



Conference Paper

Diagnosis of Cervical Cancer Using Raman Spectroscopy

M. I. Kovalev¹, A. M. Kovaleva¹, A. I. Ischenko¹, V. A. Oleinikov²,
A. A. Chistyakov², Yu. V. Alekseev³, V. M. Pominalnaya⁴, V. I. Voznesensky⁴,
A. V. Ivanov^{3,5}, and G. K. Ermoshin¹

¹Sechenovsky University, Department of Obstetrics and Gynecology #1, Elanskogo Street 2, Moscow, Russia, 119991

²Laboratory of Biophysics, Shemyakin-Ovchinnikov Institute of Bioorganic Chemistry, Russian Academy of Sciences, Moscow, Russia

³State Scientific Center of Laser Medicine of the Federal Medical and Biological Agency, Moscow, Russia

⁴Moscow City Clinical Hospital named after D. D. Pletnyov, Moscow, Russia

⁵N. N. Blokhin RCRC, Moscow, Russia

Abstract

The aim of the study was to develop a method of detecting cervical cancer using Raman spectroscopy in the examination of biopsy and surgical material. Significant differences in the spectral characteristics between the tissues of the intact cervix and tissues with squamous cell carcinoma of the cervix have been revealed. Intensity of fluorescence in cervical cancer was higher than in intact cervical tissue.

Keywords: cervical cancer, squamous cell carcinoma, diagnosis of cervical cancer, fluorescence in cervical cancer, Raman spectroscopy for the diagnosis of cervical cancer

Corresponding Author:

M. I. Kovalev

kovalevo3z@mail.ru

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1. Introduction

Relevance. For 10 years, from 2005 to 2014 in Russia, the incidence of cervical and uterine cancer increased by 31.8% from 30.2 to 39.8 thousand women [1]. The mortality of patients from cervical cancer in the first year after diagnosis in the Russian Federation for 2004–2014 was 16.3 to 20.8% [1]. We have already used new high-tech methods to diagnose precancerous diseases of the cervix. In particular, we used the method of luminescent diagnostics to develop a technique for *in vivo* diagnosis of pathological changes in the cervix [2, 3, 6]. To diagnose cervical cancer using biopsy and surgical material, we used Raman spectrometry [4, 5]. The method presented in this work is designed to work with surgical material.

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2. Purpose of the Study

To develop a method for diagnosing cervical cancer using Raman spectroscopy (spectroscopy of combination scattering).

3. Materials and Methods

The research was carried out in Shemyakin–Ovchinnikov Institute of Bioorganic Chemistry of the Russian Academy of Science on a unique scientific installation ‘System of Probe-Optical 3D Correlation Microscopy’. This installation was created in cooperation with scientists from the ‘Academician V.I. Shumakov Federal Research Center of Transplantology and Artificial Organs’, LLC ‘SNOTRA’ (Skolkovo resident) and NRNU MEPhI. The unit includes specially designed and optimized blocks: a surface modification system (ultramicrotome), a scanning probe microscopy system, an optical unit with a confocal module, a Shamrock 750 (Andor) monochromator with a CCD camera DU971P-BV (Andor Technology), an adjustable Ar- laser, He-Ne laser Melles Griot 25-LHP-928-230, and a photodiode laser (532 nm). In this work, an argon laser with a wavelength of 488 nm was used for excitation ($P = 50 \text{ mW}$).

The spectral characteristics of the following cervical tissue samples were studied.

1. As a control sample, we examined tissues of intact (without pathology) cervix (verification by histological examination).
2. The main object of the study is cervical tissue with histologically verified squamous cell carcinoma.

4. Results

Differences in the spectral characteristics between pathologically altered cervical tissues in comparison with normal tissues without pathological changes were revealed.

Differences in the spectral characteristics between pathologically altered cervical tissues in comparison with normal tissues without pathological changes were revealed. In Table 1, in quantitative terms, and in Figure 1, two spectra are presented graphically.

Spectrum 1 – spectral characteristics of the tissue unchanged (without pathological changes) of the cervix.

Spectrum 2 – spectral characteristics of cervical tissue with squamous cell carcinoma.

When studying the spectra, certain regularities were revealed.

TABLE 1: Intensity of fluorescence of tissues of the intact cervix of the uterus without pathological changes and tissues of the cervix with squamous cell carcinoma.

