

Microtubular transmission in millimeter wave therapy

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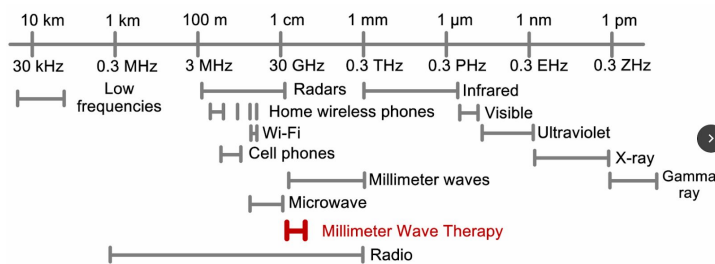
ABSTRACT

Millimeter Wave Therapy (MWT) is a physical therapy largely overlooked in the West largely due to a lack of the mechanistic understanding of its principle. Since the onset of the MWT effect is fast and wavelength-specific [16], it is likely that in addition to signaling by the release of signaling molecules to the blood, there is a more direct and fast signaling pathway from MWT-treated skin to the brain and we suggest that it is of electromagnetic nature. More specifically, we hypothesize, that MWs are not only absorbed by water, but also by microtubules and that it is microtubules that conduct MWs from the periphery to the brain thus circumventing the absorption by water. Therefore, we hypothesize that MWT's effects on the brain are mediated by electromagnetic transmission via microtubules. Moreover, since very low doses of MWT produce significant effects on mood and pain, we hypothesize that MWT taps onto existing electromagnetic microtubular signaling pathway.

HIV-associated neurocognitive disorder (HAND, a formalized diagnosis of NeuroAIDs) involves cerebral manifestations of HIV infection with the disturbance of cognitive, behavioural, motor, and autonomous functions [1]. Prevalence of HAND in HIV-infected individuals is estimated 30% and rising [2] comprising estimated 0.33 million of estimated 1.1 million HIV-infected people in the USA as of 2015 [3]. To date, clinical trials of pharmacological HAND therapies have been unsuccessful [4].

Millimeter Wave Therapy (MWT) is a physical therapy largely overlooked in the West largely due to a lack of the mechanistic understanding of its principle. In Russia, MWT is endorsed by the state and used for over 30 years for the treatment of cognitive disorders, neurodegeneration, pain and other neuroinflammatory disorders. The first MWT device was approved by the Russian state 31 years ago [5] and 8 more manufacturers obtained approvals since then. Physical therapy is part of the standard of care in Russia, most outpatient clinics have a physical therapy department and estimated 10% of physical therapy departments include an MWT instrument. Estimated 50 thousand MWT instruments are used in Russia serving estimated 0.5 million people.

Typically, weak non-heating 10mW radio waves in 4-7mm range are used for MWT [6]. This wavelength range is slightly shorter than of WiFi, cell phones, microwave ovens, and slightly longer than infrared, Fig. [Frequency].



The instrumentation is inexpensive (around \$300), low power, compact and can be made wearable. The irradiation level of MWT is within by the environmental exposure limits set by FDA. For cognitive and other CNS-related disorders MWT is applied to the skin for 5-20 min 2-7 times per week.



One of many MWT instruments approved by the Russian state Application of Millimeter Wave Therapy (MWT)

In a clinical study, mood-related self-assessment scores improved by MWT with high significance, $p < 0.001$ for each: pain-discomfort by 79%, anxiety-depression by 60%, activity by 40%, mood by 36% [7]. Also MWT increased endogenous opioids: enkephalin and Leu-enkephalin by 15% or more, $p < 0.05$ for each [7]. In a rat model of sciatic nerve regeneration MWT had increased the regeneration distance by 32% and the conduction velocity by 26%, $p < 0.01$ and the effect was non-thermal [8]. In an electrophysiological study of isolated nerves, MW irradiation significantly inhibited the decrease of the test compound action potentials induced by high-rate electrical stimulation (77% inhibition, $p < 0.05$) [9].

By now, NIH has been funding a number of studies totaling \$8.4M in MWT efficacy and mechanisms [10–14]. Yet, although the efficacy of MWT is promising, current explanations of its mechanisms are strikingly incomplete. The main inconsistency is that electromagnetic millimeter waves (MW) penetrate only 0.7mm [15] into the skin due to the absorption by water. Since MWT is applied peripherally, it remains a mystery how the signal may reach the brain. This lack of mechanistic clarity became the main obstacle to the acceptance of MWT in the West. Since the frequency of MWT (30-70 GHz) is at least a million times higher than the spiking frequency of nerves (under 1 KHz), MW irradiation cannot directly induce action potential oscillation in the nerves. It was also suggested that MWT works via the release of signaling macromolecules by dermis, neuron endings, or blood cells in the dermal capillaries. Such an indirect effect is unlikely since the power of MWT is very low (10mW) to release a sufficient amount of signaling molecules to the blood and the timing of the effect is shorter than is normally needed to release, transport these molecules to the brain and produce a reaction in the brain. For the same reasons activation of immune signaling by MWT also cannot explain the fast onset of effects of MWT. Therefore, **the problem** is that although MWT is effective in treatment of cognitive and pain disorders, the lack of understanding of it's mechanism prevents its acceptance.

Since the onset of the MWT effect is fast and wavelength-specific [16], it is likely that in addition to signaling by the release of signaling molecules to the blood, there is a more direct and fast signaling pathway from MWT-treated skin to the brain and we suggest that it is of electromagnetic nature. More specifically, we hypothesize, that MWs are not only absorbed by water, but also by microtubules and that it is microtubules that conduct MWs from the periphery to the brain thus circumventing the absorption by water. Therefore, **we hypothesise** that MWT's effects on the brain are mediated by electromagnetic transmission via microtubules.

Moreover, since very low doses of MWT produce significant effects on mood and pain, we hypothesize that MWT taps onto existing electromagnetic microtubular signaling pathway.

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