Prevalence of External Auditory Canal Exostoses in Surfers

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Objective: To determine (1) the prevalence of external auditory exostoses in a population of surfers and (2) the relationship between the length of time spent surfing and the prevalence, severity, and location of the exostoses.

Design: Cross-sectional epidemiological study.

Setting: General community.

Patients: Three hundred seven avid surfers (93.5% males and 6.5% females; age distributions: 11.2% were ≤20, 67.9% were 21 to 40, 17.5% were 41 to 50, and 3.3% were >50 years).

Main Outcome Measures: Questionnaires focusing on surfing habits (number of years, geographic region, and number of days per year of surfing) were correlated with otoscopic findings. A simple grading system was devised, based on the degree of external auditory canal stenosis. Grades of normal, mild, moderate, and severe corresponded to 100%, 99% to 66%, 65% to 33%, and less than 33% effective patent surface area, respectively.

Results: There was a 73.5% overall prevalence of external auditory exostoses and a 19.2% overall prevalence of osteomas in the group studied. Of 441 ears with exostoses, 54.2% were mild, 23.6% were moderate, and 22.2% were severe. Of individuals who had surfed for 10 years or less, 44.7% had normal ear canals and only 6% had severely obstructed auditory canals. In comparison, in the group that had surfed for longer than 20 years, only 9.1% had normal auditory canals and 16.2% were severely affected. Of surfers with no exostoses, 61.1% had surfed for 10 years or less. In contrast, of surfers with severe exostoses, 82.4% had surfed for more than 10 years. Finally, the lesions seemed to affect all external auditory canal quadrants equally.

Conclusion: A positive association exists between the amount of time individuals spend surfing and the presence and severity of exostoses of the external auditory canal.


EXTERNAL auditory exostoses (EAE) are common in individuals who frequently participate in aquatic activities. They are recognized by otoscopic examination and characterized by 1 or more broad-based elevated lesions that protrude into the external auditory canal. New bone growth along the upper edges of the tympanic bone is believed to be the source of these diffuse hyperostotic elevations. Although the cause of EAE has not been firmly established, it has nevertheless been clinically accepted that cold-water exposure is the initiation factor for temporal bone growth. With few exceptions, previous clinical studies concentrated on the treatment outcomes and consequently were unable to estimate the prevalence of the disorder among persons at risk.

Several anthropological studies have tested the cold-water hypothesis by looking at various prehistoric populations. Gregg and Bass reported an EAE prevalence of 3% when examining excavated skulls from inland North American populations, whereas Kennedy showed a 30% prevalence among civilizations known to frequently engage in cold-water activities. Standen et al sought to determine whether EAE is a consequence of habitual fishing in the cold waters of the Pacific Ocean or, rather, a genetically determined malady. They examined more than 1000 crania (dating from 7000 BC to 1500 AD) from 43 sites in northern Chile and found that inhabitants of the coastal regions had the highest prevalence of EAE (30.7%) compared with valley people (2.3%) and highlanders (0%). Furthermore, coastal and valley men had more severe EAE than women of their respective populations.

Results of several clinical studies support the cold-water hypothesis. Adams found that, among 10 swimming instructors, 9 had exostoses. Harrison examined the ears of 2352 freshwater and seawater swimmers and found a 1.2% overall prevalence of EAE. Limited research was done on the epidemiological aspects of this topic until 1989, when Umeda and Nakajima examined the ears of 51 profes-
PATIENTS AND METHODS

A total of 307 surfers (93.3% males and 6.5% females; age: 11.2% were ≤20, 32.7% were 21-30, 35.3% were 31-40, 17.3% were 41-50, and 3.3% were >50 years) were given questionnaires and free otoscopic examinations during a 3-day period at the 1994 U.S. Open of Surfing. Most (288) were Californians and hence “cold-water” surfers compared with Hawaiians and Floridians, who surf in warmer waters.

