

A PRELIMINARY STUDY TO ASSESS POSSIBLE CHROMOSOMAL DAMAGE AMONG USERS OF DIGITAL MOBILE PHONES

Abstract

In a preliminary study to examine possible lymphocyte chromosomal damage, we have tested two cytogenetic endpoints, namely, chromosomal aberrations (CA) and sister chromatid exchange frequencies (SCE), in 24 mobile users (12 nonsmoker-non alcoholic subjects + 12 smoker-alcoholics), using digital mobile phones for at least two years, employing GMSK modulations with uplink frequencies at 935-960 MHz. and downlinks at 890-915 MHz. For comparison, the control study group included another 24 individuals, matched according to their age, sex, drinking and smoking habits, as well as had similar health status, working habits and professional careers; except were not using mobile phones. Blood samples of 12 mobile users (6 smoker-alcoholic + 6 nonsmoker-non-alcoholic) and 12 controls (identical to mobile users in every respect) were further treated with a known mutagen Mitomycin-C (MMC); to find out co-mutagenic/ synergistic effect. A complete blood picture for each individual was assessed with an Automatic Particle Cell Counter.

There was a significant increase ($P < 0.05$) in dicentric chromosomes among mobile users who were smoker-alcoholic as compared to nonsmoker-non-alcoholic mobile users; as well as controls of both types. After MMC treatment, there was a significant increase in dicentrics ($P < 0.05$) and ring chromosomes ($P < 0.001$); in both smoker-alcoholic as well as nonsmoker-non-alcoholic mobile users when compared with the controls. Although SCEs showed a significant increase among mobile users, no change in cell cycle progression was noted. The hematological picture showed only minor variation between mobile users and controls.

Introduction

Although recent reviews have concluded that exposure to the radio frequency fields (RF) from mobile phones or their base stations did not cause any adverse health consequence, yet there are gaps in knowledge that have been identified for further research to better assess health risks. Most studies (1 -6) have examined the results of short term *in vitro* exposure of human lymphocytes to RF fields at levels near or higher than those normally associated with wireless communications.

The effects of non-ionizing radiations on human chromosomes have not been studied thoroughly from among the individuals who use mobile phones. There is lot of controversy about mobile phones safety. On one hand, phone manufactures, regulating agencies and service providers assure that cellular phones are safe; on the other, there is continuous global debate about health effects of these products. Cellular or mobile phones are low powered radio devices that transmit and receive microwave radiations at frequency between 900 – 1800 MHz through an antenna used close to user's head (7).

There are conflicting reports in the literature by the same authors in different studies, with respect to effects of mobile phone radiations on human chromosomes. For instance, human peripheral blood lymphocytes exposed to microwave (MW) radiation at 2450 MHz resulted in increased frequency of chromosome aberrations (CA) and micronuclei, where CAs showed dose-dependent increase (3).

Maes et al., (8) also reported increase in chromosome aberrations, especially dicentric chromosomes, in their *in vitro* experiment when blood samples were very close to the antenna from a GSM base station emitting at 954 MHz. By contrast, the same authors conducting *in vivo* experiment on professionally exposed subjects did not find significant changes in chromosome aberrations. It is interesting to note that

recent report (5) of possible cytogenetic effects of the 900 MHz (GSM) microwave radiation alone as well as with chemical and physical mutagens Mitomycin-C and X-rays indicated no mutagenic and/or comutagenic/synergistic effect. But reports of Garaj-Vrhovac et al., (9,10) showed increase in chromosomal aberrations after cells exposed to microwave radiation. Vijayalaxmi and Meltz (11) found no significant difference between RF irradiated and sham-exposed lymphocytes with respect to mitotic indices, incidences of exchange aberrations, excess fragments and micronuclei.

In a twenty year study on mice, in Poland (12), a strong link has been established between radio frequency radiation (2450 MHz.) and skin cancer. With such emerging evidences, the major concern of mobile phones technology should be with its rapid growth around the world putting millions of users at potential risk.

