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Magneto-therapy of human joint cartilage

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Purpose: The topic of the present paper concerns the human joint cartilage therapy performed by the magnetic induction field. There is proved the thesis that the applied magnetic field for concrete cartilage illness should depend on the proper relative and concrete values of applied magnetic induction, intensity as well the time of treatment duration. Additionally, very important are frequencies and amplitudes of magnetic field as well as magnetic permeability of the synovial fluid. *Material and methods*: The research methods used in this paper include: magnetic induction field produced by a new Polish and German magneto electronic devices for the therapy of human joint cartilage diseases, stationary and movable magnetic applicators, magnetic bandage, ferrofluid injections, author's experience gained in Germany research institutes and practical results after measurements and information from patients. *Results*: The results of this paper concern concrete parameters of time dependent electro-magnetic field administration during the joint cartilage therapy duration and additionally concern the corollaries which are implied from reading values gained on the magnetic induction devices. *Conclusions*: The main conclusions obtained in this paper are as follows: Time dependent magnetic induction field increases the dynamic viscosity of movable synovial fluid and decreases symptoms of cartilage illness for concrete intensity of magnetic field and concrete field line architecture. The ferrofluid therapy and phospholipids bilayer simultaneously with the administrated external electromagnetic field, increases the dynamic viscosity of movable synovial fluid.

Key words: *magnetic induction variable field, magneto-therapy, magneto electronic devices, positive and negative effects of magneto-therapy, human joint cartilage diseases*

1. Introduction

The main topic of this paper is magneto-therapy to cure osteoporosis, rheumatoid diseases and other diseases of cartilage occurring in human joint [2]–[4], [10]–[15]. Some particular results obtained in this paper for electric fields are compared with new contemporary literature achievements [1], [7], [8]. During the magneto-therapy treatment a variable magnetic induction field is produced in surroundings of joint gap and its cartilage surfaces. Here, we present the magneto electronic devices, magnetic bandage for external magnetic induction field administration and describe methods to supply the magnetic fluids to internal regions of human joint gap. It is worth noting that the successful magnetic treatment for concrete disease ought to indicate and require exact values of therapy parameters, namely: interval of magnetic induction values, for example, in *mT*, time of the treatment duration, shape of the magnetic induction field lines. The above-mentioned data will be presented in this paper.

If such parameters are not preserved, then the magnetic therapy performed can be finished with adversity, namely with regression of illness symptoms or without betterments or deterioration [4]. For magnetic induction therapy we can establish and explain the processes of prevention of the loss of dynamic viscosity of synovial fluid and explain the changes of friction forces in the lubrication of cartilage surfaces during the disease duration [6], [9], [15], [19].

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2. Material and methods

The material and methods presented in this paper have now been exactly divided adequate to finally obtained results in the following parts, namely: 2.1 new materials, and 2.2 new methods. The materials include: new magneto-electronic devices, lifeless materials and living materials. The methods consist of: theoretical methods, experimental methods, and anamnesis methods.

At first, in this section, new magneto-electronic devices are presented and described.

A new Apparatus MT-24 presented in Fig. 1 produces magnetic induction field from 0 to 20 mT, with frequencies from 1 to 100 Hz and amplitude from 0.5 to 8 s. The weight of Apparatus MT-24 is 600 N, and the size: 142×364×335 mm. The power supply has values 230 V/50 Hz/300 W.

Fig. 1. A new multi-channel Apparatus MT-24 with a new control system [22]

Applicators with various magnitudes (for diameters 200, 315, 600 mm) are illustrated in Fig. 2. Such applicators deliver the magnetic induction field with sinusoidal, rectangular and triangle shapes to the pathological cartilage on the joint surface.

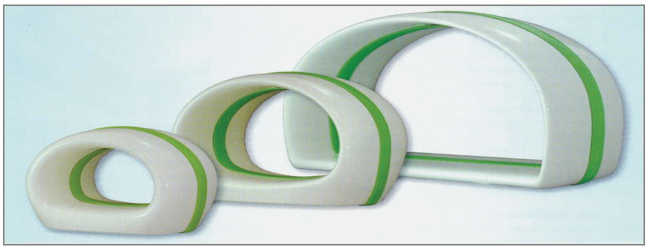


Fig. 2. Applicator: AS-200N, AS-315N, AS-600N [22]

Figure 3a shows applicator AS-600N which can be motionless or can work in horizontal direction along the couch and additionally Fig. 3b presents the applicator in the form of elevator G-10 which moves in vertical directions. In both devices, we can change automatically the place of delivery of the magnetic induction influence field.