Before the otoscopic examination, the surfers filled out a questionnaire (Table 1). The ear canals were then examined by 1 of 6 otolaryngologists (B.J.F.W., W.C., K.J.D., P.B., G.B., and E.M.) using hand-held otoscopes (Welch-Allyn, Skaneateles Falls, NY). The examiners obtained and recorded information regarding tympanic membrane visibility and the external canal quadrant involved, and made distinctions between osteomas and exostoses as needed. Also noted was the presence of a “V-sign”—described by DiBar-tolomeo as the distribution of exostoses mainly in the posterior and anterior walls of the external auditory canal—or small discrete osteomas at the tympano-mastoid suture—termed Doc’s Nubbin (Robert Scott, MD, oral communication, August, 1994). Finally, sketches of each external ear canal were drawn and recorded. Grades were used to indicate the degree of external auditory canal stenosis, based on 3 concentric ring templates placed over the sketched ear canals to indicate the percentage of effective surface area that remained patent. Quantitatively, normal, mild, moderate, and severe grades corresponded to 100%, 99% to 66%, 65% to 33%, and less than 33% effective surface area remaining patent, respectively.

The information derived from the questionnaires (demographics and length of time surfing) was compared with otoscopic findings and analyzed for any relationships between the duration and extent of cold-water exposure and the severity of EAE.

Otoscopic Findings

Table 2 depicts the presence and severity of EAE for the 600 ears examined (14 ears occluded with cerumen were excluded). The presence EAE was found in 441 ears (73.5%). Of ears with EAE, 54.2% were mild, 23.6% were moderate, and 22.2% were severe. Regarding the affected external ear canal quadrants, there was no predominant location for the EAE lesions. Three hundred nineteen ears (72.3%) had lesions in the anterosuperior quadrant, 328 (74.4%) in the anteroinferior quadrant, 295 (66.9%) in the posterosuperior quadrant, and 319 (72.3%) in the posteroinferior quadrant. Finally, the V-sign distribution was present in 218 affected ears (49.4%), and Doc’s Nubbin was present in 115 (19.2%).

Correlative Analysis

In the Figure, surfers are categorized into 3 groups, based on the number of years individuals had surfed (Table 2). Of 307 surfers, 114 (37.1%) had surfed for 10 years or less; 109 (35.5%) had surfed for 11 to 20 years; and 79 (25.7%) had surfed for longer than 20 years (3 surfers did not answer this question). Of all surfers, 70.6% surfed 2 to 3 hours per day, and 69.2% surfed 10 to 12 months of the year. One hundred thirty-two individuals (43.5%) indicated previous medical treatment for ear infections, and 17 surfers reported a history of otologic surgery related to surfing. One patient perforated an eardrum after being knocked over by a large wave and subsequently required tympanoplasty. Sixteen patients received surgical treatment for exostoses: 10 had surgery on 1 side only and 6 had bilateral procedures (all were staged). Two patients had revision surgery twice for recurrence of exostoses. One patient had surgery on both sides (the first 2 were performed transcanal). One avid 51-year-old surfer had 9 operations performed by the same neuro-otologist.

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tween the 3 groups, indicating a positive relationship bet-
tween the degree of canal obstruction and the number of years and frequency of surfing.

In 1937, Van Gilse\textsuperscript{15} postulated a thermal cause for the development of EAE after observing a higher frequency of this pathological condition among cold-water vs warm-water swimmers. Previously, authors had attributed exostoses among ocean swimmers to irritation caused by saltwater exposure. Evidence against this theory was published in a 1951 study\textsuperscript{11} of 8200 Royal Air Force recruits showing a 5.6\% incidence of EAE in seawater swimmers, a 5.0\% incidence in freshwater swimmers, and a 0.9\% incidence in nonswimmers.

