

# Does passive smoking affect the outcome of grommet insertion in children?

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## Abstract

Bilateral myringotomy with insertion of ventilation tube (grommet) is the most common surgical procedure done on children under general anaesthetic. A prospective study was conducted on children undergoing grommet insertion to ascertain any relationship between exposures of passive smoking to the outcome of grommet insertion. Six hundred and six children (with 1174 ears) who underwent grommet insertion for recurrent secretory otitis media were followed up till the grommets were extruded. Thirty-three children (65 per cent), whose mothers smoked when they were pregnant, had bilateral narrow external ear canals. The median survival rate of grommet was 59 weeks in children who were exposed to passive smoking as compared to 86 weeks for non-exposed children and the extrusion rate of grommet was 36 per cent higher at the end of one year if both parents smoked compared to the non-smoking group. Post-extrusion myringosclerosis was 64 per cent if both parents smoked and less than 20 per cent if neither parents smoked. It is concluded that post-operative infection rate, attic retraction, post-extrusion myringosclerosis and permanent perforations of tympanic membrane were more common in children exposed to passive smoking. The study provides further support to professional and governmental advice that passive smoking is harmful.

**Key words: Otitis Media with Effusion; Tobacco Smoke Pollution; Middle-Ear Ventilation**

## Introduction

Smoking kills 120 000 people each year in the United Kingdom and costs the NHS an estimated £1.7 billion annually.<sup>1</sup> Although active smoking is the largest cause of preventable death, it is clear that the harmful effects of smoking are not confined to the smoker. Passive smoking has received enormous public attention in recent years, with Ireland even passing legislation banning smoking in public places.<sup>2</sup> Passive smoking ('second hand' smoking) is associated with lung cancer,<sup>3</sup> asthma, lower and upper respiratory tract infection,<sup>4</sup> secretory otitis media and sudden infant death,<sup>5</sup> and minor ailments leading to absence from school.<sup>6</sup> Secretory otitis media is the commonest reason for admitting young children for operation<sup>7</sup> and is expected to occur in 80 per cent of children at some stage.<sup>8</sup> It is very important because it can cause negative effects on the linguistic, auditive and communicative skills of children<sup>9</sup> and is a factor in the development of chronic ear disease in adults. It has been estimated that 5–10 per cent of all children may require surgery for this condition, which may cause physical and psychological complications.<sup>10</sup> The aim of this prospective study was to evaluate whether exposure

to second-hand smoke at home or in the car had any bearing on the outcome of grommet insertion.

## Patients and methods

The material for the study was collected from children attending the day surgery unit at Princess Royal University Teaching Hospital at Farnborough, Kent from October 1998 until September 2003 for grommet insertion for secretory otitis media (glue ear). Six hundred and six children undergoing grommet insertion for the first time were included in the study. Children who had known chromosomal abnormality like Down's syndrome were excluded from the study. Details of age, sex (Figure 1), parental smoking habits in the car and inside the house (Table I) and smoking by mother during pregnancy were recorded. Parents were classified into non-smokers, mild smokers (one to nine cigarettes per day), moderate smokers (10–19 cigarettes per day) and heavy smokers (20 or more cigarettes per day). The children thus came under four categories; the first with exposure to passive smoke from the father, the second with exposure to passive smoke from the mother, the third with exposure to passive smoke from both parents and the fourth from neither.

