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Diagnostic value of microwave imaging of dielectric tissues properties in patients with Dupuytren disease

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Dupuytren's disease - a pathology of connective tissue, leading to wrinkling of the Palmar aponeurosis and progressive deformation of the fingers, is a fairly common pathology. For example, in Germany about 1.9 million people suffer from Dupuytren's contracture, but in the U.S. 3% of the population has this pathology [1, 2]. In recent years, there has been a tendency to increase the frequency of this pathology. According to the Department of hand surgery in Moscow scientific research Institute of emergency care named after N.V. Sklifosovsky, the number of patients operated for Dupuytren's contracture, is about 20% of the total number of planned operations [3].

To date, the overwhelming majority of the authors consider surgical treatment of Dupuytren's disease to be the most radiacal and effective. Partial or total fasciectomy is considered as a gold standard of surgical treatment in most cases [4, 5]. However, despite the introduction of new technologies of surgical intervention, unsatisfactory treatment outcomes reach 30%, and as the contracture progresses, the results of operations deteriorate [6]. The number of relapses after surgical treatment remains high, which ranging from 26 to 80%, according to some foreign authors [2, 4].

In our opinion, one of the reasons for the poor results of surgical treatment of Dupuytren's contracture is the complexity of determining the boundaries of the lesion of Palmar aponeurosis, which determines the choice of rational surgical tactics. As a rule, these boundaries are determined visually by the surgeon directly during the operation. I. Zh. Osmonaliev et al. (2013) suggest using magnetic resonance imaging for this purpose without using the mode with suppression of the signal from adipose tissue [7]. According to the authors, the use of MRI allows more accurate visualization of the boundaries of the affected aponeurosis in patients with I-III degree of Dupuytren's contracture, and, respectively, to select a minimally invasive access and minimal traumatical method of excision of the affected tissues.

We believe that in modern economic conditions, the use of MRI to assess lesions in Dupuytren's contracture is justified due to the high cost of the survey. That is why the search for other objective methods of diagnosis of the area and boundaries of pathologically altered aponeurosis is very relevant and promising.

In this regard, in recent decades, studies have been conducted on the microwave diagnosis of the structure of biological tissues [8-11]. The method of resonance near-field microwave tomography, which allows to study the spatial distribution of the dielectric permeability and conductivity of living tissues with a resolution significantly lower than the wavelength λ, has broad prospects among non-invasive diagnostic methods. Unlike passive microwave sensing, near-field tomography requires a much smaller sensor (probe), and the resolution increases significantly [8-14].

The advantages of the method are confirmed by experimental studies. Thus, the assessment of skin electrodynamic properties in dermatoses indicated the diagnostic value of their study in microbial eczema and keratodermia [8, 9, 15]. Resonance near-field microwave diagnosis is potentially informative for the diagnosis of organ cancer (superficial or subepithelial localization), in determining the boundaries of the pathological focus [8, 15]. A.V. Arsenyev et al. (2011) investigated the level of functional activity of tissue growth zone in children, on the basis of which the presence of sexual characteristics of this process was established [16]. In addition, near-field microwave sensing makes it possible to quickly diagnose organ viability during transplantation [8]. Thus, with the help of near-field microwave sensing of the tissue structure, it is possible to obtain information about the biological object and the processes occurring in it [17-19]. At the same time, there is no data in the literature on the possibility of using microwave imaging in Dupuytren's contracture.

The aim of this study was to estimate the dielectric properties of fibrously altered tissues in patients with Dupuytren's contracture.

Material and methods

The study included 12 patients (male, mean age 53.9 years) with Dupuytren contracture of II-III degree according to R. Tubiana (1968), treated at the University hospital of the "PRMU" of Ministry of health of Russia. All patients were examined before surgical intervention.

The dielectric properties of the skin and subcutaneous structures were studied in different areas of the hand, including in the area of fibrous (altered and healthy tissues).