Water salinity may not be the causative agent, but water temperature seems to be a significant factor.\textsuperscript{5} Water temperature below 17.5°C stimulates changes in the external auditory canal,\textsuperscript{6} and cold-water exposure leads to prolonged meatal erythema.\textsuperscript{2} Cold-water exposure is the most consistent characteristic in the history of patients with EAE.\textsuperscript{12,14} In fact, Deleyiannis and coworkers\textsuperscript{14} postulate that surfers of the warmer southern California waters (16.6°C) may require a longer duration of exposure to produce EAE. This is based on the finding that their patients (Oregon and northern California cold-water surfers) had developed significant ear canal obstruction after having surfed in water temperatures ranging from 9.4°C to 11.1°C for 5 years or longer, whereas the southern California surfers (30 [43\%] of the 70 patients) in the study by DiBartolomeo\textsuperscript{3} showed the presence of exostoses after having surfed for longer than 10 years. Similarly, our findings also show that most normal ear canals were in individuals who had been surfing for 10 years or less. An important difference, however, is that many of our patients surfed in a wide range of climates and water temperatures. Therefore, we did not make a distinction between cold-water vs warm-water surfers, although most of our patients were native southern California surfers. Only 5 patients surfed primarily in warm-water climates. In contrast, DiBartolomeo's population consisted of only surfers who sought otologic care for symptomatic exostoses. Consequently, our populations may not be comparable because our subjects did not seek medical care.

Aquatic sport enthusiasts have historically been over-represented in this disease. Results of our study indicate an overall prevalence of 73.5\% EAE among avid surfers. Our findings are also consistent with those of smaller previously published studies supporting a positive dose relationship between number of years of surfing and the severity of exostoses\textsuperscript{12,14} (Figure). The representation of moderate and severe exostoses increases as the number of years of surfing increases. The smallest percentage of normal ear canals were in those who had surfed for longer than 20 years. Normal ears and ears with severe exostoses were seen in all groups.

With respect to the location of the EAE lesions, Umeda and Nakajima\textsuperscript{12} suggested that EAE follows a specific growth pattern. They found that anterosuperior EAE occurred most frequently, followed by anteroinferior and posteroinferior, and posterosuperior exostoses were found least frequently. We found no predominant location for the EAE lesions. Each quadrant contained exostoses about three quarters of the time. DiBartolomeo\textsuperscript{3} describes that at least 2 exostoses exist in the affected ear, forming the V-sign. These lesions usually arise on the floor in the an-

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**Table 1. Questionnaire Used for Data Collection**

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>No. of years surfing</th>
<th>Months you most often surf (eg, August or September)</th>
<th>No. of days surfing per year (estimated)</th>
<th>Average No. of hours surfing per day</th>
<th>Location of surfing and No. of years having surfed there</th>
<th>Do you get ear infections (yes/no)?</th>
<th>How many ear infections have you had? per month, per year (average)</th>
<th>How many times has a doctor treated you for an ear infection?</th>
<th>Do you have a problem with hearing loss caused by surfing?</th>
<th>Do your ears ring because of surfing?</th>
<th>What other water sports do you participate in regularly?</th>
<th>Do you have sinus problems (explain)?</th>
</tr>
</thead>
</table>

**Table 2. Patients (N = 307) by Number of Years Surfing**

<table>
<thead>
<tr>
<th>Surfing, y</th>
<th>Patients, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤10</td>
<td>114 (37.1)</td>
</tr>
<tr>
<td>11-20</td>
<td>109 (35.5)</td>
</tr>
<tr>
<td>&gt;20</td>
<td>79 (25.7)</td>
</tr>
</tbody>
</table>

**Table 3. Absolute Number and Percentage of Ears (N = 600) by Severity Grade of External Auditory Exostoses**

<table>
<thead>
<tr>
<th>Severity Grade</th>
<th>Ears, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>159 (26.5)</td>
</tr>
<tr>
<td>Mild</td>
<td>239 (39.8)</td>
</tr>
<tr>
<td>Moderate</td>
<td>104 (17.3)</td>
</tr>
<tr>
<td>Severe</td>
<td>98 (16.3)</td>
</tr>
</tbody>
</table>

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terior and posterior canal walls. In the present study, half of the ears with exostoses showed the V-sign.

