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PRESS RELEASE

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Subject ling:

Non-invasive detection of unexposed cancer using Circularly Polarized Light Scattering (CiPLS) Imaging
-Towards the non-invasive diagnosis for precursor lesions of cervical cancer -

(Tokyo, February **) A research team led by Prof. Nozomi Nishizawa, Dr. Toshihide Matsumoto (Kitasato University) and Prof. Takahiro Kuchimaru (Jichi Medical University) has experimentally demonstrated an optical detection of cancerous cells (dysplasia) beneath a healthy layer using the circularly polarized light scattering (CiPLS) method, which utilizes optical scattering phenomena of circularly polarized light. This innovative approach could significantly enhance early detection and treatment strategies for cervical cancer, potentially improving patient outcomes.
Their findings have recently published in Journal of Biomedical Optics on February 6th, 2026 and the scientific illustration of the study was selected as a cover artwork in this journal.

Highlights

- Circularly polarized light scattering imaging (CiPLS) enables the evaluation of the depth of a cancerous layer creeping under a healthy layer.
- Precursor lesions of cervical cancer hidden beneath normal tissues can be measured optically.
- Non-invasive, non-staining, and label-free, making it less burdensome on patients.

Overview of Research Achievement

A research team at Kitasato University and Jichi Medical University have experimentally demonstrated a novel optical imaging approach using circularly polarized light scattering (CiPLS) method to identify cancerous tissue layers hidden beneath healthy tissue.
In this study, the team prepared artificial three-layer tissue samples consisting of healthy tissue, a buried cancerous layer, and another healthy layer. Circularly polarized light at two different wavelengths (617 nm and 850 nm) was irradiated onto the samples, and the degree of circular polarization (DOCP) of the scattered light was captured using a circular polarization imaging system.
The results showed that the DOCP values of scattered light systematically changed depending on the depth of the buried cancerous layer. By taking the difference in DOCP values between the two wavelengths, unwanted contributions from the surface reflection, surface roughness, and other factors can be minimized,

allowing the depth-dependent signal from the buried cancer layer to be clearly extracted.

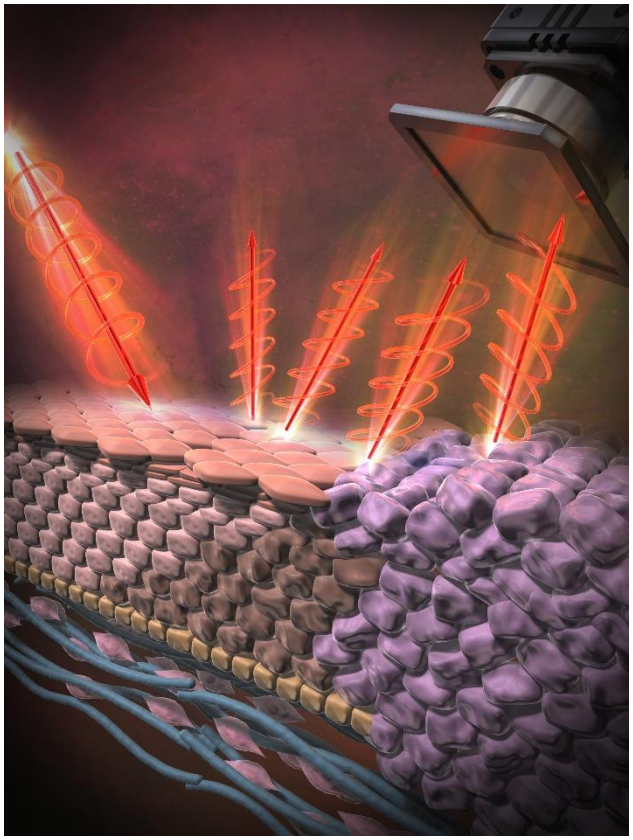

Figure 1: Schematic illustrations of *in vivo* cervical cancer diagnosis with CiPLS imaging technique

This innovative method will lead to the significant development of non-invasive optical diagnostics for early-stage cervical cancer, potentially improving early detection and treatment outcomes.

Background

Cervical cancer progresses through cervical intraepithelial neoplasia (CIN)[1], which are precursor lesions of cervical cancer. In low-grade CIN (CIN1–2), abnormal cells generate inside the squamous epithelium, making them difficult to detect using cytodiagnosis[2].

Importantly, the grade of CIN can be estimated by the depth of abnormal cell infiltration from the basal layer to the surface, rather than the cellular abnormalities. Therefore, a non-invasive diagnostic method is highly required to evaluate the depth of abnormal cells hidden at depths.

