Letter to the Editor

Electric and magnetic fields in cryopreservation: A response

A R T I C L E   I N F O
Article history:
Received 31 January 2012
Accepted 2 February 2012
Available online 10 February 2012

A B S T R A C T
Our recent studies showed that a programmed freezer with a magnetic field (CAS freezer) is helpful in the survival of periodontal ligament (PDL) cells after cryopreservation. The theory is that a magnetic field can prevent the cluster from growing by causing it to vibrate. In this letter, we commented in detail on the influence of a magnetic field during cryopreservation.

Before answering the questions from Dr. Wowk, we have to correct our data that appeared in the previous studies. First, a suitable intensity of a magnetic field for periodontal ligament cells is not 0.01 mT but 0.1 mT [1,3,4]. Second, we reported the periodontal ligament (PDL) cell cryopreservation using CAS freezer with magnetic field strengths ranging from 0 to 0.15 mT. We mentioned “normal programmed freezer” in the article [3], but actually, it was a CAS freezer with no magnetic field. However, 0.1 mT magnetic field intensity is still weak compared to previous studies. Aleksandrov [2] reported that 0.5 T of magnetic fields nucleated ice formation in distilled water causing equilibrium freezing at 0 °C. Another paper revealed that 18 T of magnetic field could supercool containerless 6 mm globules of water to −10 °C [8]. In our studies, 60 Hz alternating magnetic fields with an induced electric field generated from CAS freezer were used and it vibrated cells and water molecules by non-thermal mechanism. These vibrations were amplified in sympathy with mechanical and thermal vibration (CAS vibration). This CAS vibration can prevent intracellular ice crystal formation growing by causing it to vibrate. These phenomena were confirmed by SEM images which showed the miniaturization of intracellular ice crystals by use of CAS freezer [6]. CAS vibration can also enhance supercooling. We observed that the supercooled 5 ml preservation media with 10% Me2SO froze at around −17 °C in the CAS freezer with 0.1 mT magnetic field. Electric fields can nucleate ice formation in supercooled water, which prevent intracellular ice formation [7]. That’s why a CAS freezer can help increase the survival of PDL cells after long-term cryopreservation and following success in teeth transplantation.

The strength of Earth’s natural magnetic field present in the laboratory is between 0.025 mT near the magnetic equator to 0.06 mT near the poles and around 0.045 mT in Japan [5]. Our previous study showed that cryopreserved PDL cell survival increased from 40% to 70% when the magnetic field intensity was raised from 0 to 0.005 mT by CAS freezer. This strength was smaller than Earth’s natural magnetic field. However, a magnetic field derived by CAS programmed freezer has direct effect on the samples which were immersed in 60% w/w ethylene glycol solution cooled in a cryopreservation vial with preservation media. Furthermore, the natural magnetic field is unable to penetrate the freezer because of magnetic coils which are set on the outer wall. So, the effect of natural magnetic field is so small to be negligible.

In conclusion, 60 Hz alternating magnetic fields of 0.1 mT with an induced electric field generated from CAS freezer inhibit ice crystal formation by non-thermal mechanisms and it can be useful for long-term cell and tissue cryopreservation.

References
M. Kaku a,*
T. Kawata a
S. Abedini a
H. Koseki a
S. Kojima a
H. Sumi a
H. Shikata a
M. Motokawa a
T. Fujita a
J. Ohtani a
N. Ohwada b
M. Kurita b
K. Tanne a

a Department of Orthodontics and Craniofacial Developmental Biology, Hiroshima University, Graduate School of Biomedical Sciences, 1-2-3 Kasumi, Minami-ku, Hiroshima 734-8553, Japan

b ABI Corporation Ltd., 501 Toukatsu Techno Plaza, 5-4-6 Kashiwanoha, Kashiwa-city, Chiba 277-0882, Japan

* Corresponding author. Fax: +81 082 257 5687.
E-mail address: mkaku@hiroshima-u.ac.jp (M. Kaku).