The devices for magnetic field treatment, shown in Fig. 4, invented by Prof. Prochotta from Giessen University (Germany), are very effective. Here, the frequencies and the amplitudes of the variable magnetic induction field are controlled [19]. Another apparatus is MAGCELL-ARTHRO for PEMF being recently applied in the knee osteoarthritis treatment [1].

a) b)

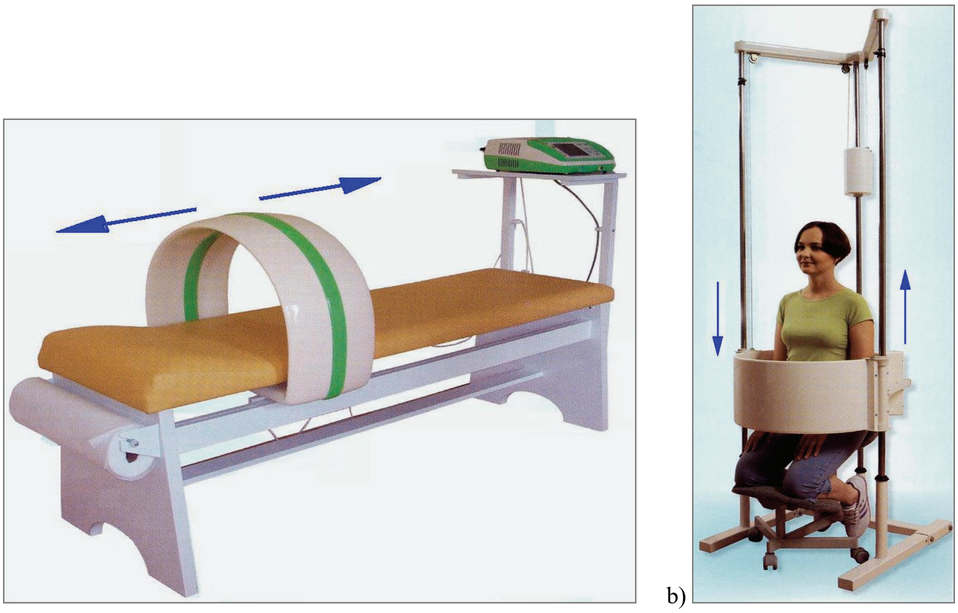
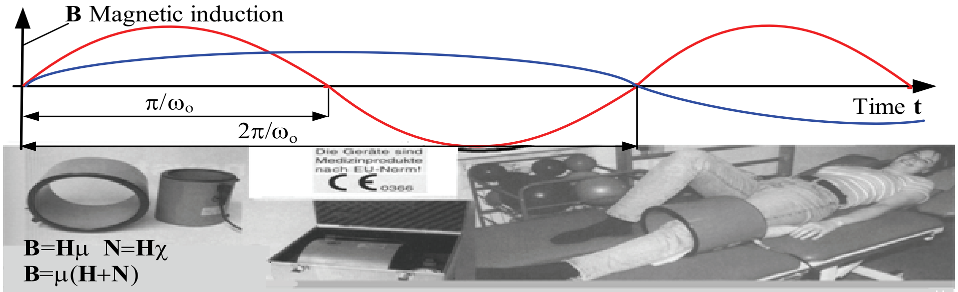


Fig. 3. Two applications of magnetic devices: (a) couch with applicator AS-600N movable in horizontal direction [21], (b) elevator with applicator G-10 movable in vertical direction [20]



Magnetic field therapy : $\mathbf{H}=\mathbf{H}_o\exp(\mathbf{i}kt\omega_o)$

Fig. 4. A device (after Prof. Prochotta, University Giessen) for human joint treatment with magnetic field (variable frequencies of magnetic induction field), N – magnetization vector, H – magnetic intensity vector

a) b)

Fig. 5. Magnetic bandage: (a) APE-1 [22], (b) band [20]

The lifeless materials include: applicator in the form of magnetic bandage presented in Fig. 5a, b is applied to wear in various pathological places occurring on the human body. Such bandage produces magnetic induction field which is delivered into pathological place when the human body is motionless and in the case of motion. Such bandages are very often mounted in orthopedic corsets.

Now we show living materials.

At first, as a living material we will present a human body with the application of various pathological places to which magnetic bandage (lifeless material) is to be fastened.

Figures 1–6 are helpful in therapy where the magnetic induction field is delivered from the external side. Now, we show magnetic induction treatment by means of internal and external administration of magnetic field into and onto the sound and pathological cartilage surfaces occurring in human hip joint. Such materials include the following living materials: normal joint, bio-accepted ferrofluid, cartilage with phospholipids bi-layer.

