Effects of the Universal Mobile Telecommunication System on Hearing in Rats

Universal Mobil Telekomunikasyon Sistemin Farelerde İşitme Üzerine Etkileri

UMTS'in İşitme Üzerinde Etkileri / Effects of UMTS on Hearing

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Özet

Amaç: Çalışmanın amacı üniversal mobil telekominükasyon sistem dalgalarının (UMTS) iç kulak üzerindeki olası etkilerinin değerlendirilmesi ve bilinen bir ototoksik ajan olan amikasin ile karşılaştırılmasıdır. Gereç ve Yöntem: Çalışmada 24 sağlıklı dişi wistar albino fare 8'li üç grup halinde incelendi. UMTS grubunda yer alan 8 fare 90 gün boyunca günde 30 dakika UMTS dalgalarına maruz bırakıldı. Amikasin grubuna 15 gün boyunca günlük 200mg/kg amikasin intramuskuler olarak uygulandı. Kontrol grubuna herhangi bir ilaç uygulanmadı ve elektromanyetik alana maruz bırakılmadan 90 gün boyunca takip edildi. Tüm grupların işitmeleri maruziyetten önce ve sonra distorsiyon ürünü otoakustik emisyon ile değerlendirildi. Bulgular: Çalışma başında ve sonunda yapılan ölçümler UMTS ve kontrol grubunda anlamlı bir değişim olmadığını gösterdi. Amikasin grubunda ise işitme ilaç veriliminden sonra çalışma başlangıcına göre anlamlı olarak kötüleşti. Tartışma: UMTS dalgalarına 90 gün boyunca günlük 30 dakika maruziyetin farelerde işitme üzerine istatistiksel olarak anlamlı bir etkisi yoktur.

Anahtar Kelimeler

Universal Mobil Telekomünikasyon Sistem; Otoakustik Emisyon; İşitme; Amikasin; Fare

Abstract

Aim: The aim of the study was to asses the potential effects of universal mobile telecommunication system (UMTS) waves on inner ear and compare with those of the well-known ototoxic agent amikacin. Material and Method: The study examined 24 healthy female Wistar albino rats in three groups of eight. The UMTS group was exposed to UMTS waves for 30 minutes per day for 90 days; the Amikacin group was given 200 mg/kg amikacin intramuscularly for 15 days; and the control group was not exposed to magnetic fields and was not given amikacin for 90 days. The hearing status of the rats were evaluated using distortion product otoacoustic emission before and after exposure. Results: Comparing the results before and after exposure to UMTS waves, there was no significant difference in the distortion product gram in the UMTS and control groups, whereas measurements showed significant deterioration in the Amikacin group after exposure. Discussion: Exposure to UMTS waves for 30 min per day for 90 days had no statistically significant effect on hearing in rats.

Keywords

Universal Mobile Telecommunication System; Otoacoustic Emission; Hearing; Amikacin; Rat

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Introduction

Mobile communication technologies are used extensively worldwide, but their effects on human health have not been clearly determined. Early studies concluded that non-ionizing radiation presented no risk to human health, except heating; however, recent studies have claimed some associated health risks [1]. With the expansion of mobile communication technologies to include internet connections and transfer of visual materials, new wavelengths have been added. Therefore, studies are required to assess the effects of these different wavelengths on human health. The exposure of users of mobile phones are quantified in terms of the amount of energy absorbed by the unit mass of object and expressed as the spesific absorption rate (SAR)[2].

Most evaluations of electromagnetic field effects have examined second-generation mobile communication technologies and do not reflect the effects of the universal mobile telecommunication system (UMTS), with the common name third-generation (3G) technology [3-5]. The few studies on the association between UMTS waves and human health have considered only short-term effects [6,7].

Aminoglycoide antibiotics have been used for more than 50 years. They cause loss of hair cells in the organ of corti beginning from apex [8]. Amikacin causes formation of free oxygen radicals which lead to apoptosis at the hair cells and hearing loss [9].

The present study aimed to asses potential long-term effects of UMTS waves and compare with the effects of a known ototoxic agent, amikacin.

Material and Method

The Istanbul University Animal Research Ethics Committee approved the study. The study was performed at Istanbul University Experimental Medicine Institute between February and May 2010.

The study used 24 healthy, female adult Wistar albino rats weighing 200–240 g. They were kept on a 12-hours dark/light cycle at 21°C and had free access to water and food. The ambient noise level was below 50 decibels (dB). All animals passed an otoscopic examination before they were included in the study; rats with ears containing cerumen, acute otitis media, an effusion, or adhesive otitis media were excluded. For distortion-product otoacoustic emission (DPOAE) testing, the animals were anesthetized with 45 mg/kg ketamine hydrochloride and 10mg/kg xylazine intraperitoneally. Rats were excluded from the study if the emissions could not be measured.

