vivo* Skin Cancer: Diagnostics-Laser Induced Plasma Spectroscopy Combined with Artificial Intelligence

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DESCRIPTION

There have been many attempts to develop and apply *in vivo* skin cancer diagnostic methods based on different types of technologies, such as multi-spectral imaging, reflectance confocal microscopy, optical coherence tomography, Raman spectroscopy and electrical impedance spectroscopy, etc. However, they have insufficient diagnostic accuracy for clinical use, resulting in none of the aforementioned technologies are widely used as reliable skin cancer diagnostic method in real clinical settings.

Laser Induced Plasma Spectroscopy (LIPS) is a relatively recently developed laser spectroscopic method which utilize an ultrashort pulsed laser to extract chemical information of a target material noninvasively in real time. LIPS is regarded as a rapid and accurate tool for the analysis of molecularly complex clinical samples. LIPS have been used for the analysis of malignant tissues, such as breast cancer, colorectal cancer, liver cancer and cutaneous melanoma.

It has been revealed that LIPS is effective for discriminating organic compounds with different biochemical compositions. In principle, a few nanosecond-long pulse of light from a pulsed laser is irradiated onto the tissue surface to induce microplasma without any tissue damage or scarring. The emitted light from the microplasma is collected and resolved spectrally to generate emission spectra from the tissue enabling both elemental and molecular analysis.

In this paper, a LIPS system combined with deep learning-based diagnostic algorithms was developed and clinically validated for the *in vivo* discrimination of skin cancers, including Basal Cell Carcinoma (BCC), Squamous Cell Carcinoma (SCC), and malignant melanoma from benign lesions. A total of 353 patients were recruited for the study. *In vivo* LIPS emission spectra were acquired from 296 skin cancers (186 BCCs, 96 SCCs, and 14 melanomas) and 316 benign lesions. The diagnostic performance was tested with 10-fold cross-validations. For each round, an average of 7,731 and 859 spectral data points were used for training and testing respectively. The sensitivity and specificity for differentiating skin cancers from benign lesions using LIPS and the DNN-based algorithm were 94.3% (95% CI: 91.6%-96.9%) and 88.6% (95% CI: 85.1%-92.1%), respectively. The Area Under the Curve (AUC) of the Receiver Operating Characteristic (ROC) was recorded to be 0.955. No adverse events, including macroscopic or microscopic visible marks or pigmentation due to laser irradiation, were observed.

CONCLUSION

We have demonstrated that a novel LIPS system combined with deep learning-based diagnostic algorithms can be a tool for discriminating skin cancers from benign lesions with high sensitivity and specificity in a real-time and non-invasive manner. The system generates a combination of atomic, ionic and molecular emission signal containing biochemical information. The spectral difference between the skin cancers and benign lesions clearly revealed the difference in the signal intensity of atomic components and diatomic molecules, resulting in a sensitivity of 94.3% and a specificity of 88.6%. In addition, the extensive clinical studies are needed to even improve the current diagnostic accuracy because as more data are collected and trained, more different outliers and subtypes of the data can be reflected in the classifier.

The LIPS and deep learning-based skin cancer diagnostic device in this article can be an objective tool to assist medical professionals for the evaluation of suspicious lesions and the decision for biopsy. This article shows promising opportunities for an accurate, real-time *in vivo* skin cancer detection and diagnostics in real clinical settings.

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