Figure 7a presents natural hip joint and its gap filled with ferrofluid. Ferrofluid is considered mostly in joints where load capacity is generated by rotation and the magnetic induction field is supplied from the external side. The gap height in Fig. 7a is presented in enlarged scale in comparison with the remaining sizes of the joint. Into the joint gap there is supplied bio-

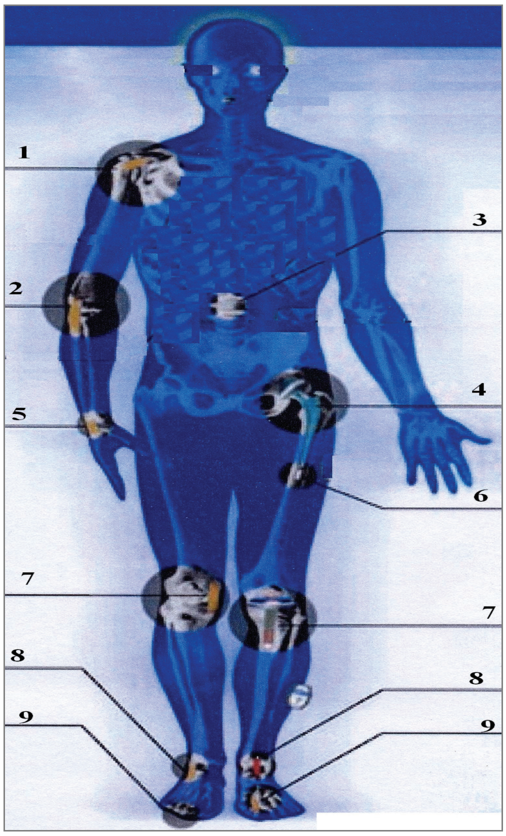


Fig. 6. Human body (living material) and magnetic bandage (lifeless material) in the various pathological places [20]: 1 – humeral joint, 2 – elbow joint, 3 – lumbar spine, 4 – hip joint, 5 – carpometacarpal joint (thumb), 6 – femoral bone, 7 – knee joint, 8 – ankle joint, 9 – phalangeal joints

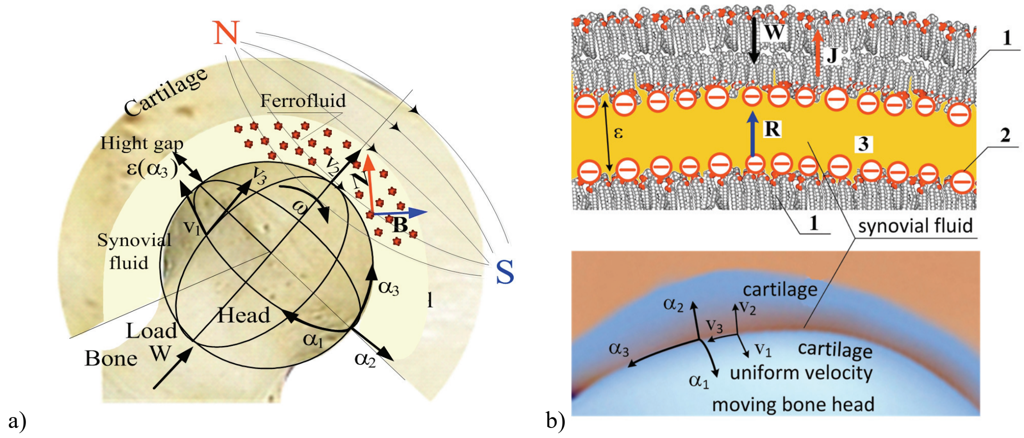


Fig. 7. A new form of e-m-treatments: (a) magnetic induction field supplied from external side into the human rotating hip joint gap. The ferrofluid is delivered into joint gap. Notations: N – magnetization vector, B – magnetic induction vector, ω – angular velocity of human hip joint bonehead; (b) pulsed electro-magnetic fields (PEMF) from external device into phospholipid membrane lying on the cartilage superficial layer for squeezing lubrication: 1 – PL bi-layer, 2 – lipids with negative charge, 3 – synovial fluid, R – repulsion force, J – current density supplied from MAGCELL device

accepted ferrofluid by injection. Such ferrofluid flow in continuous motion of synovial fluid in human joint gap creates the intensive internal magnetic induction field if additionally even very weak external magnetic field is delivered, for example, by means of magnetic bandages. The ferroliquids are a colloidal mixture of a dissipating (basic) agent and dissipated one (magnetic particles). Usually, ferric oxide Fe_3O_4 is used as a dissipated agent. Water, synovial liquid, hydrocarbons, esters, fluoro-derivatives of hydrocarbons and organic fetes are applied as a dissipating agent. One cubic millimeter of ferroliquid contains about 10^{15} magnetic particles of 5 to 15 nanometers in size. Ferroliquid viscosity may be controlled by means of an external magnetic field.

