

Cellular Telephone Use and Risk of Intratemporal Facial Nerve Tumor

Hillary G. Warren, BS; Angela A. Prevatt, BS; Kathleen A. Daly, PhD; Patrick J. Antonelli, MD

Objectives/Hypothesis: Microwave radiation exposure from cellular telephone use has been implicated in the development of intracranial tumors. The intratemporal facial nerve (IFN) is exposed to higher levels of cellular telephone radiation than intracranial tissues. The purpose of the study was to determine whether cellular telephone use is associated with an increased risk of IFN tumors. **Study Design:** Case-control using a structured telephone survey at an academic, tertiary-care referral center. **Methods:** Patients with IFN tumors (n = 18) were case-matched with patients treated for acoustic neuroma (n = 51), rhinosinusitis (n = 72), and dysphonia or gastroesophageal reflux disease (n = 69). Risk of facial nerve tumorigenesis was compared by extent of cellular telephone use and other risk factors. **Results:** The odds ratio of developing an IFN tumor was 0.6 (95% CI, 0.2–1.9) with any handheld cellular telephone use and 0.4 (95% CI, 0.1–2.1) with regular cellular telephone use. No factors were associated with an increased risk for IFN tumor development. **Conclusions:** Regular cellular telephone use does not appear to be associated with a higher risk of IFN tumor development. The short duration of widespread cellular telephone use precludes definite exclusion as a risk for IFN tumor development. **Key Words:** Cellular telephone, facial nerve, tumor.

Laryngoscope, 113:663–667, 2003

INTRODUCTION

Cellular telephone use has exploded since the early 1990s. As of July 2002, the Cellular Telecommunications Industry Association identified 137,458, 902 U.S. wireless subscribers. This represents an increase of 30 million subscribers over an 18-month period, and the number of subscribers is projected to continue to escalate exponentially.¹ Similar increases have been observed in several European countries as well.² Concurrent with this dramatic growth in cellular telephone use, there has been an increase in the prevalence of intracranial tumors.³ During the 1990s, we

have observed an apparent rise in the frequency of intratemporal facial nerve (IFN) tumors. Because the facial nerve may be exposed to high levels of microwave radiation from cellular telephone use, consideration must be given to the possibility of cellular telephone electromagnetic radiation exposure as a causative agent of facial nerve tumors.

PATIENTS AND METHODS

Patients

After obtaining Institutional Review Board approval, 18 patients diagnosed with IFN tumor between July 1, 1995, and July 1, 2000, were identified from the fiscal database at our academic, tertiary-care medical center. These patients were case-matched with 12 control subjects per patient, who were divided among the following groups: (1) rhinosinusitis (nontumor control), (2) dysphonia or gastroesophageal reflux disease (nontumor control), and (3) acoustic neuroma (intracranial tumor alternative case group). Two nontumor control groups were selected to minimize any possible selection bias. The acoustic neuroma (alternative tumor case) group was included because the vestibular nerve would be exposed to intermediate levels of cellular telephone microwave radiation. If an effect of cellular telephone radiation was observed in IFN tumors, a similar, albeit smaller, effect should be seen with acoustic neuromas.

Case-matching was based on age (control subject born within 6 years of the patient), sex, and race (Table I). Control subjects were identified from the same fiscal database. Interviews of patients (cases) and control subjects were conducted over telephone by health care professionals or health care professionals in training using a structured questionnaire.

Assessment of Exposure

Previous studies have demonstrated the reliability of self-recall on cellular telephone use⁴; therefore, we prepared a questionnaire that assessed pertinent medical history, occupation, social habits, and use of various telephones and other types of communication devices. Investigation of the pertinent medical history^{5,6} included queries concerning head injuries that resulted in loss of consciousness or a fracture, medical conditions (seizures, multiple sclerosis, tuberous sclerosis, neurofibromatosis, meningitis, brain abscess or infection, and tumors of the brain, spine, or nerves), and family history of brain, spinal, or nerve tumors. Relevant occupations³ assessed were service as a police officer, firefighter, or paramedic, service in the military, and employment at a radio station. Social habits such as wearing of

From the Department of Otolaryngology (h.g.w., a.a.p., p.j.a.), University of Florida, Gainesville, Florida, and the Department of Otolaryngology (K.A.D.), University of Minnesota, Minneapolis, Minnesota, U.S.A.