The rats were divided into three groups of eight rats each. Rats in the UMTS group were kept in two cages, and the UMTS source was placed between the two cages and 5 cm away from each. A Samsung L 700 mobile phone was used as the source. The total SAR measured at the cages was 0.718 W/kg. Rats were exposed to UMTS waves 30 min per day for 90 days. The DPOAE testing was repeated at the end of exposure period.

Rats in the Amikacin group were given an injection of 200 mg/kg of amikacin intramuscularly once daily for 15 days. DPOAE testing was repeated at the end of exposure period.

Rats in the Control group were kept away from magnetic fields and were given nothing other than food and water. DPOAE testing was repeated after 90 days.

DPOAE testing was performed using the smallest available probe (Otodynamics, London, UK). The distortion product gram (DP-gram) level were recorded. Two different frequencies were chosen such that f2/f1 = 1.22, to give the strongest response, and 80/80 dB was used for the stimulation. The probe display and stimulator wave form were deemed suitable before starting the recording.

Each DP-gram was measured at 1001, 1501, 2002, 3003, 4004, 6006, and 7996 Hz. The DP-gram was measured at 50 Hz above the frequencies of the DPOAE. Measurements 3 dB above the frequency of 2f1-f2 were accepted as positive. The recordings were continued until the top level was reached for every measurement. Emission values were under the noise threshold at 1001, 1501, 2002, and 3003 Hz, and above it at the other frequencies.

Baseline and final measurements were compared for each group and among the groups. The results at 4, 6, and 8 kHz were analyzed statistically using SPSS 15. Analyses included descriptive methods (mean and standard deviation) and ANOVA, for the intergroup analysis of normally distributed values. Kolmogorov-Smirnov test was used in order to assess whether data was normally distributed or not. Tukey's honestly significant difference test was used to identify group-caused differences. Baseline and final results were compared using the paired sample t-test.

Results

Amikacin administration and UMTS exposure were well tolerated by the rats, with no weight changes and no differences in food or water consumption. The intragroup and intergroup analyses of the emission values at 4, 6, and 8 kHz are illustrated in figures 1 to 3, respectively. UMTS exposure caused no statistically significant difference in DPOAE amplitudes. Control group did not show statistically significant difference at the end of

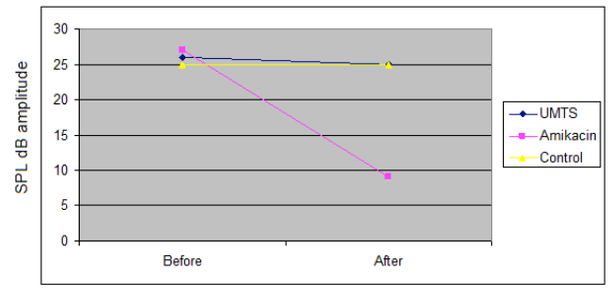

Figure 1. Distortion product otoacoustic emission amplitudes before and after exposure at 4000 Hz. Values are means of decibel. SPL: sound pressure level, dB: decibel, UMTS: Universal mobile telecommunication system

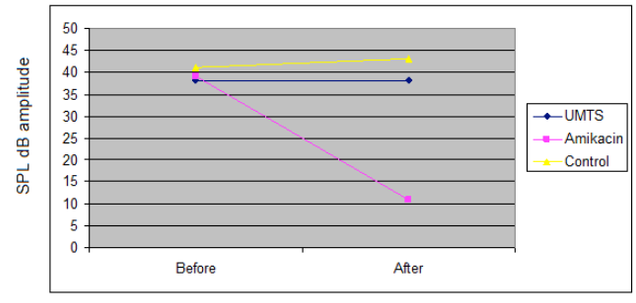

Figure 2. Distortion product otoacoustic emission amplitudes before and after exposure at 6000 Hz. Values are means of decibel. SPL: sound pressure level, dB: decibel, UMTS: Universal mobile telecommunication system

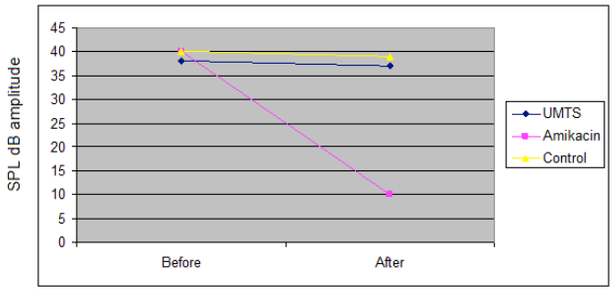

Figure 3. Distortion product otoacoustic emission amplitudes before and after exposure at 8000 Hz. Values are means of decibel. SPL: sound pressure level, dB: decibel, UMTS: Universal mobile telecommunication system

the study. On the other hand, amikacin caused statistically significant decrease in DPOAE amplitudes. There was statistically significant difference between amikacin and UMTS groups but there was not statistically significant difference between UMTS group and control group at the end of the study. (Table 1,2,3)

Table 1. Distortion product otoacoustic emission amplitudes before and after exposure at 4000 Hz.