Figure 7b presents phospholipid (PL) bilayer resting on the cartilage in real human joint for squeezing lubrication. PL-bi-layers lining the hydrophilic negatively charged cartilage surfaces in human natural hip joint can be supplied by external PEMF [6].

The joint gaps in Fig. 7b are limited by the upper and lower phospholipid membrane (PL-bilayer) and filled with the synovial fluid. We have the load carrying capacity force denoted by the letter P and caused by the hydrodynamic pressure obtained from squeezing during the lubrication process. In general the senses and lines of forces R and P are the same. There is visible the repulsive force R caused by the negatively charged phospholipids membrane especially of the $(-PO_4^-)$ groups with sodium countercations strongly hydrated in the presence of synovial fluid. Such charged surfaces are observed on both external PL bilayer surfaces contacting with the synovial fluid. The repulsion force caused only by the electrostatic charged cartilage surface is negligibly small but mutual conversion of the aforementioned charge with power hydrogen ion concentration pH in SF leads to about 5 percentage decrements of the synovial fluid (SF) viscosity. Supplied PEFM from external side by the MAGCELL device to the PL-membrane has quantity of current density J about 43 mA/m^2 [23] and generates as well repulsion forces as it gives important SF viscosity increments suitable for the osteoarthritis treatments [1], [7], [8], [23]. The load force W of the human joint presented has, in general, the reverse sense and the same line as the forces P and R.

The methods

Analytical methods

Now, we are going to show the analytical methods to present the advantages of magnetic therapy. In a numerical way are proved the human joints load carrying capacity increments after magnetic induction therapy. We assume rotational, periodic and unsteady flow of viscoelastic synovial fluid, periodic time-dependent gap height, changeable synovial fluid viscosity, variable geometry of gap height, constant density of synovial fluid, ρ_o, and isothermal, incompressible flow of synovial fluid in magnetic field.

In the case of unsymmetrical flow of synovial fluid, three components v_1, v_2, v_3 of its velocity vector depend on the variables α_1, α_2, α_3, while the time t and the pressure function p depend on α_1, α_3, t. The gap height ε may be a function of the variables α_1, α_3

and the time t. The symbol α_1 denotes the co-ordinate in circumferential direction, α_2 is the co-ordinate in gap- height direction, α_3 stands for a generating line of rotational bone surface or co-ordinate in longitudinal direction. Lubrication problem of human hip joint is presented by means of the conservation of momentum, continuity, energy and Maxwell's equations [17]–[19]:

$$\mathrm{Div}\mathbf{S} + \mu_o(\mathbf{N}\nabla)\mathbf{H} + \mathbf{J}\times\mathbf{B} = \rho d\mathbf{v}/dt,$$
$$\mathrm{div}(\mathbf{v}) = 0, \qquad (1)$$
$$\nabla^2\mathbf{H} = \mu_m\mu_e\partial^2\mathbf{H}/\partial t^2,$$

$$\mathrm{div}(\kappa\,\mathrm{grad}T) + \mathrm{div}(\mathbf{vS}) - \mathbf{v}\mathrm{Div}\mathbf{S} - \mu_m T\Xi(\mathbf{v}\nabla)\mathbf{H} = 0 \quad (2)$$

where $\mathbf{S}$ – the stress tensor (Pa), $\mathbf{v}$ – synovial fluid velocity (m/s), $\mathbf{H}$ – the magnetic intensity vector (A/m) with the components (H_1, H_2, H_3), $\mathbf{N}$ – the magnetization vector (A/m) with components (N_1, N_2, N_3), μ_m – the magnetic permeability coefficient of synovial fluid ($mkgs^{-2}A^{-2}$), μ_e – the electric permeability coefficient of synovial fluid ($s^4A^2m^{-3}kg^{-1}$), κ – thermal conductivity coefficient of the ferrofluid (W/mK), Ξ – first derivative of the magnetization vector with respect to the temperature (A/mK), T – temperature (K).