Editor's Note: This Manuscript was accepted for publication December 6, 2002.

Send Correspondence to Patrick J. Antonelli, MD, Department of Otolaryngology, University of Florida, Box 100264, 1600 Southwest Archer Road, Gainesville, FL 32610-0264, U.S.A. E-mail: antonpj@ent.ufl.edu

TABLE I.
Characteristics of Subjects With IFN Tumors, Acoustic Neuromas (tumor controls), and Non-tumor Controls.

	IFN Tumor	Acoustic Neuroma	Rhinosinusitis	Dysphonia or Gastroesophageal Reflux
No.	18	51	72	69
Mean age (y)	47.0	57.8	52.6	50.8
Male	38.9%	51.0%	38.9%	40.6%
Race				
White	88.9%	98.0%	88.9%	91.3%
Black	5.6%	2.0%	5.6%	5.8%
Hispanic	5.6%	0.0%	5.6%	2.9%

IFN = intratemporal facial nerve.

metal-rimmed eyeglasses and metal earrings, as well as smoking and alcohol use, were also addressed.

Assessment of exposure included all types of cellular telephones, including cordless telephones, handheld cellular telephones, "tote" cellular telephones, and automobile cellular telephones, as well as ham radios, citizen's bands, and two-way portable radios or walkie-talkies. As Rothman et al.⁷ suggested, evaluation addressed the type of signal transmitted by the phone, whether analogue, digital, or both; the duration of exposure from year of first use to year of last use or current year if still in use; and whether during this time the device was used on a regular basis, specified as more than one call a week. If the patient (case) or control subject reported regular use, a more detailed quantification of use was obtained, including average minutes per day, average duration of call, average number of calls made per week, minutes used per month, regional area of general use (urban, suburban, or rural), and preferred ear of use.

Statistical Analysis

Because subjects with rhinosinusitis and gastroesophageal reflux disease or dysphonia represented nontumor control subjects, they were collapsed into a single group for analysis. These subjects were compared against patients with IFN tumors and the subjects (in the alternative case group) with acoustic neuromas. A multivariate unconditional logistic regression determined the best model for the data. Odds ratios with 95% confidence intervals were calculated for all exposure measures (Tables II and III). The odds ratio (OR) was calculated as:

$$OR = \frac{n_{11} n_{22}}{n_{12} n_{21}}$$

The confidence intervals for the OR were constructed by calculating the confidence intervals for the logarithm of the OR and then back-transforming.

RESULTS

Surveys were completed by 18 patients with IFN tumors, 51 subjects with acoustic neuromas, 72 subjects with rhinosinusitis, and 69 subjects with rhinosinusitis (Table I). Regular use of handheld cellular telephones occurred in two patients (11.1%) with IFN tumors, 11 subjects (21.6%) with acoustic neuroma, and 31 subjects (22.0%) who served as nontumor control subjects. Regular use of mobile automobile cellular telephones occurred in two patients (11.1%), five control subjects with acoustic neuroma (9.8%), and seven control subjects with rhinosinusitis or gastroesophageal reflux disease (5.0%). No sub-

jects reported regular use of "tote" cellular telephones. Average hours per month and average number of years, respectively, were 208.93 and 1.00 for patients with IFN tumors compared with 130.84 and 5.67 for subjects with acoustic neuroma and 59.60 and 1.00 for control subjects.

