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BIOTRIBOLOGY ELEMENTS FOR MAGNETIC FIELD INFLUENCES ON THE HUMAN JOINT OPERATION

Abstract: This paper shows some elements of influences of magnetic induction field to be good on the human hip joint, elbow joint, and other joints. Every now magnetic field is used in a new therapy in orthopaedics. Magnetic field ameliorates squeeze lubrication flow in the human joint and hydrodynamic lubrication by help of the ferrofluid additions in synovial fluid.

Key words: human joint, lubrication, magnetic field therapy

1.INTRODUCTION

The rotational motion of the bone causes the flow of synovial fluid in human joint gap. Help of magnetic induction field in ranges from 0,05 T to 0,10T many times performs non conventional magnetic field therapy for shoulder and hip human joints. Clinical applications of magnetic field in medicine and orthopedics were presented by Sieroń A., and Cieślar G.[1],[5]. In treatment of osteopetrosis and inflammation arthritis very good are not only classical methods [3] but very helpful is apparatus Vifor, firm Medical & Life Poland too (see Fig.1) [1],[5]. The therapy with variable magnetic field for frequency 5-24 Hz and induction 25 mT, dosed 30 minutes times a day per 18 days was applied in the case of inflammation arthritis. Result of such therapy causes the improvement of the health and tempers illness [1],[5].

The geometry of human joint gap in magnetic field for hydrodynamic lubrication is presented on Fig.2. The symbol α_1 means the co-ordinate in circumference direction, α_2 - is the co-ordinate in the gap height direction, α_3 -denotes the generating line of the rotational bone surface or co-ordinate in longitudinal direction. For the axially asymmetrical synovial fluid flow pressure function depends on α_1, α_3 and the gap height may be a function of variable α_1 and α_3 [6],[7],[8],[9].

Squeeze synovial fluid lubrication in the human joint gap between bone head and cartilage surface is presented in Fig.3. Motion of the bone causes squeeze flow of synovial fluid. We have two various co-operating bone surfaces during squeeze synovial film lubrication in elbow or hip human joints. Two curvilinear bone surfaces separated by the small joint gap height, come up with the uniform motion of velocity U. This velocity is

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caused by the human limbs motion. The small region of its contact of surfaces we anticipate approximately as a circle or ellipse.

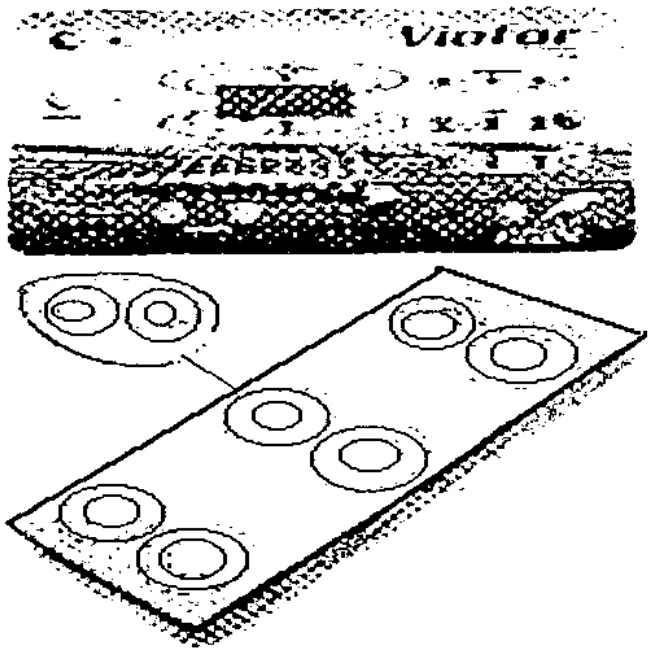


Fig. 1. Cap plate and set of applicators for apparatus Vifor ,firm Med.& Life Poland [5]