We assume that synovial fluid is a good insulator, i.e., its electric conductivity coefficient $\sigma = 0$. Moreover, the second-order approximation of the general constitutive equation given by Rivlin and Ericksen can be written in the following form [16]–[19]

$$\mathbf{S} = -p\mathbf{I} + \eta_o\mathbf{A}_1 + \alpha(\mathbf{A}_1)^2 + \beta\mathbf{A}_2, \quad \mathbf{A}_1 \equiv \mathbf{L} + \mathbf{L}^{\mathrm{T}},$$
$$\mathbf{A}_2 \equiv \mathrm{grad}\mathbf{a} + (\mathrm{grad}\mathbf{a})^{\mathrm{T}} + 2\mathbf{L}^{\mathrm{T}}\mathbf{L}, \quad \mathbf{a} \equiv \mathbf{L}\cdot\mathbf{v} + \frac{\partial\mathbf{v}}{\partial t}, \qquad (3)$$

where p – pressure, $\mathbf{I}$ – the unit tensor, $\mathbf{A}_1$ and $\mathbf{A}_2$ – the first two Rivlin–Ericksen tensors, $\mathbf{L}$ – the tensor of gradient fluid velocity vector (s^{-1}), $\mathbf{L}^{\mathrm{T}}$ – the tensor of transpose of a matrix of gradient vector of a biological fluid (s^{-1}), t – time (s), $\mathbf{a}$ – the acceleration vector (m/s^2). The symbols: η_o, α, β stand for three material constants of synovial fluid, where η_o denotes dynamic viscosity (Pas), the symbols α and β determine the pseudo-viscosity coefficient (Pas^2) and describe the friction forces between viscoelastic particles of synovial fluid. The acceleration terms have been neglected. Only time derivatives of velocity component have been retained. The tangential and vertical acceleration of joint surface, variable with time, is taken into account. We also neglect the terms of the order Reynolds number $\times\Psi$ and $\Psi \equiv \varepsilon/R \cong 10^{-3}$ where R is the radius of curvature of bone surface, and we neglect the centrifugal forces. We assume that the components of magnetic intensity vector and the components of magnetization vector are constant in the height direction of joint gap. We apply the curvilinear, orthogonal system of co-ordinates α_1, α_2, α_3 with the respective Lamé coefficients h_1, h_2, h_3. From the boundary conditions of thin layer it follows that $h_2 = 1$.

- Experimental methods: Among the various measurements there were made: dynamic viscosity measurements versus magnetic induction field and dynamic viscosity versus shear rate performed in laboratory of Maritime University Gdynia.
- Anamnesis method: Data from patients were obtained after individual author anamnesis gained in Biological Boundary Layer Laboratory in Karlsruhe and Law Orthopedics Clinic in Goettingen and in University Giessen.

3. Results

The results are obtained from two sources. In the first source, we obtain data from own and literature measurements and from own analytical and numerical corollaries referring to the influence of the magnetic induction field on the liquid dynamic viscosity values. In the second source, we obtain data after individual inquired anamnesis from 20 patients .

At first, we describe the measurement results and own corollaries.

Figure 8a, b, c shows the dynamic viscosity of the ferrofluid versus magnetic induction field and versus share rate. The largest increments of dynamic viscosity are in interval from 5 to 100 mT of magnetic induction field and for eight percent of volumetric Fe_3O_4 additions. If share rate increases, then dynamic viscosity decreases. If magnetic field intensity increases, then dynamic viscosity increases, too.

Variable frequencies and amplitudes of magnetic induction fields applied into the human joint gap during the treatment cure the synovial fluid by means of the dynamic viscosity increments. The dissipated agent makes Brown's motions in ferrofluid that prevents the particles against clustering and increases their dissipation. Figure 9 shows that the magnetic particles are covered by a surface active agent in the form of long chains of molecules or an electrostatic layer. This agent prevents clustering the magnetic particles and increases synovial fluid flow resistance. Magnetic particles are combined with the hydrogen ions H^+ in SF, which enables the necessary and desired SF viscosity increments [6].

