OCT in Gynecology

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39.1 Introduction: Motivation for OCT Application in Gynecology

Timely and efficient diagnosis of diseases of the female reproductive system is very important from the social viewpoint [1, 2]. Diagnostic efficacy of the existing techniques still needs improvement because malignant neoplasms of the female reproductive system organs are stable leaders among causes of death (over 35.9%) [3]. Each year, 851.9 thousands genital cancer cases are recorded worldwide [1, 2].

Cervical cancer is among the most common malignant neoplasm in women and the most common cause of death from cancer in young women worldwide. It commonly occurs at the height of women’s productive lives often when they still have young children at home. Yearly, 510.000 new cervical cancer cases are registered worldwide, and 288,000 women die, and over 5–6 billion dollars are spent on patients’ treatment [2].

A decrease in the cervical cancer incidence has occurred in the senior age group, while a significant increase is observed for women in the early reproductive age group (by 2% yearly, on the average) [4–6]. In the USA, according to the data of American Oncological Society as of 2002, 47% of the cervical cancer patients are women up to 35 years old [7]. Cervical cancer in young women has a less favorable prognosis, because it progresses faster, late stage is observed more frequently than in the senior age group, and consequently 5-year survival is lower [7].

Initial risk stratification for cervical neoplasia is performed using screening techniques including Pap smear and HPV (human papilloma virus) testing. The next step for diagnosis is a visual examination of the cervix. The potentially neoplastic lesions can be better visualized using application of acetic acid. The unmagnified examination of the cervix is known as VIA (visual examination with acetic acid), and the magnified examination using low-magnification, long working distance microscope, is known as
colposcopy. Both VIA and colposcopy are frequently combined with biopsies. Histopathology evaluation of the biopsies serves as a “gold standard” for diagnosis.

However, the diagnostic efficacy of the visual examination with biopsy is limited. Similar visual abnormalities can be observed for a variety of cervical conditions, benign and malignant, which reduces specificity and positive predictive value. Correct interpretation of colposcopic features requires high skills and long-term clinical experience, which makes colposcopy very subjective and limits interobserver agreement [8–10].

In addition, histological processing of biopsy requires several days or even weeks, which creates several problems. In most cases, treatment decisions cannot be made until histology results are received and reviewed, which requires more visits, increases healthcare cost and patient anxiety. In underdeveloped countries (which account for 80% of the world’s cervical cancer cases) additional visits can be difficult or impractical. Therefore, in many cases a real time decision should be made without biopsy results, representing a difficult tradeoff between potentially unnecessary but not specific diagnostics, or alternatively, potentially leaving early and curable cervical cancer untreated, which could then grow into a life-threatening condition.

OCT is known to visualize in vivo and noninvasive tissue microstructure with spatial resolution approaching the histologic level, and therefore, can be expected to guide biopsies and to provide real-time tissue structure information when biopsies are contraindicated or impractical. Although thorough clinical studies are required to determine if OCT can be suitable for this purpose in gynecology, in general, and for cervical cancer, in particular, the early results look encouraging.

The first in vivo OCT images of the uterine cervix were obtained by a Nizhny Novgorod team in 1997 [11]. Later, the clinical feasibility of OCT in gynecology was discussed in a number of papers [12–22]. The papers published by the MIT group in 1999 [23, 24] also described the OCT features typical for a normal exocervix (a sharp, high contrast interface between stratified squamous epithelium, and connective tissue stroma), endocervix (visualization of cervical glands), and endometrium (contrast of glands). It was shown that the possibility to detect neoplastic changes in stratified squamous epithelium by the OCT is associated with the disappearance of the interface between the epithelium and connective tissue. These findings were later confirmed in the studies performed by the CCF and Nizhny Novgorod group [25,26] and The University of Texas at Austin [27].

The OCT potential for pelvic organ visualization during laparoscopy was explored in several papers [12, 15, 23, 28, 29]. The Nizhny Novgorod group [15] and the MIT group [29] explored the use of OCT to assess the functional condition of the fallopian tubes in reproductive gynecology. A University of Arizona group, considering four categories of the ovarian conditions