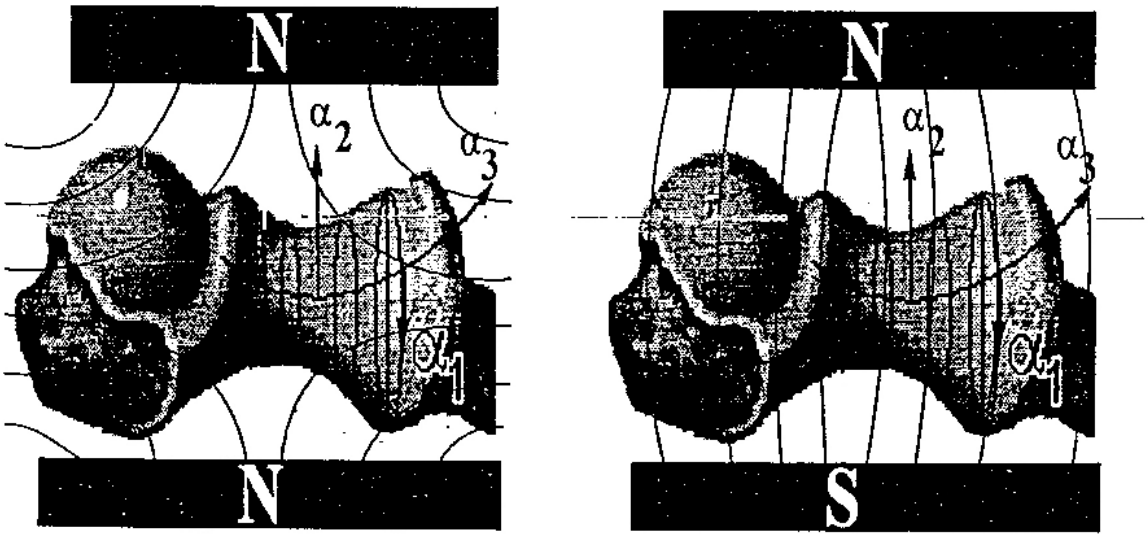


Fig. 2. Hydrodynamic lubrication of elbow joint in magnetic field (N-S-magnet pole)

This region on bone surface, we can recognize as plane surface, by virtue of its very small greatness compare with the diameter of bonehead.
Magnetic field in joint gap is produced by the external electromagnets (see Fig.1,Fig.2 and Fig.4) or by the ferrofluids (see Fig.5). Bioaccepted ferrofluid creates alone magnetic field. The therapy by injection of ferrofluid in human joint is a topic of actual research. Magnetic fluids-commonly called Ferrofluids-are suspensions of small magnetic particles with a mean diameter of about 10 nm in appropriate carrier liquids.

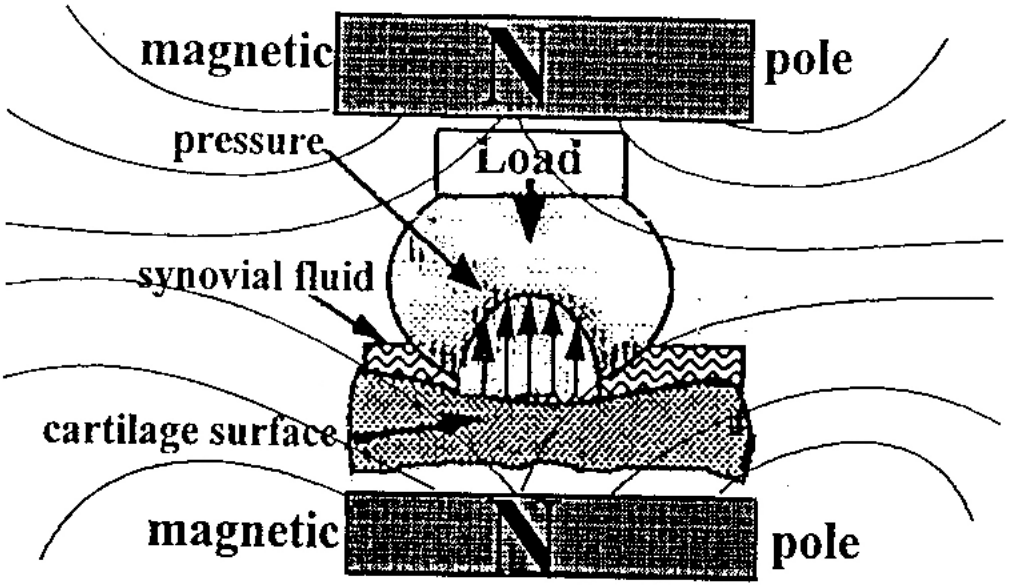


Fig. 3. Squeeze synovial fluid flow between bone head and cartilage surface in magnetic field