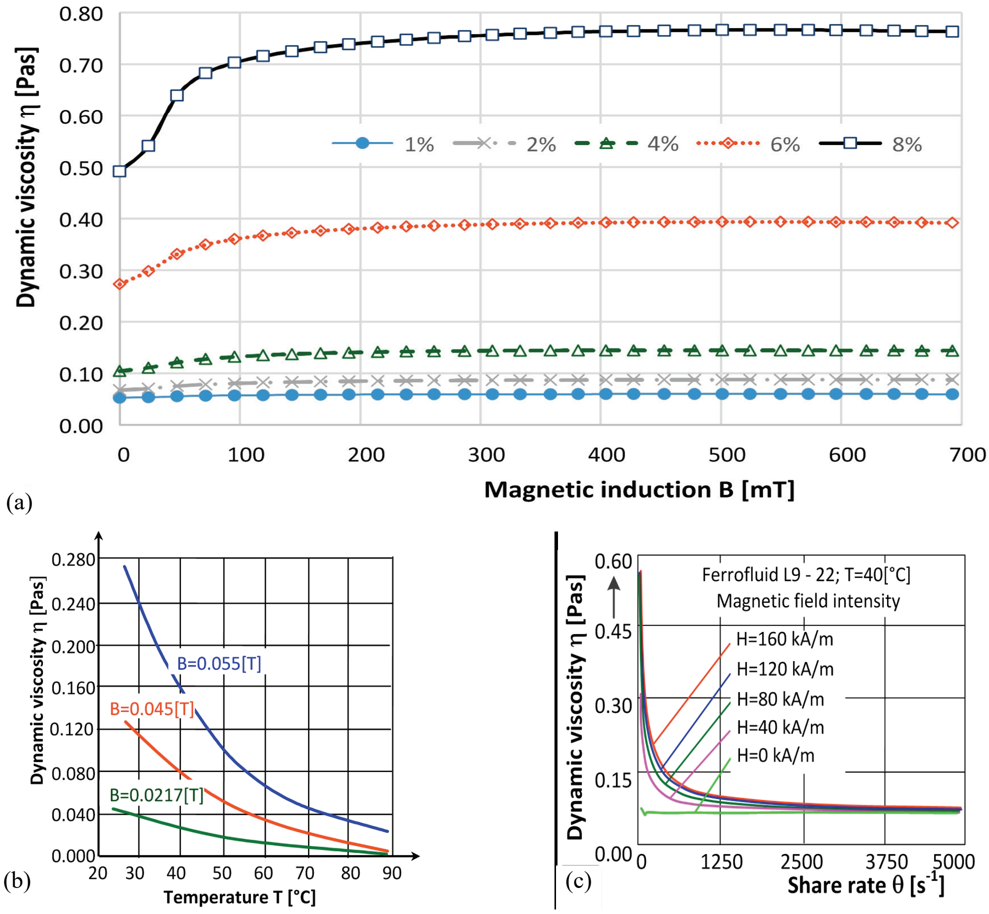


Fig. 8. Influences of magnetic field on the fluid dynamic viscosity: (a) the changes of ferrofluid dynamic viscosity values versus the magnetic induction field for various percentage (1%–8%) Fe_3O_4 volumetric additions [5], (b) the ferrofluid dynamic viscosity versus temperature for various magnetic induction field induction [9], (c) the changes of the ferrofluid dynamic viscosity versus share rate for various magnetic field intensity [16]

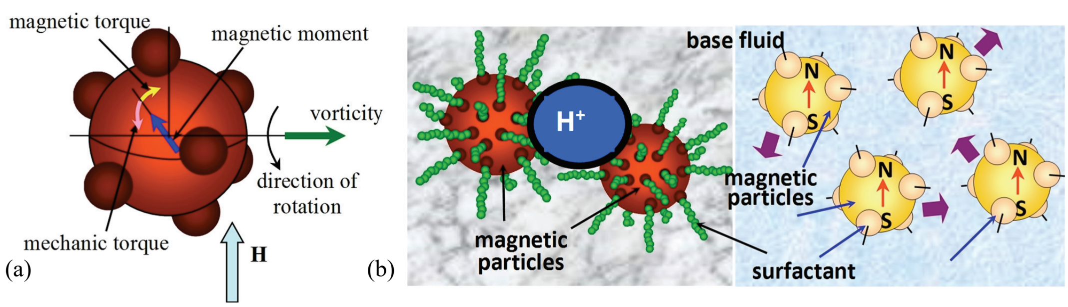


Fig. 9. Magnetic particles in ferrofluid covered by surface active agent (surfactant) [6]: (a) magnetic moment interpretation, (b) pictures of magnetic particles and pH ions H^+

Now, we go to the data obtained after individual anamnesis. In accordance with the author's experience gained in German research institutes of Biological Boundary Layers in Karlsruhe, and Jaw Orthopedics Clinic in Göttingen, and in University Giessen, the thermal deformation of a joint under magnetic induction field may change joint's gap height by about 15% which, in consequence, may result in pressure and capacity changes by about 30%. The research made on magnetic and thermodynamic properties of biomaterials will change the traditional methods of calculation of deformation values of joint gap height. Most often the deformations have not been determined so far [19].

Table 1 shows the values of magnetic induction fields produced by the sources occurring in human environment. In general, magnetic induction field is perceptible and noticed if its value is more than earth magnetic induction field, i.e., about 30–70 μT ($T = \text{kg/s}^2$, $A = \text{Wb/m}^2$).

The geometrical shapes of magnetic induction field lines and their changes during the therapy as well as proper induction magnetic values have important influence on the final success of the treatment performed. Unfortunately, many magneto-physiotherapy rooms in Poland have not more expensive applicators which could with sufficient accuracy administrate and control the proper values of magnetic induction and the shapes of magnetic field lines in the case of concrete disease in therapy duration.

The efficacy of magnetic treatments and betterments as well as typical parameters of magnetic induction field from 80 to 90 μT are described in Tables 2 and 3.