The dielectric characteristics of the biological tissues was evaluated by the method of resonance near-field microwave sensing. Near-field microwave sensing of tissues was performed using a special installation created at the Institute of Applied Physics of the Russian Academy of Sciences (Nizhny Novgorod), as well as specialized software that interfaces the installation with a PC and allows to calculate the effective part of the dielectric permittivity [8, 9]. This indicator was recorded and evaluated at depths of 2 to 5 mm using a series of probes.

The results were processed using the program Statistica 6.0.

The results and discussion

The study allowed to establish that in the field of healthy tissues the microwave profile of the skin corresponds to the physiological pattern formed by us on the basis of examination of healthy volunteers [10, 15]. It is revealed that the real part of the permittivity in the intact part of the Palmar aponeurosis increases monotonically with increasing sensing depth (Fig. 1).

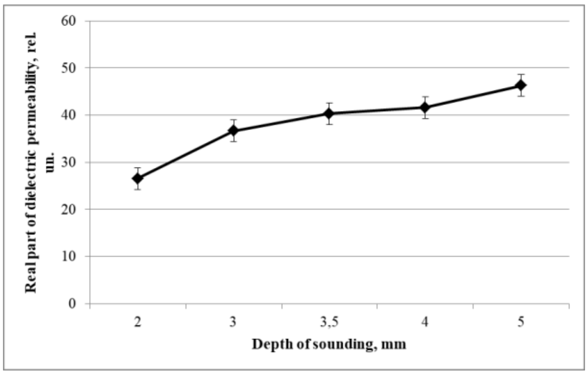

Fig. 1. Dielectric profile of intact area of the hand in patients with Dupuytren contracture

Then the microwave profiles of sub-skin tissues were compared at points 1 and 3 corresponding to intact and fibrous-modified areas (Fig. 2). It is established that fibrosis-changed tissues su-substantially differ in their dielectric parameters from the healthy, which leads to the significant transformation of the microwave profile in the area of measurement and control hardware of the Palmar aponeurosis are relatively to physiological pattern. The data obtained allow the conclusion that fibrosis in the tissue absorb microwave radiation, has extremely low values of the real part of dielectric permittivity. Such shifts are recorded at a depth of 2-3.5 mm, which approximately corresponds to the depth of pathologically altered tissues under Dupuytren's contracture [20, 21]. It should be emphasized that the sounding of deeper layers (4-5 m) does not detect significant deviations from the norm. This indicates the presence of intact morphological structures.

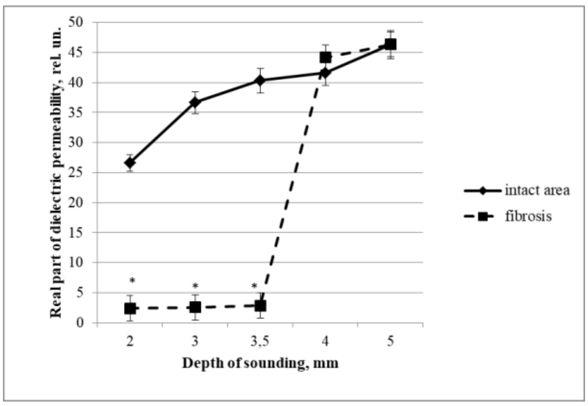

Fig. 2. Dielectric profile of subcutaneous tissues in intact and transformed area of the hand in patients with Dupuytren's contracture ("*" – statistical differences to intact area $p<0.05$)

Conclusion

The conducted studies allowed to form a microwave pattern of the actual part of the dielectric permeability in patients with Dupuytren's contracture in the area of healthy and fibrous-changed tissues, and a sharp decrease in this parameter was found in the zone of the pathological process at depths up to 3.5 mm.at the same time, in the area of healthy tissues, there were no features of dielectric properties compared with healthy volunteers. It is also shown that the fibrous-modified Palmar aponeurosis has a fairly uniform microwave structure, which allows us to count on the possibility of accurate visualization of its boundaries. This is crucial for the planning of surgery in patients with Dupuytren's contract.

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