Polarization-interference mapping of biological fluids polycrystalline films in differentiation of weak changes of optical anisotropy

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ABSTRACT

The theoretical background of the azimuthally stable method of polarization-interference mapping of the histological sections of the biopsy of the prostate tissue on the basis of the spatial frequency selection of the mechanisms of linear and circular birefringence is presented. The diagnostic application of a new correlation parameter – complex degree of mutual anisotropy – is analytically substantiated. The method of measuring coordinate distributions of complex degree of mutual anisotropy with further spatial filtration of their high- and low-frequency components is developed. The interconnections of such distributions with parameters of linear and circular birefringence of prostate tissue histological sections are found. The objective criteria of differentiation of benign and malignant conditions of prostate tissue are determined.

Keywords: polarization, interference, optical anisotropy, differentiation, biological fluids

1. INTRODUCTION

Methods of optical diagnostics of biological tissues (BT) include three directions - spectral [1-3], polarization [4-12] and correlation-interference [13-16].

Polarization-interference correlation metrology is generalized for biomedical applications in [17-21]. This study presents the possibilities of diagnostics of benign and malignant changes in prostate tissue based on the determination of the coordinate distributions of the magnitude of the complex degree of mutual anisotropy (CDMA) [18,19].

2. MATERIALS AND METHODS

The experimental measurement of CDMA components is based on the approach suggested in [20].

As objects of investigation were selected from optically thin (attenuation coefficient) histological sections of biopsy of benign (adenoma) and malignant (carcinoma) prostate tumors.

Were formed of two groups of patients with the following diagnoses, prepared according to the standard technique on the freezing microtome:

- group 1 - adenoma;
- group 2 - carcinoma.

Figures 1 and 2 present the results of polarization-interference mapping of low-frequency (linear birefringence – Fig. 1) and high-frequency (circular birefringence – Fig. 2) CDMA distributions of prostate tissue histological sections. Figures consists of the coordinate distributions (fragments (1),(3)) and histograms $N(q)$ (fragments (2),(4)) of sample randomly taken from group 1 (fragments (1),(2)) and from group 2 (fragments (3),(4)).
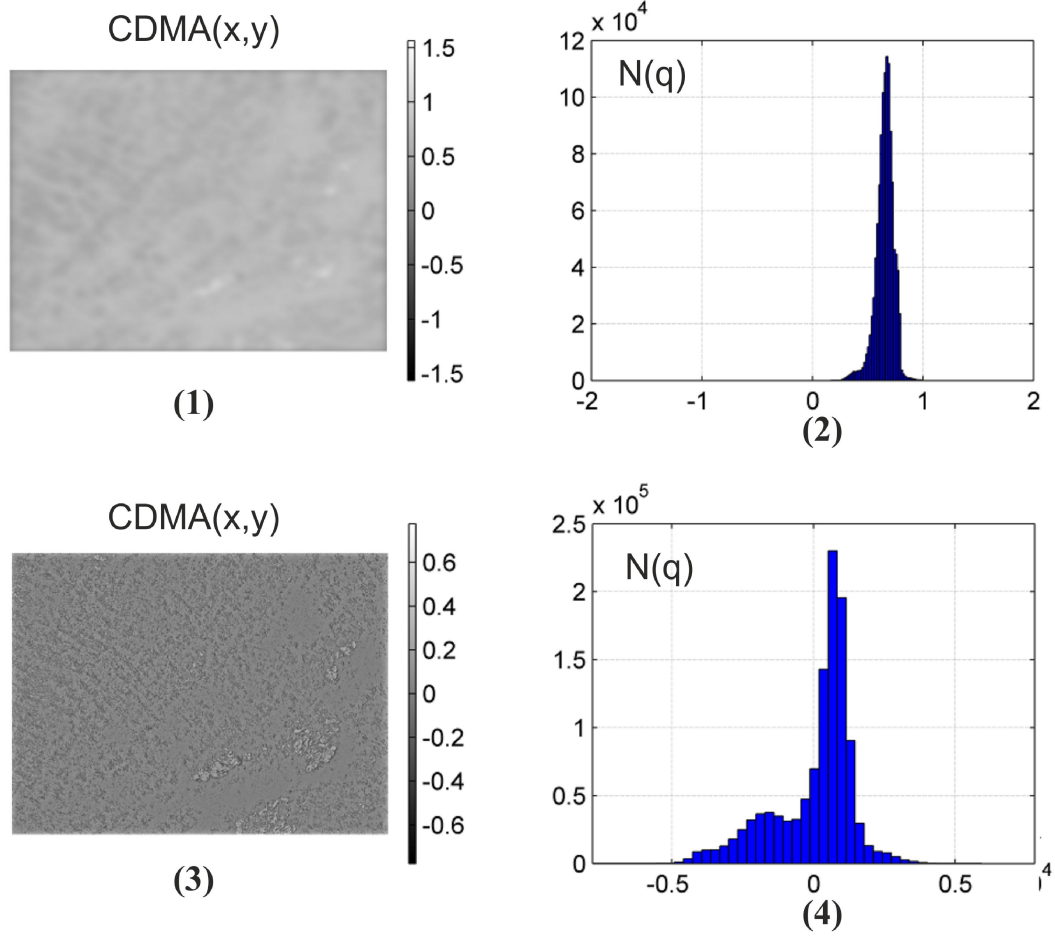
Figure 1. Coordinate structure ((1),(3)) and histograms ((2),(4)) of CDMA distributions of linear birefringence of histological sections of biopsy of prostate tissue of group 1 ((1),(2)) and group 2 ((3),(4)).
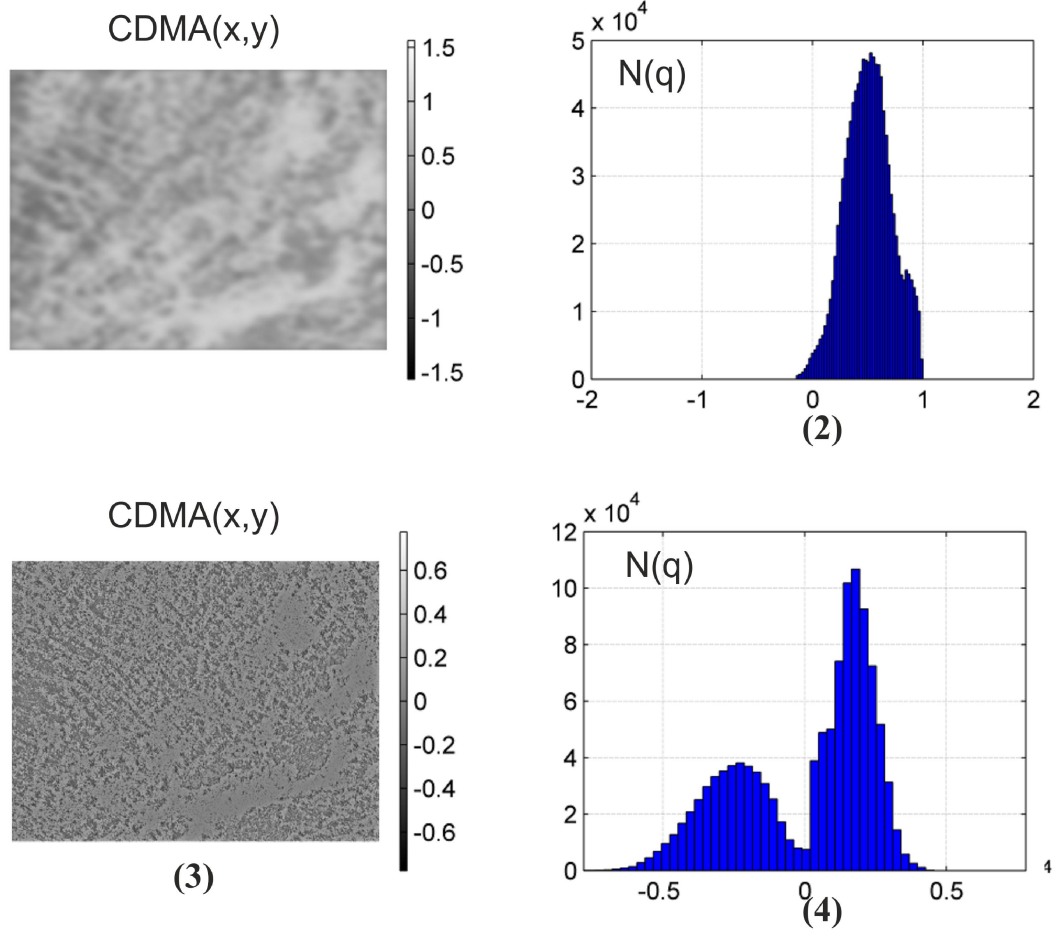
Figure 2. Coordinate structure ((1),(3)) and histograms ((2),(4)) of CDMA distributions of circular birefringence of histological sections of biopsy of prostate tissue of group 1 ((1),(2)) and group 2 ((3),(4)).

