CASE REPORT

Neurological changes induced by a mobile phone

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Dysaesthesiae of the scalp after mobile phone use have been previously reported, but the basis for this has not been clear. We report a case of a 34-year-old journalist who complained of symptoms associated with use of a mobile phone. She agreed to a provocation study with her phone. Current perception threshold testing before and after exposure showed marked changes in the C-fibre nerves of the affected area compared with the opposite side. The case is supportive of a neurological basis for some cases of dysaesthesiae associated with mobile phone use.

Key words: Cell phone; dysaesthesiae; mobile phone; neurological; provocation test.

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Introduction

Hocking [1] reported a case series of 40 people who complained of symptoms associated with use of a mobile phone. A burning sensation or dull ache (quite distinct from an ordinary headache) was felt ipsilateral to the side of use of the phone. It occurred minutes after use and lasted minutes or hours. Some cases also reported visual symptoms or not thinking clearly (similar to being 'hung over'). The mechanism was speculated to be neurological. The following case report provides evidence in support of neurological changes occurring in some cases.

Case report

We studied a 34-year-old female journalist who complained of symptoms associated with use of a mobile phone (always used on her left side) for ~5 years. She first used an analogue phone in 1995. She noticed a moderate dull pain that came in sharper waves over her (left) occipital area ~3–4 cm behind and level with her ear. Her ear became hot. She also noticed a change in left side hearing, similar to having water in the ear. The pain usually began shortly (5–10 min) after using the phone and it lasted for a time proportionate to her use of the phone. She has now limited her calls to two or three per day, and tries to use a landline; she now uses a GSM (digital) phone.

She suffers brief headaches every ~2–3 weeks and distinguishes them clearly from the mobile phone symptoms, which have a particular character and site. She suffered a head injury in 1983 when she fell from a train, experiencing a brief loss of consciousness and a hairline fracture of the occiput. She was well otherwise.

On examination she had full movement of the neck; there were no abnormalities on the scalp and no changes in sensation over the face or behind the ears.

She agreed to a provocation study in which her phone was wrapped in thin polystyrene (to avoid heating effects) and she spoke into the phone (to generate a signal) until symptoms occurred after ~7 min. Neurophysiological testing was performed using a Neurometer CPT/C® (by R.W.). This device is a variable constant current sine wave stimulator that uses three test frequencies: 2000, 250 and 5 Hz, corresponding to Aβ, Aδ and C-fibres, respectively [2]. The test sites were selected within the affected C3 dermatomes and corresponding locations on both normal and symptomatic sides were tested. The stimulus was initially increased until a sensation was reported and then short stimuli (2–5 s) were applied at progressively lower current amplitudes until a minimal threshold for constant detection was determined. The device has a dummy switch to allow the on/off status of the machine to be concealed from the patient during determination of an approximate threshold level. After

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Table 1. Pre-provocation control AC CPTs (mA) by Neurometer CPT/C®

AC frequency/N-fibre type	*R. mastoid site (C2, C3)*	*L. mastoid site (C2, C3)*	*Coefficient of variation*	
2000 Hz/Aβ	0.87 mA	1.18 mA	±0.19	Not significant
250 Hz/Aδ	0.12 mA	0.18 mA	±0.10	Not significant
5 Hz/C-fibres	0.02 mA	0.07 mA	±0.05	Not significant

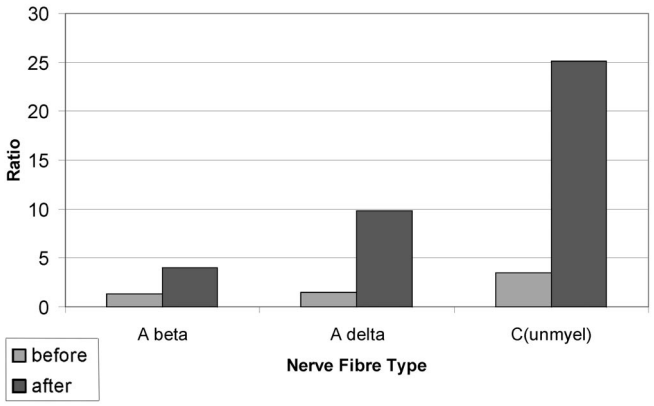
this level was determined, a double-blind, forced-choice paradigm was used to confirm the minimal threshold for perception [2,3]. The Neurometer presents the stimuli randomly in one of two 'active' time windows, A or B, separated by a brief 'no stimulus' rest window. The stimuli use decreasing or increasing constant current levels according to an internal machine paradigm based upon the subject's previous correct/incorrect responses. It also randomly suppresses the current stimulus usually delivered in one or other of the time windows A or B. In this way the testing procedure and stimulus delivery are 'double blind' for both subject and test operator. However, in order for the full testing protocol to be fully double blind, it would be necessary to repeat the test procedure on two separate occasions, with the mobile phone being inactivated on one of the occasions, this being 'blind' to both subject and test operator. This is not necessary for the clinical purpose of a provocation test.