On the other hand, an optical technique using circularly polarized light (CPL) [3] can detect the size distribution of cell nuclei in tissue. Near-infrared CPL penetrates deep layers of biological tissue and undergoes depolarization due to multiple scattering against cell nuclei. The intensity of the depolarization strongly depends on the ratio of the size of cell nuclei in the tissue to the wavelengths of CPL. Therefore, the degree of circular polarization (DOCP) [4] of the light scattered from the tissue indicates structural information about cell nuclei non-invasively. This method, called the "Circularly Polarized Light Scattering (CiPLS)" method, have been demonstrated for cancer diagnosis by detecting enlarged cell nuclei in cancerous tissue. Moreover, near-infrared CPL can penetrate to a depth of approximately 3 mm without

complete depolarization, allowing the CiPLS method to investigate the ratio of abnormal cells in the scattering volume.

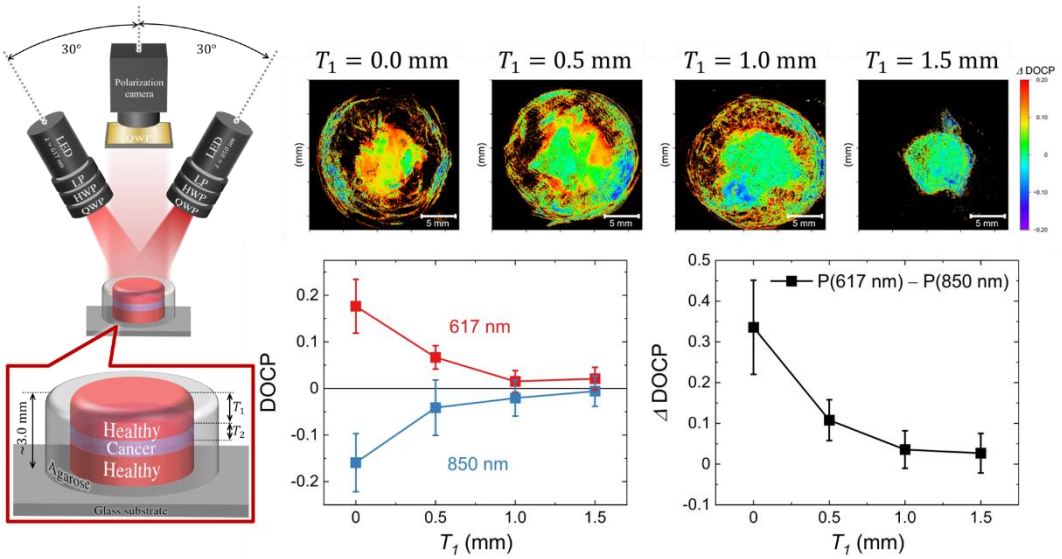

Figure 2: (Left) Schematic illustrations of the optical setup with the biological tissue sample. The circularly polarized light with wavelengths of 617 nm and 850 nm were irradiated onto the sample and the DOCP distribution images (CiPLS images) are captured with a polarization-sensitive camera and a quarter wave plate. The samples imitate the low-graded CIN cervical tissues by varied the thickness of topmost healthy tissue layer(T_1) . (Upper right) CiPLS images of the tissue samples with T_1 =0.0, 0.5, 1.0 and 1.5 mm. (Lower center) Averaged DOCP values at the center part with both wavelengths. (Lower right) Difference of DOCP values obtained with two wavelengths

Significance

The CiPLS method is non-invasive, non-staining, label-free, and *in situ*, offering both surface and spatial resolution. It is particularly suited for detecting early-stage or precancerous lesions that are not exposed on the tissue surface. The detectable depth range covers the typical thickness of cervical squamous epithelium in CIN1–2 cases (approximately 0.3–0.7 mm). These findings suggest that CiPLS-based imaging could significantly improve early detection and risk assessment of cervical cancer while reducing patient burden.

Future Outlook

While the current study was conducted using artificially layered tissue samples, future work will focus on validating the technique with actual cervical tissue specimens. The researchers also aim to integrate circular polarization imaging into endoscopes or colposcopes[5], paving the way for real-time, *in situ* optical diagnosis during routine cervical screening.

Beyond cervical cancer, this technology may be applicable to the detection of other early-stage cancers or precancerous conditions hidden beneath tissue surfaces, and the observation of assimilation of transplanted tissue.