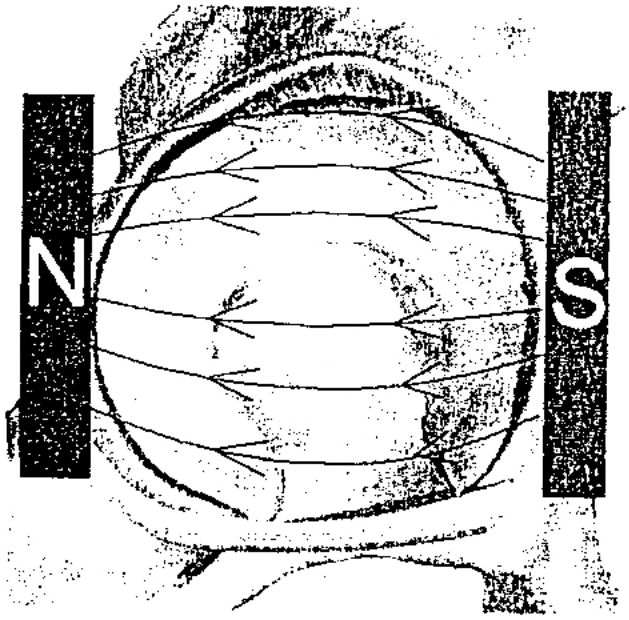


Fig. 4a. The acetabulum in the human hip joint in magnetic field (N-S) magnet pole

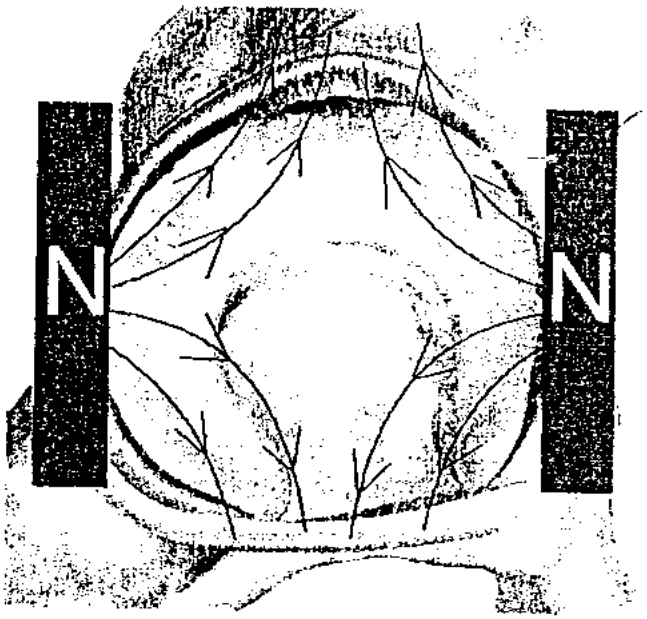
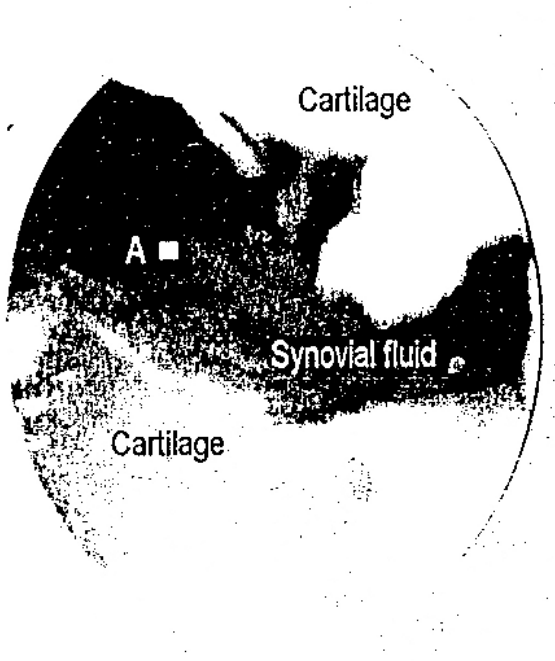