There was no association with regular use of handheld cellular telephones in patients (cases) with IFN tumor (OR = 0.4; 95% CI, 0.1–2.1) or in subjects with acoustic neuroma (OR = 1.0; 95% CI, 0.4–2.2). Likewise, there was no significant increased risk between regular use of mobile automobile cellular telephones and development of IFN tumor (OR = 2.4; 95% CI, 0.4–13.0) or development of acoustic neuroma (OR = 2.1; 95% CI, 0.6–7.0). Four factors addressed in the questionnaire (personal history of seizures; family history of brain, spinal, or nerve tumors; past or current employment as a police officer, firefighter, or paramedic; and past or current employment at a radio station) had odds ratios greater than 2.0 in patients with IFN tumor; however, none of them was statistically significant (Table II). History of ear surgery was associated with a significantly increased risk of acoustic neuroma (Table III). Because of the paucity of patients who described regular use of handheld and automobile cellular telephones, we did not assess the relative risk of handedness of phone use with "sidedness" of tumor.

DISCUSSION

Microwave radiation has long been known to contribute to tumorigenesis.⁸ Cellular telephone antennas, the primary source of microwave radiation in these devices, are held in close proximity to the temporal bone.⁹ Hence, the IFN, particularly the tympanic segment, is exposed to *relatively* high doses of microwave radiation. If microwave radiation from cellular telephones were responsible for neural tumorigenesis, a higher rate of IFN tumor development should be associated with cellular telephone use. However, we observed no relationship between the regular use of cellular telephones and the risk of IFN tumor. Other recent studies have also failed to demonstrate an association between cellular telephone use and risk of brain cancer^{10–12} or risk of acoustic neuroma.¹³

Other risk factors that have been implicated as tumorigenic were also studied. For example, we observed no significantly increased risk for IFN with work as a para-

TABLE II.
Listing of Survey Results and Odds Ratios for IFN Tumors.

		IFN Tumor	Non-tumor Controls	Odds Ratio	Confidence Interval (95%)
Have you had head injuries that resulted in a loss of consciousness or a fracture?	Yes	1	19	0.4	0.1–3.1
	No	17	122		
Have you had any seizures?	Yes	2	8	2.1	0.4–11.0
	No	16	133		
Have you had any prior ear surgery?	Yes	2	9	1.8	0.4–9.6
	No	16	132		
Do you have a family history of brain, spinal, or nerve tumors?	Yes	2	6	2.8	0.5–15.7
	No	16	135		
Are you a policeman, fireman, or paramedic?	Yes	2	4	4.3	0.7–26.2
	No	16	137		
Were you in the military?	Yes	4	29	1.1	0.3–3.7
	No	14	112		
Did you work at a radio station?	Yes	2	7	2.4	0.4–13.0
	No	16	134		
Did you wear metal-rimmed eyeglasses?	Yes	8	77	0.7	0.2–1.8
	No	10	64		
Did you wear metal earrings?	Yes	7	72	0.6	0.2–1.7
	No	11	69		
Did you have any children?	Yes	5	37	0.9	0.03–2.8
	No	13	107		
Did you smoke cigarettes?	Yes	10	61	1.6	0.6–4.5
	No	8	80		
Did you drink alcohol?	Yes	13	91	1.4	0.5–4.3
	No	5	50		
Did you use a cordless phone?	Yes	10	112	0.3	0.1–0.9
	No	8	29		
Did you use a cordless phone on a regular basis, more than 1 time per week?	Yes	10	94	0.6	0.2–1.7
	No	8	47		
Did you use a handheld cellular phone?	Yes	5	53	0.6	0.2–1.9
	No	13	88		
Did you use a handheld cellular phone more than 1 call per week?	Yes	2	31	0.4	0.1–2.1
	No	16	110		
Did you use a transportable or “tote” phone?	Yes	2	17	0.9	0.2–4.5
	No	16	124		
Did you use an automobile phone?	Yes	2	16	1.0	0.2–4.8
	No	16	125		
Did you use an automobile phone more than one call per week?	Yes	2	7	2.4	0.4–13.0
	No	16	134		
Did you make calls from a commercial airline?	Yes	1	14	0.5	0.1–4.5
	No	17	126		
Did you use a CB, citizen’s band, radio in an automobile?	Yes	4	41	0.7	0.2–2.3
	No	14	99		
Did you use a two-way portable radio or walkie-talkie?	Yes	2	28	0.5	0.1–2.4
	No	16	112		
Did you use a paging device or beeper?	Yes	2	38	0.4	0.1–1.6
	No	16	102		