Wavelength (λ), nm	The wave number (v), cm^{-1}	Intensity of fluorescence, relative units		
		(1) Normal tissue	(2) Squamous cell carcinoma	Difference Between 1 and 2
492.8	200	10935	15020	4085 (37.4%)
495.3	300	8485	16051	7566 (89.2%)
497.7	400	8915	17649	8734 (98.0%)
502.7	600	8982	20063	11081 (123.4%)
507.8	800	9623	22902	13920 (144.7%)
513.0	1000	10260	25712	15452 (150.6%)
518.3	1200	11256	28412	17156 (152.4%)
523.8	1400	12215	31004	18789 (153.8%)
529.3	1600	13564	33134	19570 (144.3%)
535.0	1800	13423	33987	20564 (153.2%)
540.8	2000	13732	34520	20788 (151.4%)
543.7	2100	14167	34945	20778 (146.7%)

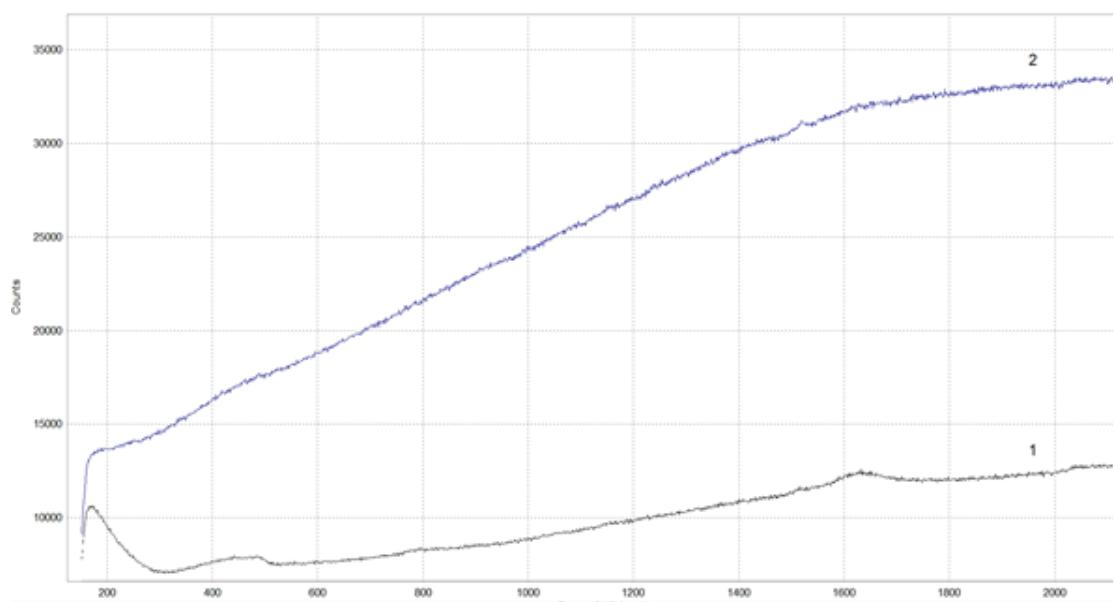


Figure 1: Spectra of normal tissue of the intact cervix (1), cervical tissue with squamous cell carcinoma (2).

4.1. Spectral characteristics of normal tissue of the intact cervix

The fluorescence intensity for a wavelength of 493 nm ($\lambda = 492.8 \text{ nm}$, wave number $v = 200 \text{ cm}^{-1}$) was 10935 relative units,

for a wavelength of 495 nm ($v = 300 \text{ cm}^{-1}$), the fluorescence intensity dropped by 2450 relative units (by 22.4%) to 8485 relative units,



for a wavelength of 498 nm ($\nu = 400 \text{ cm}^{-1}$), the fluorescence intensity tended to increase to 8915 relative units,

for a wavelength of 503 nm ($\nu = 600 \text{ cm}^{-1}$), the fluorescence intensity tended to increase to 8982 relative units,

for a wavelength of 508 nm ($\nu = 800 \text{ cm}^{-1}$), the fluorescence intensity increased by 641 relative units (by 7%) to 9623 relative units,

for a wavelength of 513 nm ($\nu = 1000 \text{ cm}^{-1}$), the fluorescence intensity increased by 637 relative units (by 6.6%) to 10260 relative units,

for a wavelength of 518 nm ($\nu = 1200 \text{ cm}^{-1}$), the fluorescence intensity increased by 996 relative units (by 9.7%) to 11256 relative units,

For a wavelength of 524 nm ($\nu = 1400 \text{ cm}^{-1}$), the fluorescence intensity increased by 959 relative units (by 8.5%) to 12215 relative units,

for a wavelength of 529 nm ($\nu = 1600 \text{ cm}^{-1}$), the fluorescence intensity increased by 1349 relative units (by 11%) to 13564 relative units,

for a wavelength of 535 nm ($\nu = 1800 \text{ cm}^{-1}$), the fluorescence intensity tended to decrease to 13423 relative units,

for a wavelength of 541 nm ($\nu = 2000 \text{ cm}^{-1}$), the fluorescence intensity tended to increase to 13732 relative units, and

for a wavelength of 544 nm ($\nu = 2100 \text{ cm}^{-1}$), the fluorescence intensity tended to increase to 14167 relative units.