Moreover, magneto-therapy treats additionally early symptoms of Alzheimer disease and multiple sclerosis (SM) using proper magnetic induction field 6–12 pT with frequencies 2–8 Hz, and magnetic induction field 3–4 μT with frequencies 3–13 Hz [15].

The results obtained during the author's studies presented in Table 4 exactly indicate the magnetic

Table 1. Typical magnetic induction values caused by the sources occurring in human environment (after authors' modification)

Sources of magnetic induction	Frequencies	Values of magnetic induction
Earth's magnetic induction field	constant	30–70 μT
Typical farming arrangements	50–60 Hz	0.1–30.0 μT
Conduit lines of electric field	constant	2–100 mT
Magnetic nuclear resonance	constant	0.15–1.50 T
Typical magneto-therapy apparatus	1–75 Hz	1–30 mT
Personal identifier	6–1000 kHz	0.1 mT
Cordless telephone	10–100 kHz	1–50 μT
Welding arrangements	1–1000 kHz	0.1–100 mT
Induction furnaces	50–60 Hz	1–130 mT

Table 2. Evaluation of efficacy of magnetic therapy for selected diseases after subjective patients feeling after literature [11], [14] and author studies

Name of disease and number of tested patients	Regression of symptoms	Significant betterment	Betterment	Without betterment
Degeneration changes of vertebral joints, 100	15%	45%	35%	5%
Silver-fork fracture and compression fracture, 20	50%	25%	20%	5%
Osteoporosis, 20	0%	49%	31%	20%
Rheumatoid disease, 20	10%	45%	35%	10%
Degenerative cartilage inflammation, 5	10%	40%	45%	5%

Table 3. Percentage betterment after magnetic therapy for selected diseases from subjective patients feeling after literature [11] and author studies

Name of disease and number of tested patients	Pain decreases	Betterment of motion efficiency	Numb symptoms decreases	Swelling symptoms decreases
Degeneration changes of vertebral joints, 100	95%	20%	5%	0%
Silver-fork fracture and compression fracture, 20	85%	35%	0%	10%
Osteoporosis, 20	95%	25%	0%	0%
Rheumatoid disease, 20	70%	25%	0%	10%
Degenerative cartilage inflammation, 5	90%	25%	0%	0%

Table 4. Typical proper values of magnetic induction field, frequencies and shapes of field lines applied during the treatments in concrete disease and illness localization after author's studies

Disease	Localization	Magnetic induction	Frequencies	Shape of field lines	Treatment duration
Degeneration changes, inflammation of vertebral joints, disc diseases	Lumbar vertebral column	15–10 mT	10–15 Hz	Triangle or rectangular	Once a day, 12 minutes per 28 days
Limb joint diseases	Hip joint	15 mT	20 Hz	Triangle	Once a day, 12 minutes per 21 days
Limb joint diseases	Shoulder joint	10 mT	20 Hz	Rectangular	Once a day, 12 minutes per 21 days
Limb joint diseases	Knee, elbow, phalange joint	10 mT	15 Hz	Rectangular	Once a day, 12 minutes per 21 days
Osteoporosis, Osteoarthritis	Hip, knee, elbow	10–15 mT	10–15 Hz	Rectangular and triangle	Tree time a day, 24 minutes, per 90 days
Apoplexy	Human head	10 mT	40 Hz	Sinus shape	Tree time a day, 2 minutes, per 42 days

Attention! The above data (row 5) are valid for osteoarthritis treatment performed in the osteoarthritis diseases where the pH index attains yet average values between 1.5 and 8 or approximately average values but not in the last phase of osteoarthritis with the cases where pH index has radically small values, i.e., 1.5. For this case the minor correction of the above-mentioned data is necessary. If we have not respected the data given in the table during the treatment and more if we do not respect even one of these data items, then the therapy can be unsuccessful or the therapy can give the non-desired effects. Hence, very important are good applicators with the possibility to control the data of supplied magnetic induction field.

induction field, frequencies, shape of field lines, treatment duration of therapy.

The negative effects of magneto-therapy are as follows:
(1) warm sensation 43%,
(2) numb symptoms 32%,
(3) sensation of general relaxation 4.5%,
(4) muscular contraction or flower limbs 3%,
(5) the pain at the beginning of therapy.

Do not use magneto-therapy in the following cases:
(1) new growth (tumor) disease,
(2) pregnancy,
(3) presence of electronic implants.