Non-tumor controls: rhinosinusitis, dysponia, and gastroesophageal reflux disease.
IFN = intratemporal facial nerve.

medic, police officer, or firefighter or with prior head injury. Several relatively large-scale studies have failed to demonstrate an association between intracranial tumor development and these risk factors.^{3,5,6,14,15}

There are a number of possible reasons why no link between cellular telephone use and development of IFN tumors or acoustic neuromas was observed in the present study. First, this study was based on self-

TABLE III.
Listing of Survey Results and Odds Ratios for Acoustic Neuromas.

		Acoustic Neuroma	Non-tumor Controls	Odds Ratio	Confidence Interval
Have you had head injuries that resulted in a loss of consciousness or a fracture?	Yes	6	19	0.856	0.315–2.326
	No	45	122		
Have you had any seizures?	Yes	3	8	1.0	0.3–4.2
	No	48	133		
Have you had any prior ear surgery?	Yes	11	9	4.0	1.5–10.6
	No	40	132		
Do you have a family history of brain, spinal, or nerve tumors?	Yes	1	6	0.5	0.1–4.0
	No	50	135		
Are you a policeman, fireman, or paramedic?	Yes		4		
	No	51	137		
Were you in the military?	Yes	14	29	1.5	0.7–3.1
	No	37	112		
Did you work at a radio station?	Yes	1	7	0.4	0.04–3.3
	No	50	134		
Did you wear metal-rimmed eyeglasses?	Yes	26	77	0.9	0.4–1.7
	No	25	64		
Did you wear metal earrings?	Yes	24	72	0.9	0.4–1.6
	No	27	69		
Did you have any children?	Yes	43	37	1.9	0.8–4.5
	No	8	107		
Did you smoke cigarettes?	Yes	22	61	1.0	0.5–1.9
	No	29	80		
Did you drink alcohol?	Yes	32	91	0.9	0.5–1.8
	No	19	50		
Did you use a cordless phone?	Yes	38	112	0.8	0.4–1.6
	No	13	29		
Did you use a cordless phone on a regular basis, more than 1 time per week?	Yes	34	94	1.0	0.5–2.0
	No	17	47		
Did you use a handheld cellular phone?	Yes	21	53	1.2	0.6–2.2
	No	30	88		
Did you use a handheld cellular phone more than 1 call per week?	Yes	11	31	1.0	0.4–2.2
	No	40	110		
Did you use a transportable or “tote” phone?	Yes	6	17	1.0	0.4–2.7
	No	45	124		
Did you use an automobile phone?	Yes	7	16	1.2	0.5–3.8
	No	44	125		
Did you use an automobile phone more than one call per week?	Yes	5	7	2.1	0.6–7.0
	No	46	134		
Did you make calls from a commercial airline?	Yes	7	14	1.4	0.5–3.8
	No	44	126		
Did you use a CB, citizen’s band, radio in an automobile?	Yes	8	41	0.4	0.2–1.1
	No	43	99		
Did you use a two-way portable radio or walkie-talkie?	Yes	6	28	0.5	0.2–1.4
	No	45	112		
Did you use a paging device or beeper?	Yes	14	38	1.0	0.5–2.1
	No	37	102		

Non-tumor controls: rhinosinusitis, dysponia, and gastroesophageal reflux disease.
IFN = intratemporal facial nerve.

reporting of cellular telephone use. However, Funch et al.⁴ found that patient recall of cellular telephone use correlated positively with actual billing records. Other investigators have reported similar findings.^{11–13} How-

ever, the statistical results of the present study imply, counter-intuitively, that patients with IFN tumors had less cellular telephone use than control subjects. One would expect recall bias to act in the opposite direction

with patients (cases) being more likely to recall past exposures than control subjects because they have a serious illness and have been thinking about possible causes. Because of the small number of patients with IFN tumor who reported any cellular telephone use, this implication is insubstantial.

