The Journal of Laryngology & Otology
June 2004, Vol. **118,** pp. 413–416

Noise exposure in orthopaedic practice: potential health risk

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Abstract

Noise exposure is one of the major causes of permanent hearing loss in society. Exposure of health service staff to intense levels of noise in the workplace is a potential risk for the development of temporary and permanent hearing loss.

In this prospective study, 18 members of the orthopaedic staff underwent hearing assessment by pure tone audiometry and speech discrimination prior to noise exposure at the workplace and immediately following cessation of work. The number of hours of exposure and noise levels in the workplace was also analysed.

Only minimal temporary sensorineural threshold shifts were detected post-noise exposure. There was no change in speech discrimination scores and no individuals complained of tinnitus. The number of hours of exposure ranged from 1.5 to 8.5 hours (mean 5.2 hours). Recorded sound levels for instruments ranged from 119.6 dB at source to 73.1 decibels at 3 metres.

Although high sound levels are recorded in the orthopaedic operating theatre, the intermittent nature exposure to the intense noise may protect staff against hearing loss, speech discrimination difficulties and tinnitus.

Key words: Noise, Occupational; Orthopaedic Equipment

Introduction

Orthopaedic staff can be exposed to intense noise levels for long periods. This exposure has the potential to induce a hearing loss characterized by pure tone threshold shifts, speech discrimination difficulties and tinnitus. A temporary sensorineural threshold shift can occur after exposure to intense levels of noise but usually recovers within 24 hours. Permanent sensorineural hearing loss may occur in individuals after repeated exposure to intense noise that may initially only cause a temporary threshold shift.

The aim of this prospective study was to measure the levels of temporary threshold shift, speech discrimination and occurrence of tinnitus in staff who had been exposed to intense levels of noise. The number of hours of exposure and noise levels in the workplace was also analysed.

Materials and methods

Eighteen members of the Orthopaedic staff, 12 males and six females were included in this study. Age, occupation, number of years of employment in the Orthopaedic Department, relevant past medical and drug history were recorded. Pure tone audiometry and speech discrimination scores were recorded prior to the individual's exposure to noise by an audiology technician in a sound proof environment. Immediately following exposure, the individual returned to the Audiology department to have pure tone audiometry and speech discrimination scores re-tested by the same audiology technician. The number of hours of exposure to intense noise levels and the distance from the noise source was recorded. Individuals were also questioned as to whether they experienced tinnitus following noise exposure.

A properly calibrated Quest Model 2700® sound meter was used to record the levels of noise of a variety of orthopaedic instruments commonly used in the workplace. Noise levels were measured at source, one metre, two metre and three metre distances.

Pre- and post-exposure pure tone audiograms and speech discrimination scores were analysed.

Results

The ages of the staff in this study ranged from 27–52 years (mean 38.3 years). The occupation of those included is listed in Table I. The number of years of employment in the Orthopaedic department ranged

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Accepted for publication: 15 February 2004.

TABLE I
OCCUPATION OF STAFF

Occupation	Number
Consultant orthopaedic surgeon	3
Orthopaedic SpR	2
Orthopaedic SHO	2
Consultant Anaesthetist	2
Anaesthetic SpR	1
Anaesthetic SHO	1
Nurse	5
Plaster technician	2

SpR = Specialist Registrar; SHO = Senior House Officer

from 1.5 to 20 years (mean 11.9 years). No individuals were taking potentially ototoxic medication. One individual had a previous history of otitis media, one had had grommets inserted in childhood, one had a previously perforated tympanic membrane and one had undergone a mastoidectomy 20 years previously.

The number of hours exposure to intense noise ranged from 1.5 to 8.5 hours (mean 5.2 hours) and the distance from the source of the noise ranged from 0 to 2 metres (mean 0.72 metres). No individual complained of tinnitus following exposure.

The background noise level in the operating theatre was recorded at 58 decibels. Recorded sound levels for instruments are listed in Table II. They ranged between 93.6 and 119.6 decibels (mean 100.7 decibels) at source, 76.4 and 103.4 decibels (mean 85 decibels) at one metre, 74.8 and 98.2 decibels (mean 82 decibels) at two metres and 73.1 and 96.3 decibels (mean 81 decibels) at three metres.