Group	Before	After	P
UMTS	26.71 (5.53)	25.84 (6.44)	0.6391
Amikacin	27.03 (5.93)	9.52 (6.90)	<0.0001
Control	25.99 (4.40)	25.85 (4.00)	0.9016
P	0.7321	<0.0001	

Values are the means as decibel (standard deviation), UMTS: Universal mobile telecommunication system

Table 2. Distortion product otoacoustic emission amplitudes before and after exposure at 6000 Hz.

Group	Before	After	P
UMTS	38.51 (7.12)	38.70 (10.10))	0.9423
Amikacin	39.87 (6.94)	11.67 (11.30)	<0.0001
Control	41.91 (7.16)	43.75 (5.80)	0.2890
P	0.3571	<0.0001	

Values are the means as decibel (standard deviation), UMTS: Universal mobile telecommunication system

Table 3. Distortion product otoacoustic emission amplitudes before and after exposure at 8000 Hz.

Group	Before	After	P
UMTS	38.67 (4.78)	37.11 (4.16)	0.2199
Amikacin	40.05 (4.60)	10.73 (11.44)	<0.0001
Control	40.03 (4.51)	39.50 (3.52)	0.6402
P	0.2915	<0.0001	

Values are the means as decibel (standard deviation), UMTS: Universal mobile telecommunication system

Discussion

There are public concerns about the possible health effects of EMF from mobile phones and base stations [10]. Both low- and high-energy EMFs are thought to affect humans, possibly via heating, chemical disturbances, or genetic changes. Exposure to a high-Watt EMF has been shown to cause heating of tissues, and prolonged exposure to a low-Watt EMF has been reported to induce chemical or genetic changes [11]. The UMTS is used worldwide, and its wide bandwidth enables transmission of multimedia data and connection to the Internet at high speeds [12]. Therefore its effect on human should be investigated in detail.

Most studies using DPOAE measurements to examine the effects of EMFs on hearing have involved exposures of only 1 month, and all concluded that the EMFs produced by mobile phones had no effect on hearing [4,5,13]. Kayabaşoğlu et al. [13] found no effect of an EMF on hearing in adult and neonatal rats. Using the auditory brainstem response to assess hearing, Politanski et al. [14] concluded that an EMF caused increased reactive oxygen products after noise exposure, but no permanent functional damage was reported. Furthermore, Morales et al. [15] detected no functional or morphological alteration in the outer hair cells of guinea pigs with a low-frequency EMF. None of these animal studies performed with a range of EMFs found any hazardous effect in the short term.

Studies have also assessed the ototoxicity of second-generation mobile technology in humans [16-20]. Uloziene et al. [16] found no acute effects of the EMF produced by mobile phones, compared with a control group. Davidson and Lutman [18] assessed the long-term effects of EMFs on both the audiological and vestibular systems and found no harmfull effect on audiovestibular system . Sievert et al. [19] concluded that the increased heat caused by an EMF did not affect the inner ear, vestibular receptors, or inferior colliculus. Panda et al. [20] emphasized that long-term exposure to mobile phones may have a tendency to cause audiological disturbances, but no statistical differences were identified in their study.

A few studies have examined the effects of UMTS waves on hearing [6,7]. Parazzini et al. [6] evaluated the acute effects of UMTS waves on 134 volunteers after exposure to 69 mWatt/kg UMTS waves for 20 min; post-exposure audiological tests detected no significant differences. Galloni et al. [7] detected no significant hearing differences in rats exposed to 10 Watt/kg UMTS, at the end of 4 weeks. This study was the most similar to ours and had similar results.

We preferred DPOAE because monitoring outer hair cell which is the most vulnerable area of the cochlea provides a vey sensitive index of cochlear damage. In addition, DPOAE changes were detected before morphological damage occurred in the outer hair cells in experimental animals [21]. Our study period was 90 days, and we compared the results of UMTS exposure with the effects of the known ototoxic agent amikacin. Our study, which had the longest follow-up period, found that UMTS exposure for 30 min per day for 90 days did not have statistically significant effect on hearing in rats.