Fig. 4a. The acetabulum in the human hip joint in magnetic field (N-N)

The particles contain only a single magnetic domain and can thus be treated as small thermally agitated permanent magnets in the carrier liquid. The special feature of ferrofluids is the combination of normal liquid behaviour with superparamagnetic properties. The most famous influence of magnetic fields on the properties of ferrofluids is the field dependent change of their viscosity called rotational viscosity.

Dependence between magnetic intensity values and oil viscosity changes [3] is presented in Fig.6. Dynamic viscosity increases for synovial fluid with ferrofluid additions compare to the dynamic viscosity of classical synovial fluid. Magnetic force is able to increase the hip joint load.



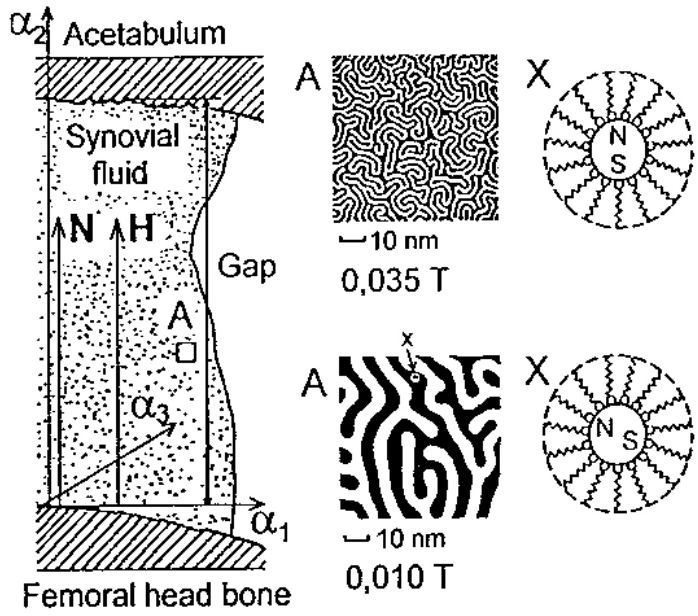


Fig. 5a. Arthroscopy view of the biobearing gap in human hip joint with ferromagnetic additions

Fig. 5b. Ferromagnetic additions and magnetic particles In a magnetic field where N-magnetisation vector, H-magnetic intensity vector. Gap height has about 40 microns