Reference

Authors: Nozomi Nishizawa[1], Mahiro Ishikawa[1], Mike Raj Maskey[1], Asato Esumi[1] , Toshihide Matsumoto[2], Takahiro Kuchimaru[3]

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Terms

［1］ Cervical intraepithelial neoplasia (CIN)

One of the precursor lesions of cervical cancer. The cervical squamous epithelium is separated from the stroma by the basal layer. Human papillomavirus (HPV) infection causes the generation of abnormal cells at the bottom of the cervical squamous epithelium immediately above the basal layer. CIN is classified into three stages based on the ratio of abnormal cells in the cervical lining. When abnormal cells occupy more than one-third of the epithelial lining, mild CIN (CIN1) shifts to moderate CIN (CIN2). Abnormal cells occupying more than two-thirds of the epithelial lining corresponds to severe CIN (CIN3). When the spread of abnormal cells reaches the surface of the epithelial layer, known as carcinoma *in situ*, its direction of spread turns inward, progressing to invasive cancer. The evolution of malignant cervical lesions is not unidirectional; the progression or regression between the grades of CIN occurs bidirectionally because of host immune protection. However, CIN is not associated with subjective symptoms. Therefore, even if the

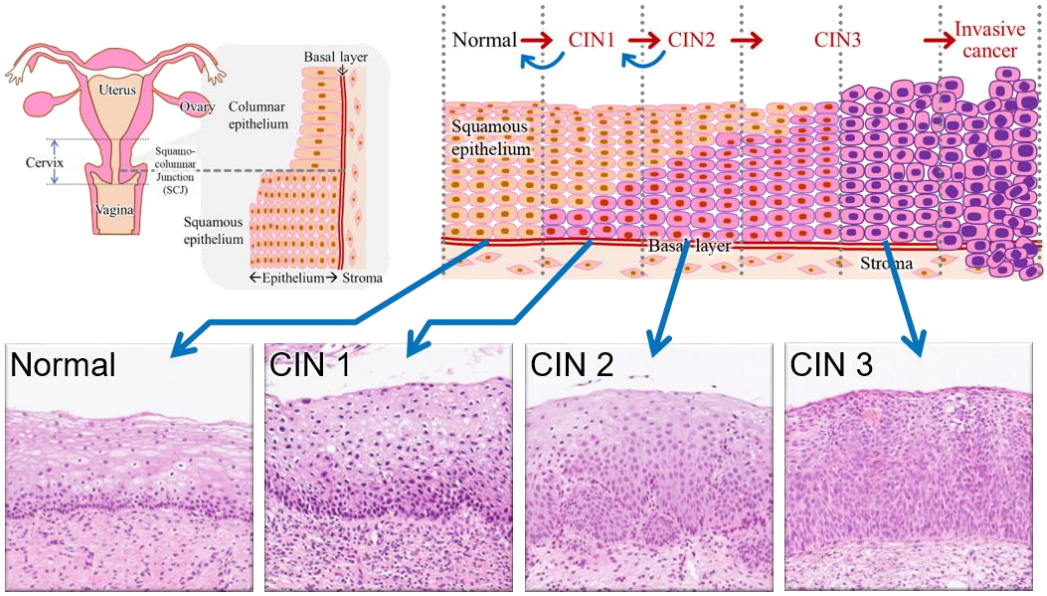

Figure 3: Schematic illustrations of the (Upper left) cervix and uterus with the tissue structure near the SCJ and (Upper right) cervical pre-cancer and cancer progression: normal, CIN1, CIN2, CIN3, and invasive cancer. Representative hematoxylin and eosin images of the squamous epithelium in normal, CIN1, CIN2, and CIN3 cases (lower figures from the left).

CIN grade is 1 or 2, periodic inspections are required to monitor the condition. (Figure 3)

［2］ Cytodiagnosis

A primary, highly effective screening method for detecting precancerous and cancerous cervical cells, often caused by high-risk HPV.

［3］ Circularly polarized light (CPL)

An electromagnetic wave is characterized by the rotation of its electric field vector in a circular motion,

either clockwise (right-handed) or counterclockwise (left-handed), as it propagates.

［4］ Degree of circularly polarization (DOCP)

This value indicates the purity of circularly polarized light, ranging from -1 (left-handed) to $+1$ (right-handed). The intermediate values mean elliptically polarized light.

［5］ Colposcope

An outpatient diagnostic procedure using a lighted magnifying instrument to examine the cervix, vagina, or vulva for abnormal cells, typically following an abnormal Pap test with cytodiagnosis or a positive HPV result.

Further information

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