Pre-exposure and post-exposure pure tone averages (0.5, 1, 2, 4 kHz) are listed in Table III. Mean pre-exposure pure tone averages (0.5, 1, 2, 4 kHz) were 7.7 and 6.7 decibels for the right and left ears respectively. Mean post-exposure pure tone averages (0.5, 1, 2, 4 kHz) were 8.1 and 7.6 decibels for the right and left ears respectively. There was no difference between the pre- and post-exposure speech discrimination scores.

Differences between the pre- and post-exposure hearing levels at six and eight kHz are listed in Table IV.

Two individuals did not return for their post-exposure pure tone audiograms and speech discrimination scores and were excluded from the study cohort.

Discussion

Exposure of Orthopaedic staff to intense noise levels for long periods may result in noise-induced hearing loss.

A temporary shift in the sensorineural hearing threshold occurs after exposure to loud noise, but usually recovers completely within 24 hours. More intense sounds lead to larger shifts, with the frequencies to which the human ear is most sensitive (1–5 kHz) being the most susceptible. Constant, long exposure leads to an increased temporary threshold shift, whereas interrupted exposures, with the same overall duration, produces a less severe temporary threshold shift. The correlation between temporary threshold shift and permanent noise-induced hearing loss remains uncertain, although daily exposures that do not cause a temporary threshold shift are unlikely to result in permanent noise-induced hearing loss.

Repeated exposure to loud noise sufficient to cause a temporary threshold shift may result in permanent sensorineural hearing loss. The degree of hearing loss and the frequencies most affected depend on the acoustic parameters of the noise. These permanent threshold shifts do not progress after cessation of exposure and, as with temporary threshold shifts, intermittent exposure is less damaging to the cochlea. Exposure to industrial noise, which is typically broad-spectrum, initially causes hearing loss in the higher frequencies (3–6 kHz). Long-term noise exposure (greater than 10 years) results in a plateauxing of loss in the higher frequencies and may also result in the broadening of loss into the lower frequencies. The sensitivity of

TABLE II
RECORDED NOISE LEVEL READINGS (DECIBELS)

	Distance (metres)			
	0	1	2	3
Instrument				
Air driver	93.2	85.7	83.8	82.3
Cleancast circular saw	107.2	83.2	80.9	79.8
Denoulter plaster saw	119.6	86.2	84.3	85.4
DeSoutter plaster saw	98.6	76.4	75.7	73.1
Hammering	113	103.4	98.2	79.8
Howmedica chirodrill	98.3	84.3	80.3	79.1
Mini driver	83.6	78.3	74.8	73.8
Maxi driver	95.9	85.9	82.9	84.3
Zimmer oscillator	94.7	81.9	76.3	75.6
Zimmer reamer	93.6	82.7	78.9	77.4
Zimmer reciprocator	109.8	87.3	85.8	84.3
Disconnection of air hose				
Mini driver	107.9			
Maxi driver	111.3			
Air driver	99			
Howmedica chirodrill	100.3			
Zimmer reamer	105.7			

https://doi.org/10.1258/002221504323219509 Published online by Cambridge University Press

TABLE III
PRE- AND POST-EXPOSURE PURE TONE AVERAGES (0.5, 1, 2, 4 KHZ)

	Pre-exposure PTA (dB)		Post-exposure PTA (dB)	
Case	Right	Left	Right	Left
1	50	44	50	42
2	6.25	5	–	–
3	0	0	–	–
4	36.25	17.5	32.5	18.75
5	5	8.75	5	16.25
6	0.25	0	2.5	0
7	10	16.25	7.5	18.75
8	11.25	12.5	12.5	8.75
9	0	2.5	0	0
10	0	0	0	0
11	7.5	3.75	8.75	3.75
12	6.25	6.25	2.5	6.25
13	3.75	0	0	0
14	0	0	0	0
15	1.25	0	1.25	0
16	0	3.75	2.5	4
17	1.25	1.25	4	3.75
18	0	0	1.25	0

the human ear to frequencies between one to five kHz, and the protective effect of the acoustic reflexes for frequencies below two kHz, may explain the characteristic four kHz notch.