Second, lack of an association between cellular telephone use and IFN tumor development could have resulted from selection bias. The tumor patients and control subjects included in the study were diagnosed after 1995. All previously diagnosed subjects were excluded from the study because risk factors for prevalent disease may be risk factors for either incidence or duration or both and cannot be distinguished.

The lack of statistical power of the study may have led to insufficient sensitivity in detecting a difference beyond chance in cellular telephone use between patients (cases) and control subjects. In an attempt to detect the relatively small difference in rate of cellular telephone use in the present study, more patients would be required.

Most important, cellular telephones have only been at the forefront of the consumer market in the past 5 to 10 years. Hence, the period of exposure to cellular telephone radiation is probably insufficient to assess a relative risk between cellular telephone use and the incidence of IFN tumors. As cellular telephone sales are increasing at an exponential rate and many more millions of people are exposed to microwave energy, a relationship may become more apparent. Therefore, future studies are necessary to verify whether more years of exposure are associated with an increased risk.

Acknowledgments

The authors thank Gary Stevens, PhD (Department of Biostatistics, University of Florida, Gainesville, FL), for performing the statistical analysis, and Jennifer McCullors for assisting with preparation of the manuscript.

BIBLIOGRAPHY

1. Cellular Telecommunication Industry Agency. Available on the web at: www.wow-com.com.
2. Hardell L, Nasman A, Pahlson A, et al. Use of cellular telephones and the risk for brain tumors: a case-control study. *Int J Oncol* 1999;15:113-116.
3. Inskip PD, Linet MS, Heineman EF. Etiology of brain tumors in adults. *Epidemiol Rev* 1995;17:382-414.
4. Funch DP, Rothman KJ, Loughlin JE, et al. Utility of telephone company records for epidemiologic studies of cellular telephones. *Epidemiology* 1996;7:299-302.
5. Schlehofer B, Blettner M, Becker N, et al. Medical risk factors and the development of brain tumors. *Cancer* 1992;69:2541-2547.
6. Schlehofer B, Blettner M, Preston-Martin S, et al. Role of medical history in brain tumour development: results from the international adult brain tumour study. *Int J Cancer* 1999;82:155-160.
7. Rothman KJ, Chou CK, Morgan R, et al. Assessment of cellular telephone and other radiofrequency exposure for epidemiologic research. *Epidemiology* 1996;7:291-298.
8. Adey WR, Byus CV, Cain CD, et al. Spontaneous and nitrosurea-induced primary tumors of the central nervous system in Fischer 344 rats chronically exposed to 836 MHz modulated microwaves. *Radiat Res* 1999;152:293-302.
9. Balzano Q, Garay O, Manning T. Electromagnetic energy exposure of simulated users of portable cellular telephones. *IEEE Trans Veh Technol* 1995;44:390-403.
10. Auvinen A, Hietanen M, Luukkonen R, et al. Brain tumors and salivary gland cancers among cellular telephone users. *Epidemiology* 2002;13:356-359.
11. Inskip PD, Tarone RE, Hatch EE, et al. Cellular-telephone use and brain tumors. *N Engl J Med* 2001;344:79-86.
12. Muscat JE, Malkin MG, Thompson S, et al. Handheld cellular telephone use and risk of brain cancer. *JAMA* 2000;284:3001-3007.
13. Muscat JE, Malkin MG, Shore RE, et al. Handheld cellular telephones and risk of acoustic neuroma. *Neurology* 2002;58:1304-1306.
14. Kaplan S, Etlin S, Novikov I. Occupational risks for the development of brain tumors. *Am J Ind Med* 1997;31:15-20.
15. Kaplan S, Novikov I, Modan B. Nutritional factors in the etiology of brain tumors. *Am J Epidemiol* 1997;146:832-841.