Conclusion

Exposure to UMTS waves for 90 days had no effect on the inner ear of rats, as assessed using a commercial DPOAE test. Further studies that asses higher frequencies and have longer exposure periods are required to understand the effects of UMTS waves on the inner ear.

References

1. Lerchl A. Comments on "Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes" by Schwarz et al. (Int Arch Occup Environ Health 2008: doi: 10.1007/s00420-008-0305-5). Int Arch Occup Environ Health 2009;82(2):275–8.
2. International Non-Ionizing Radiation Committee of international Radiation Protection Association. Guidelines for limiting exposure to time varying electric magnetic and electromagnetic field (up to 300 GHz). Health Phys 1998;74:404-522
3. Szentpali B. Human exposure to electromagnetic fields from mobile telephones. IEEE 1999;47:222–31.
4. Galloni P, Parazzini M, Piscitelli M,Pinto R, Lovisolo GA, Tognola G, et al. Elec-

tromagnetic fields from mobile phones do not affect the inner auditory system of Sprague-Dawley rats. Radiation Research 2005;164(6):798–804.
5. Kızılay A, Özturan O, Erdem T, Kalcioglu MT, Miman MC. Effects of chronic exposure of electromagnetic fields from mobile phones on hearing in rats. Auris Nasus Larynx 2003;30(3):239–45.
6. Parazzini M, Sibella F, Lutman ME, Mishra S, Moulin A , Sliwinska-Kowalska M, et al. Effects of UMTS cellular phones on human hearing: Results of the European Project "EMFnEAR". Radiat Res 2009;172(2):244–51.
7. Galloni P, Lopresto V; Parazzini M, Pinto R, Piscitelli M, Ravazzani P, et al. No effects of UMTS exposure on the function of rat outer hair cells. Bioelectromagnetics 2009;30(5):385–92.
8. Forge A, Schacht J. Aminoglycoside antibiotics. Audiol Neurootol 2000;5(1):3-22
9. Rizzi MD, Hirose K. Aminoglycoside ototoxicity. Curr Pharm Des 2007;15(5):352-7
10. Sommer AM, Bitz AK, Streckert J, Hansen VW, Lerchl A. Lymphoma development in mice chronically exposed to UMTS-modulated radiofrequencyelectromagnetic fields. Radiat Res 2007;168(1):72-80
11. Yağmur F, Bozbıyık A, Hancı İH. Elektromanyetik dalgaların insan biyokimyası üzerine etkileri. Sted 2003;12(8): 296–7.
12. Canales M, Hernandez-Solana A, Gallego JR, Valdovinos A. Adaptive resource sharing strategies for UMTS multiservice mobiles. Telecommunication systems 2005;28(2):151-67
13. Kayabaşoğlu G, Sezen OS, Eraslan G, Aydin E, Coskuner T, Unver S. Effect of chronic exposure to cellular telephone electromagnetic fields on hearing in rats. J Laryngol Otol 2011;125(4):348–53. Epub 2010 Nov 9.
14. Politanski P, Rajkowska E, Pawlaczyk-Łuszczyńska M, Dudarewicz A, Wiktorek-Smagur A, Sliwińska-Kowalska M, et al. Static magnetic field affects oxidative stress in mouse cochlea. Int J Occup Med Environ Health 2010;23(4):377-84.
15. Morales J, Garcia M, Perez C, Valverde JV, Lopez-Sanchez C, Garcia-Martinez V, et al. Low frequency electromagnetic radiation and hearing. J Laryngol Otol 2009;123(11):1204–11
16. Uloziene I, Uloza V, Gradauskiene E, Saferis V. Assessment of potential effects of the electromagnetic fields of mobile phones on hearing. BMC Public Health BMC Public Health 2005;19(5):39–45.
17. Stefanics G, Kellényi L, Molnár F, Kubinyi G, Thuróczy G, Hernádi I. Short GSM mobile phone exposure does not alter human auditory brainstem response. BMC Public Health 2007;12(7):325-30.
18. Davidson HC, Lutman ME. Survey of mobile phone use and their chronic effects on the hearing of a student population. Int J Audiol 2007;46(3):113–8.
19. Sievert U, Eggert S, Goltz S, Pau HW. Effects of electromagnetic fields emitted by cellular phone on auditory and vestibular labyrinth. Laryngorhinootologie 2007;86(4):264–70.
20. Panda NK, Jain R, Bakshi J, Munjal S. Audiologic disturbances in long-term mobile phone users. J Otolaryngol Head Neck Surg 2010;39(1):5–11.
21. Brown AM, McDowell B, Forge A. Acoustic distortion products can be used to monitor the effects of gentamicin treatment . Hear Res 1998;42(2-3):143-56