It is clearly evident from the foregoing discussion that there is controversy about mobile phone and health risk. Therefore, the present study was undertaken to assess chromosomal aberrations and SCE frequencies among mobile users who used digital mobile phones frequently, for a maximum period of 4 – 5 hours a day, continuously for two years.

Materials and methods

Totally 48 individuals were selected for taking the blood samples. One half of these (i.e. 24) were mobile users, using digital mobile phones since last two years, which employed GMSK modulations at uplink frequencies of 935-960 MHz and downlinks at 890-915 MHz. The other half served as controls where individuals matched according to that age, sex, drinking and smoking habits, as well as had similar health status, working habits and professional careers; except were not using

mobile phones. Prior to the collection of blood samples, a detailed information proforma with a consent was filled up for each subjects.

Based on smoking and drinking habits, subjects from both groups (i.e. control as well as mobile users) were further divided into subgroups of 12 individuals in each. The particulars regarding the number of samples in each subgroup, with respect to their occupational status, average consumption of cigarettes per day, average time period in hours for use of mobile phone per day has been presented in Table-I.

Lee (1995) (13), reported that GMSK (Gaussian Minimum Shift Keying) is the modulation scheme of GSM (Global System for Mobile communication), with the pulse modulated modulation rate of 274 Kbps. The instruments of the mobile users in the present study employed, either TDMA or FDMA transmission techniques. With FDMA, there were 124 channels and each had 200 KHz. With TDMA within 200 KHz., 8 time slots formed a frame, the frame duration was 4.615 mS and time slot duration burst period was 0.577 mS.

Routine lymphocyte cultures were done with slight modifications as described elsewhere (14). For SCE analysis (15), about 10 ug/ml of 5-bromodeoxyuridine (BUdR) was added to the cultures 24 hours after initiation of culture and were terminated at 72 hours. Slides were stained with Hoechst-33258 and placed under white light for 24 hours, then incubated in 2 X SSC (Standard Sodium Citrate) for 1 hour at 60°C. Finally the slides were stained with 4% Giemsa prepared in PBS (pH-6.8).

To check the sensitivity of mobile users to a known chemical mutagen, six blood samples from both groups were exposed to Mitomycin-C at final concentration of 10 ng/ml after 24 hours of initiation of culture, till termination. Controls were treated identically. To assess the hematological picture, a complete blood count

analysis for each individual was performed in an Automatic Particle Cell Counter (Erma, Japan).

All culture slides were coded blind and randomized to avoid personnel bias in scoring. 100 well spread metaphases were scored for CAs and 30 well spread second division metaphases were scored for SCE analysis. For replicative index (RI), first division metaphases (M_1), second division (M_2) and third division (M_3) metaphases were scored.

For statistical analysis Student's 't' test was applied. Further, to know the real variations in mean CAs (including chromatid gaps) as well as mean SCEs among various related subgroups; analysis of variance (ANOVA) was applied.

Results

Chromosomal aberrations (CA) of mobile users and controls are summarized in Table-II. There was a significant ($P < 0.05$) increase in dicentric chromosomes and chromatid gaps between smoker and alcoholic phone users as compared to their controls. Similarly, a significant increase in dicentric chromosomes ($P < 0.05$) occurred in smoker-alcoholic mobile users in comparison to non-smoker and non-alcoholic mobile users. As expected, MMC-treated cells produced a significant increase in dicentric ($P < 0.05$) and ring ($P < 0.001$) chromosomes among mobile users of both types as compared to controls treated with MMC. Chromatid gaps were significantly higher ($P < 0.001$) among smoker-alcoholic mobile users after MMC treatment.

Mobile users, especially smoker-alcoholics also showed hyperdiploid metaphases, endoreduplication, chromatid interchange and G1 type PCC after MMC

treatment but were not statistically significant in comparison to MMC treated controls.