4. Discussion

However, none of the magneto-therapy treatments can be effective without prior administration of suitable hormones to patients, which cooperate with the applied magnetic field to increase synovial liquid viscosity and strengthen joint cartilage tissue. Numerical and analytical simulations in the area of influence of ferro-liquids and PEMF on the viscosity increments of synovial liquids have not been carried out in Poland so far. However, in Germany, many clinical treatments are investigated of knee osteoarthritis and other disease using PEMF. But unfortunately, in the available foreign literature there have not been found any essential connections between the magneto-electro-thermo-elasticity equations, Maxwell equations, and heat conduction ones applied to porous multi-phase bone cartilage with real PL-bilayer, liposomes and micelles and the fluid mechanics equations, to which belong the equations of conservation of momentum, continuity and conservation of energy. It is necessary to assume that the above-mentioned equations are valid for the hydrodynamic region of a thin lubricating layer in human joint for magnetic induction field and electric field action in the course of suitable therapy. It is the problem of non-stationary conjugate fields. To the best of the authors' knowledge, such a problem has not been thoroughly solved so far for human joints both in the Polish and foreign publications. In the experimental research results published to date no connections between description of deformation of thin cartilage layer and deformation of the entire mass of bone acetabulum and head under influence of magnetic induction field and pulsed electric field have been found. In the authors's opinion, such missing problem is necessary for real electromagnetic therapy application and appreciation. The analytical model presented in this paper can make it possible to properly determine magneto-thermodynamic and electro-thermodynamic properties of biomaterials intended for acetabulum manufacturing and thereby to very realistically assess joint gap height changes. This fact, in consequence, will make it possible to achieve reliable values of operational parameters of human joints upon accounting for temperature, heat exchange, magnetic field and pulsed electromagnetic effects.

Recently, in Germany, many interesting clinical treatments PMIDs are investigated: 26705327; 26562074; 24106421; 23973142 [1], [7], [8], [23] of knee osteoarthritis and other diseases using PEMF. But, unfortunately, in the above-mentioned treatments we have not seen the role of PL during the treatments and influence of PL on the results of treatments performed. Phospholipids bi-layers have important meaning during the treatments performed, especially in the case of PEMF methods preferred in Germany.

To explain this fact, one should take into account that the osteoarthritis reduces activity of the PL-bilayer and reduces the power hydrogen ion concentration pH in synovial fluid even to value 2 which for sound joint, pH index attains values in the interval from 1.5 to 8. Right value of index pH of synovial fluid with the electric intensity E of electrostatic field created idiopathic-ally, autonomously on the superficial layer of cartilage simultaneously with the electric current density supplied from external side by the PEMF using MAGCELL-ARTHRO device leads to the necessary viscosity of synovial fluid and next to the load carrying capacity of treated human joint.

Let us stress that the PEMF treatment with MAGCELL-ARTHRO device without foreseen knowledge of pH index and foregoing knowledge about electrostatic charge existing idiopathically on the PL membrane on the superficial cartilage layer of joint cartilage exact in the time of measurements performed, leads to non realistic data and not in all cases gives the desired results.

Thus, it is proposed to equip the MAGCELL-ARTHRO device with the possibility to read the pH and idiopathically created intensity E on the PL membrane of cartilage before the application and supplying the electric current density, for example, $J = 43$ mA/m^2 supplied from external side by the PEMF using MAGCELL-ARTHRO device.

It is worth noting that the autonomous electric intensity E created on the superficial PL-bi-layer is very small, gives very small and negligibly small values of Lorentz forces, but connected with the proper pH index gives important influence on the dynamic viscosity of synovial fluid and has important influence on the betterment in osteoarthritis pain and indispositions.

5. Conclusions

After many experiences and information from patients and after analytical considerations, we can go to the following conclusions about the efficacy of the magnetic induction therapy performed.

- The magnetic induction field increases the dynamic viscosity of synovial fluid during the cure and treatment.
- The magnetic induction field puts back the progress of the sickness or decreases the symptoms of illness if necessary conditions are assumed. Such conditions require that for the concrete disease the corresponding magnetic induction field values be applied in exactly determined interval. Moreover, requirements are imposed that the magnetic induction field lines have the proper shapes, magnetic induction field waves have the proper frequencies and amplitudes as well as the treatment time is consequently adopted for each disease.

  Such corollaries are implied from the medical examinations presented in Tables 1–4 and from the numerous experiments, measurements and analytical calculations.
- Synovial fluid viscosity increments imply enlargement of the human joint hydrodynamic pressure values, increase the joint load carrying capacity values and increase the efficiency of human limbs.
- The significant effects on the SF viscosity changes caused by electrostatic charge generated on the joint PL membrane and, if needed, enlarged with the external PMEF, are visible if two effects, particularly in the presence of boosted squeezing and weeping joint lubrication are considered simultaneously, namely mutual influences of the power hydrogen ion concentrations after dissociation process in joint gap and proper electric charge on the superficial cartilage layer.

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