Intense noise exposure damages the outer hair cells within the cochlea. It appears that the stereocilia of the outer hair cells become more flexible and therefore respond poorly to stimulation. With more intense and longer exposure more severe damage can occur, with fusion of adjacent stereocilia and loss of stereocilia. This can result in the loss of outer hair cells and their replacement with scar tissue. Continued exposure may also damage the inner hair cells and supporting cells in the organ of Corti, with secondary neural degeneration.[1,2]

Recently in the literature it has been suggested that otoacoustic emissions provide an indication of cochlear damage prior to any change in pure tone audiometric thresholds.[3,4] Otoacoustic emissions are quick, objective, repeatable and sensitive in detecting differences in hearing threshold, which makes them ideal for monitoring individuals at risk of hearing loss due to noise exposure.

Current UK legislation regarding occupational noise exposure, as defined in the *Noise at Work Regulations*,[5] came into force in 1990 and is intended to protect workers from the risk of hearing damage due to excessive noise. These regulations set a maximum dose of sound energy of 90 dB for an eight-hour working day. For every increase in sound level of three dB, the duration of exposure time should be halved. For example, an individual should only be exposed to a sound level of 93 dB for four hours, 96 dB for two hours or 99 dB for one hour.

- **This prospective study measured the effect of noise on 18 members of orthopaedic staff. They underwent hearing assessment by puretone audiometry and speech discrimination prior to noise exposure at the workplace and immediately following cessation of work. The number of hours of exposure and the level of noise was also analysed**
- **Although high levels of noise were recorded (73.1–119.6 dB from source to a distance of 3 metres), the intermittent nature of exposure to the intense noise may protect staff against hearing loss, speech discrimination difficulties and tinnitus**

The current *Noise at Work Regulations* define three action levels relating to noise exposure. The first action level is a daily exposure of 85 dB at which level employers are required to provide information and training on hearing protection and supply suitable hearing protection at the employee's request. The second action level relates to a daily exposure level of 90 dB whereby employers are required to attempt to reduce noise exposure, as far as practicable, by means other than ear defenders. Ear defenders must be provided and areas of high noise exposure must be clearly signposted. A third 'peak' action level relates to the maximum pressure created by a single sound wave and is set at 140 dB (200 Pascals).

TABLE IV
PRE- AND POST-EXPOSURE HEARING LEVELS (DB) AT 6 AND 8 KHZ

	Right ear	Left ear
Man pre-exposure hearing level at 6 kHz	15	17.5
Mean post-exposure hearing level at 6 kHz	17.8	20
Mean pre-exposure hearing level at 8 kHz	12	13.5
Mean post-exposure hearing level at 8 kHz	16.7	17.2

https://doi.org/10.1258/002221504323219509 Published online by Cambridge University Press

In February 2003 the European Physical Agents (Noise) Directive was adopted by the European Parliament and is set to replace current UK noise legislation by February 2006. This new directive reduces the daily exposure limit for the first and second action levels to 80 dB and 85 dB respectively, and stipulates a maximum sound pressure for a single sound wave of 112 Pa and 140 Pa respectively for each of these action levels. In addition, the directive sets a limit on sound exposure to 87 dB per day and 200 Pa.

The results of this study show only minimal sensorineural threshold shifts, with no changes in speech discrimination and no incidence of tinnitus. This may be because intense noise exposure in orthopaedic practice occurs intermittently. However, the recommended exposure time for the maximum-recorded level of noise of 120 dB, using the Denoulter plaster saw, is only 28 seconds per day!

In conclusion, although high levels of sound are recorded in the orthopaedic operating-theatre, the nature of the exposure to intense noise, generally taking the form of brief intermittent bursts of noise, may reduce the potential for hearing loss and tinnitus. However, the potential for noise exposure in orthopaedic practice demonstrated in this study, and in previously published work,[6,7] is such that hospital employers are required by UK law to take action to protect personnel from noise exposure.

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Mr R. Ullah takes responsibility for the integrity of the content of the paper.
Competing interests: None declared