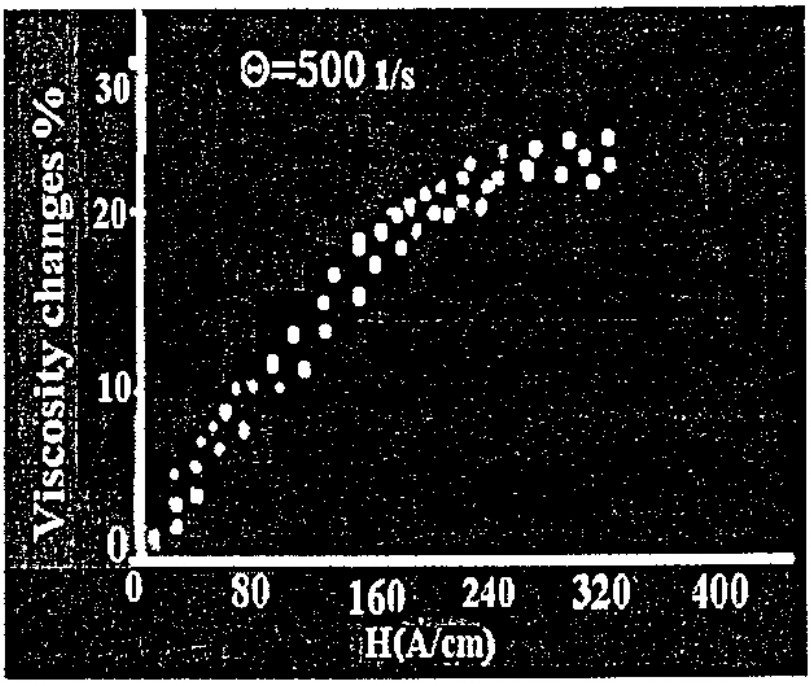


Fig. 6. Viscosity changes in percent versus magnetic intensity for shear rate $\Theta = 500$ Hz from [4]

The greatness and frequency of magnetic induction field has various values for various diseases. Table 1 shows the various quantities of magnetic induction field and various treatments or time of therapy.

Table 1

Typical parameters of the magnetic field used for magnetic therapy of selected diseases in The Hospital of Physical Medicine of The Silesian Medicine Academy

Nosologic unit	Localization of applicator	Magnetic induction [mT]	Frequency [Hz]	Kind of field	Operation frequency and time of therapy
Diseases of vertebral, degeneration and inflame changes, discopathy	Cervical vertebral	15	15	semi-triangular	1×daily per 12 minutes for 2 weeks
	Cervical vertebral	10	20	rectangular	
	Lumbar-sacral vertebral	15	10	triangular	
	Lumbar-sacral vertebral	10	15	rectangular	
Diseases of joint, degeneration and inflame changes, trauma	Hip joints	15	20	triangular	1×daily per 12 minutes for 3 weeks
	Hip joints	10	20	rectangular	
	Knee and elbow joints	15	15	semi-triangular	
	Knee and elbow joints	10	15	rectangular	
	Hand and foot joints	15	10	semi-triangular	
	Hand and foot joints	10	10	rectangular	
Diseases of bone, delayed adhesion, pseudoarthrosis, osteoperosis	Fraction of joints	15	10-15	triangular	3×daily per 24 minutes for a few weeks
	Fraction of joints	10	15	rectangular	
	fraction of joints	15	10	triangular	

2.CALCULATION METHODS

For the axially asymmetrical synovial fluid flow in human joint gap we find four unknown functions: three components of the synovial fluid velocity and hydrodynamic pressure. α_3 The joint gap height may be a function of variable α_1 and α_3. Neglecting the inertia terms and centrifugal forces, then for the layer boundary simplifications we obtain the system of conservation of momentum and continuity equation [4]. In calculations we must taking into account various geometry of the joint gap and various geometry of two co-operating bone surfaces. In numerical calculations we solve partial differential equations of motion with respect to the proper boundary conditions for the unknown synovial fluid velocity components caused by the motion of the orthogonal curvilinear bone and hydrodynamic pressure.

By virtue of data obtained experimentally by Dowson D and Mow C. [2] the approximation formulae for the dynamic viscosity values of synovial fluid for small and large shear rates are obtained in paper [6]. Poor synovial fluid or synovial fluid with ferromagnetic additions is a non Newtonian fluid. Therefore dynamic viscosity of synovial fluid depends on shear rate. Moreover dynamic viscosity of synovial has elastic properties and magnetic properties too if ferrofluid additions are inside the joint gap.

CONCLUSIONS

Present paper shows practical and theoretical comments about the application of magnetic field in the treatment of human joints.

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ELEMENTY BIOTRIBOLOGII W ZAKRESIE WPŁYWU PÓL MAGNETYCZNYCH NAS FUNKCJONOWANIE STAWÓW CZŁOWIEKA

Streszczenie: Niniejsza praca przedstawia pewne elementy informacji w zakresie pozytywnych oddziaływań pola magnetycznego na funkcjonowanie takich stawów człowieka jak staw biodrowy, łokciowy i inne. W ostatnich latach pole magnetyczne jest używane w ortopedii w leczeniu stawów w zakresie smarowania poprzez wyciskanie oraz typową hydrodynamikę. Ferrociecz wprowadzona do stawu przez iniekcję wytwarza pożądane pole magnetyczne.