SCE frequencies and cell cycle replicative index are presented in Table-III. There was a significant increase ($P < 0.05$) in SCE frequencies among all mobile phone users including smoker-alcoholic and nonsmoker nonalcoholic groups as compared to respective controls. After MMC treatment SCE frequencies increased significantly ($P < 0.01$) among mobile users when compared with MMC treated controls. There was no change in the RI. Hematological study (Table - IV) of total RBC, total WBC, hemoglobin percentage and platelet's count did not reveal significant variation among mobile users compared to controls.

Table-V summerises the results of ANOVA analysis for total chromosomal aberrations as well as total SCEs among various related subgroups. Statistically significant ($P < 0.05$) F- value was observed only among smoker-alcoholic mobile users with smoker alcoholic controls.

Discussion

The current study was focused on the effects of MW radiation emitted from mobile phone on human chromosomes, with a significant increase in dicentric chromosomes and chromatid gaps recorded among smoker-alcoholic mobile users as compared to their controls. This finding is in accordance with the study of Maes et al., (3), who considered creation of dicentric chromosomes to be the "hallmark" of radiation exposure.

In our study sensitivity to the chemical mutagen Mitomycin-C (MMC) was checked among mobile users to see comutagenic/synergisitic effects. Results revealed a significant increase in dicentric as well as ring chromosomes. Maes et al.,

(4) also reported that microwave coupled with chemical mutagen MMC enhanced chromosomal aberrations as well as sister chromatid exchanges. Similarly, very recently, Tice et al (2) demonstrated that RF signals at an average SAR of at least 5 W/kg are capable of inducing chromosomal damage as well as micronuclei in human lymphocytes.

However, *in vitro* experiment (6) on rat bone marrow and lymphocytes exposed to RFR at cellular telephone frequency reported no evidence for induction of chromosomal aberrations and micronuclei.

In the present study besides chromosomal aberrations there was significant increase in SCE frequencies among mobile users as compared to control. In addition, MMC treatment also increased SCE frequencies indicating comutagenic/synergistic effect. On the other hand, no differences were found between mobile users and controls with respect to their clinical hematological patterns.

Our results further indicate significant 'F' value for smoker-alcoholic mobile users with smoker-alcoholic controls only. This clearly indicates an additive effect of smoking and drinking habits with mobile use. Hence exposed smokers and alcoholics show more damage than their respective controls. Obe and Hera (16) have found that smoking coupled with alcohol consumption causes higher frequency of CAs. Many other studies (17-19) have reported higher values of CAs for smokers than control groups. Therefore mobile users who are both smoker and alcoholics are at greater risk of having genetic damage from microwaves of cell phones.

A statistically significant increase in malignant tumors and lymphoma in rats exposed to long term low level microwave radiation (20) and mice exposed to 900 MHz electromagnetic fields (21) has been reported. DNA single strand breaks in rat brain cells after exposure to RFR at low intensity has also been reported (22-23). By

contrast Vijayalaxmi and Meltz (11) reported no evidence for induction of DNA single strand breaks and alkali-labile lesions in human blood lymphocytes exposed *in vitro* to pulsed wave 2450 MHz RFR.

There is paucity of information existing on effects of mobile phones on human genome. A laboratory finding (24) reported that high levels of cell phone radiation (3-5 times greater than legal cell phone limits) could cause chromosomal abnormalities in human blood cells.

In the present study our attempt was to check possible effects of microwave radiations emitted from mobile phones on human lymphocytes using biological indicators such as chromosomal aberrations and sister chromatid exchange frequencies. Our preliminary results clearly indicate that, microwave radiation emitted from the mobile phones does increase chromosome aberrations (dicentric configuration) and SCEs in mobile users (mainly smoker alcoholics) in comparison to controls. Further studies with different biological indicators will be required to arrive at definite conclusions.

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