The pathological features of EAE are grossly distinct from those of the rarer osteoma of the external ear canal. Osteomas are described as benign tumors composed of densely sclerotic, well-formed bone jutting out from the cortical surface. In this population, 19.2% of the external ear canals showed the presence of osteomas (Doc’s Nubbin). In EAE, lesions are found as solitary pedunculated bony growths and usually lateral to the isthmus. Exostoses of the external auditory canal are described as localized hyperplasia in a broad-based elevation deep within the isthmus. Although exostoses and osteomas of the external auditory canal are widely accepted as distinct clinical entities based on their gross appearance, much disagreement still exists as to whether they should be considered separate or similar histopathologic entities. Results of a masked study method conducted by Fenton et al16 demonstrate that exostoses and osteomas of the external ear canal cannot be reliably differentiated by routine histopathologic examination.

Practically all exostoses arise from the tympanic ring along its line of union with the temporal bone at the tympanomastoid and tympanosquamous sutures. The external auditory canal develops from the first ectodermal branchial groove, between the first (mandible) and the second (hyoid) branchial arches. Lateral growth along the sides and floor of the external auditory canal occurs over thin skin. These areas seem to proliferate more rapidly and may be more sensitive and susceptible to irritation. Exostoses are almost always bilateral and symmetrical. The hyperplasia continues painlessly, resulting in obstruction of the ear canal, conductive hearing loss, and frequent bouts of otitis externa.

Exostoses are generally benign maladies that do not require surgery. It is unclear as to what degree of canal obstruction requires medical treatment. Short-term complications such as otitis externa or impacted cerumen should be treated in a conservative, conventional manner. In the case of severe disease in which recurrent otitis externa and long-term hearing impairment exists, surgery is indicated and is generally successful.17,18 Fisher and McManus17 report that major complications, including canal stenosis, temporomandibular joint prolapse, sensoneural loss, persistent deep bony lisp, and persistent tympanic membrane proliferation occurred in 5% of 127 exostectomy procedures that their group performed. Although they did not report any facial palsies, Green and colleagues19 report a 14% incidence of facial nerve injury during exostoses removal. Careful consideration must be given when evaluating individuals for elective exostectomy. In our patient population, 43.5% had received conventional therapy for external auditory infection and 5.2% had undergone elective surgical intervention (tympanostomy tubes and canalplasty) for severe disease.

In summary, we found a 73.5% overall prevalence of EAE and a 19.2% overall prevalence of osteomas among 307 avid surfers. The lesions seemed to affect all quadrants equally and therefore did not seem to follow a determined manner. In support of previous work, we found that a positive relationship exists between years of active surfing and presence and severity of exostoses. Our findings suggest that it is possible to determine the likelihood of developing EAE as a function of the number of years the patient has surfed.

Health promotion and disease prevention in populations with increased risk for EAE need special attention. Surfers, ocean swimmers, sailors, and deep-water divers should be advised of the benefit of limiting cold-water exposure. Wearing ear molds, ear plugs, visored caps, and hoods may prevent exostoses by preventing the entry of cold water into the external ear canal. Further research is required to determine whether the early use of such ear protection equipment will in fact prevent this disorder.

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We thank Robert “Doc” Scott, MD, International Aquatic Traders, Santa Cruz, Calif, who was involved in this study in every way. His efforts and previous clinical observations of surfer’s exostoses for 50 years have made this study richer and more meaningful. This article is especially dedicated to George Brauel, MD, a surfer and otolaryngologist involved in this study. He lost his life on a humanitarian mission shortly after this study (Arch Otolaryngol Head Neck Surg. 1995;121:717). The sport and lifestyle of surfing were central in his life, and his contributions to otolaryngology and surfing will be missed.

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REFERENCES