The differentiation between the group 1 and group 2 was determined by next methods[21-28].

Table 1. Parameters of statistical structure of CDMA coordinate distributions

Parameters	$H_{\rho,\omega}$		H_{ψ}	
	Adenoma	Carcynoma	Adenoma	Carcynoma
M_1	0.67 ± 0.045	0.62 ± 0.041	0.095 ± 0.005	0.066 ± 0.004
M_2	0.23 ± 0.013	0.26 ± 0.018	0.12 ± 0.006	0.09 ± 0.007
M_3	0.43 ± 0.026	0.23 ± 0.015	0.77 ± 0.055	1.28 ± 0.081
M_4	0.68 ± 0.045	0.97 ± 0.47	1.13 ± 0.093	1.89 ± 0.15

Table 2 presents operational characteristics of the method of polarization-interference mapping of optical anisotropy of histological sections of biopsy of prostate tissue

Table 2. Operational characteristics of the method of polarization-interference mapping of optical anisotropy of histological sections of biopsy of prostate tissue

Parameters	M_i	$H_{\rho,\omega}$	H_ψ
$Ac(M_i)$	M_1	63%	69%
	M_2	68%	72%
	M_3	91%	88%
	M_4	93%	90%

The obtained results enable to state a rather high level of accuracy of azimuthally stable polarization-interference mapping. According to the criteria of probative medicine [26] the parameters $Ac(\psi) \sim 90\%$ correspond to good quality, while $Ac(\rho,\omega) \succ 90\%$ – to high quality.

CONCLUSION

The comparative investigations of the effectiveness of the developed technique of spatial-frequency Fourier polarimetry of CDMA in the diagnostics of the oncological changes of prostate tissue are carried out.

The criteria of differentiation between the benign (adenoma) and malignant (carcinoma) states of prostate tissue on the basis of the statistical (statistical moments of the $1^{st} - 4^{th}$ order) analyses of the spatial-frequency filtered distributions of CDMA of protein networks with linear and circular birefringence are determined.

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