The results of these current perception threshold (CPT) measures for all three frequencies (2000, 250 and 5 Hz) on the right and left neck (mastoid C2, 3) skin zones are shown in Table 1 and summarized in Figure 1, for before and after the mobile phone provocation. CPT testing before and after the exposure showed marked changes in the nerves of the affected area compared with the opposite side.

These pre-provocation (control) neck/mastoid CPTs are all in the normal range. Although there appears to be slight asymmetry of CPTs between right and left sides, this is not statistically significant. In normal subjects, the CPT thresholds at all frequencies for the left and right mastoid sites are very close. The noxious CPT for 250 Hz was not determined in order to avoid persistent sensory changes, although this would be most unlikely. There is a left–right difference in the CPT results because of the variability of the test: the coefficient of variation is ±0.19 mA for 2000 Hz, 0.10 for 250 Hz and 0.05 for 5 Hz (see Table 1).

At the mastoid test site, CPTs for all three frequencies post-provocation were markedly (significantly) higher at the left mastoid site than at the right; this is clearly shown when the current amplitudes for left and right sides are expressed as a ratio (see Table 2). These data are consistent with a marked reduction in sensory acuity for all three current frequencies which elicit activity in larger sensory fibres (2000 Hz = Aβ) and smaller (250 Hz = Aδ and 5 Hz = C) sensory nerve fibres. Figure 1 shows the ratios of the CPT for left and right sides, before and after phone use, for the three fibres. The change in the ratio for C-fibres is most marked, increasing from 3.5 to 25.2.

Figure 1. Left:right ratio of the current perception threshold of C2 and C3 fibres before and after mobile phone use.



Discussion

The induction of reversible symptoms and neurophysiological changes is evidence that mobile phone use can cause symptoms in some people. The study was not double blind. However, it was 'single blind', as the test procedure is independent of the observer after initial settings are made. Also, the selective changes in the C-fibres are not consistent with a placebo response, when tests on all fibres would probably have been affected. The study provides a possible explanation for the symptoms reported in the previous case series [1]. The changes may not always be reversible. Hocking and Westerman [4] reported a case of a 72-year-old businessman who had onset of a persistent 'bruised' feeling on the scalp after extensive use of a mobile phone. Neurological investigation found no medical cause. On examination by us 1 year later he had altered sensation to cotton wool on the scalp on the affected side. On CPT testing, changes were found for the C3 and trigeminal nerve distributions in the area of his symptoms.

The question has been raised regarding whether the radiation *per se* or a property of the phone itself, such as heating or posture of the head, causes these symptoms. Relevant information has been gained from another study [5]. A 31-year-old rigger suffered accidental exposure of

Table 2. Post-provocation AC CPTs (mA) by Neurometer CPT/C® (ratio L:R)

AC frequency/N-fibre type	*R. mastoid site (C2, C3)*	*L. mastoid site (C2, C3)*	*Coefficient of variation*	*L:R ratio comparison*	
2000 Hz/Aβ	1.18 mA	4.75 mA	±0.19	4.03	Significant
250 Hz/Aδ	0.36 mA	3.54 mA	±0.10	9.83	Significant
5 Hz/C-fibres	0.17 mA	4.28 mA	±0.08	25.2	Significant

The coefficient of variation is the quotient (SD/mean). It is therefore the standard deviation in units of the mean and an indicator of the variability of the readings for each test frequency. Significance of between-side differences for the pre-provocation and post-provocation results was assessed by calculating at each frequency the L–R difference in CPT (mA). If this exceeded 2.5× the coefficient of variation, it was deemed significant. This is a paired *t*-test.

the left side of his face to an 870 MHz code domain multiple access (CDMA) panel antenna which was supposed to be off. He worked for ~2 h before feeling unwell when the antenna was recognized to be operating at low power. He developed headache and blurred vision. When seen the next day, he had a smaller left pupil and altered sensation to cotton wool on his left forehead. CPT testing found abnormalities of the C-fibres in the left ophthalmic division of the trigeminal nerve, which was again abnormal on testing after 1 month, but had returned to normal when tested 6 months later. The exposure to the head was reconstructed and measured to be 0.01 mW/cm^2, which is below the whole-body occupational exposure standard of 1 mW/cm^2 and similar to that from a mobile phone [5]. The case showed that neurological effects in mobile phone users may arise from the radio frequency radiation (RFR) *per se*, independently of the phone and such alleged affects as heating of tissues or position of the head causing compression neuropathy.

This present case describes the results of a positive provocation test in a sensitive subject who had repeatedly developed symptoms from moderate mobile phone use. Considered together, these case reports indicate that in some people symptoms may arise during mobile phone use which have a neurological basis, and suggest the radiation as being causal.

References

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