Analysis of the obtained data allows us to assume that as the wavelength of the induced radiation increases, the fluorescence intensity of normal tissue gradually increases. The intensity of fluorescence varied in the range from 8915 relative units for $\lambda = 495 \text{ nm}$ to 14167 relative units. (i.e., increased by 5252 relative units or 59%) for $\lambda = 544$.

4.2. Spectral characteristics of cervical tissue with squamous cell carcinoma

The fluorescence intensity for a wavelength of 493 nm ($\lambda = 492.8 \text{ nm}$, $\nu = 200 \text{ cm}^{-1}$) was 15020 relative units,

for a wavelength of 495 nm ($\nu = 300 \text{ cm}^{-1}$), the fluorescence intensity increased by 1031 relative units (by 6.8%) to 16051 relative units,

for a wavelength of 498 nm ($\nu = 400 \text{ cm}^{-1}$), the fluorescence intensity increased by 1598 relative units (by 10.1%) to 17649 relative units,



for a wavelength of 503 nm ($\nu = 600 \text{ cm}^{-1}$), the fluorescence intensity increased by 2414 relative units (by 13.7%) to 20063 relative units,

for a wavelength of 508 nm ($\nu = 800 \text{ cm}^{-1}$), the fluorescence intensity increased by 2414 relative units (by 14.1%) to 22902 relative units,

for a wavelength of 513 nm ($\nu = 1000 \text{ cm}^{-1}$), the fluorescence intensity increased by 2810 relative units (by 12.3%) to 25712 relative units,

for a wavelength of 518 nm ($\nu = 1200 \text{ cm}^{-1}$), the fluorescence intensity increased by 2700 relative units (by 11.8%) to 28412 relative units,

For a wavelength of 524 nm ($\nu = 1400 \text{ cm}^{-1}$), the fluorescence intensity increased by 2592 relative units (by 9.1%) to 31004 relative units,

for a wavelength of 529 nm ($\nu = 1600 \text{ cm}^{-1}$), the fluorescence intensity increased by 2130 relative units (by 6.9%) to 33134 relative units,

for a wavelength of 535 nm ($\nu = 1800 \text{ cm}^{-1}$), the fluorescence intensity tended to increase by 857 relative units (2.5%) to 33987 relative units,

for a wavelength of 541 nm ($\nu = 2000 \text{ cm}^{-1}$), the fluorescence intensity tended to increase by 533 relative units (1.6%) to 34520 relative units, and

for a wavelength of 544 nm ($\nu = 2100 \text{ cm}^{-1}$), the fluorescence intensity tended to increase by 425 relative units (1.2%) to 34945 relative units.

Analysis of the obtained data allows us to assume that as the wavelength of the induced radiation increases, the fluorescence intensity of the cervical tissue with squamous cell carcinoma gradually increases. The intensity of fluorescence varied in the range from 15020 relative units for $\lambda = 495 \text{ nm}$ to 34945 relative units for $\lambda = 544 \text{ nm}$ (i.e., increased by 19925 relative units or 132.7%).

As the wavelength of the induced radiation increased, all samples both of normal cervical tissue and of pathologically altered cervical tissue with squamous cell carcinoma showed a rise in the fluorescence intensity.

The intensity of fluorescence in the cervical tissue with squamous cell carcinoma was higher than in the tissue of the intact cervix. The difference in fluorescence intensity was from 4085 relative units (37.4%) to 20788 relative units (151.4%) and on an average amounted to 14874 relative units or 129%.



5. Conclusions

1. In future, the method of laser fluorescence spectroscopy can be used to diagnose precancerous diseases and cervical cancer in examining biopsy and surgical material.
2. The intensity of fluorescence in the cervical tissues with squamous cell carcinoma exceeds the intensity of fluorescence in intact cervical tissues without pathological changes from 93 to 129%.

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