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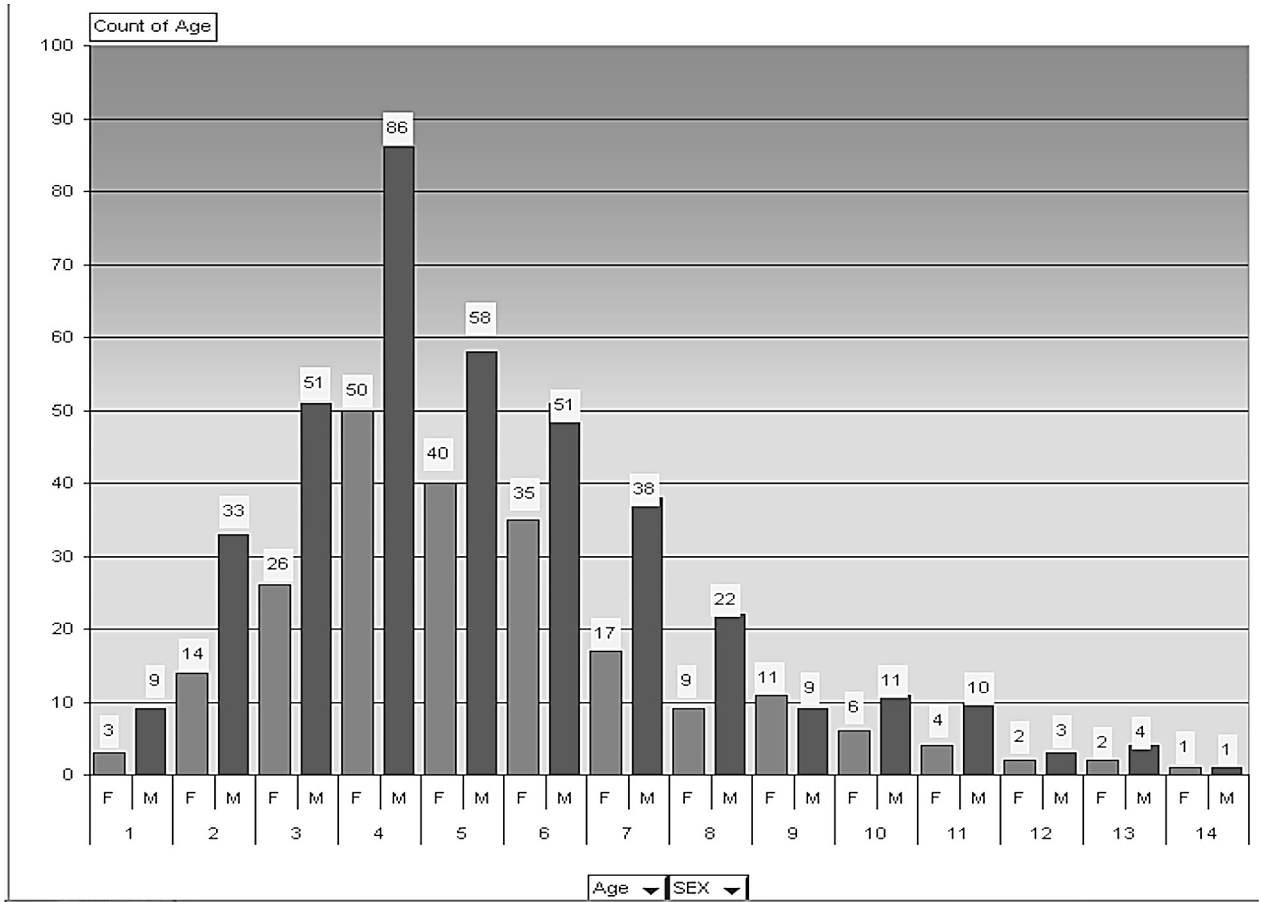


FIG. 1

Age and sex distribution on 'X' axis and number of patients on 'Y' axis. Boy to girl ratio of 1.8:1. F = female; M = male

At the time of operation details of the external auditory canal, appearance of tympanic membrane including presence of myringosclerosis and appearance of the attic region were recorded. Those who already had myringosclerosis pre-operatively were excluded from the study. Shah ventilation tubes were used in all the patients and all the operations were carried out by the first author (CVP). The middle-ear effusion was not aspirated before inserting the grommet unless it was essential. The ear canal was considered to be narrow if only 2 mm of the tympanic membrane was visible with a Heath aural speculum.

The children were followed up six weeks after operation and then every three to four months thereafter, to assess their ears otoscopically, until after grommet extrusion. The nature of tympanic membrane, post-operative symptoms such as otorrhoea, otitis media and myringosclerosis after extrusion of grommet were all recorded. Those children whose tympanic membrane was not fully visible otoscopically, were examined with an out-patient microscope. Children receiving two or more courses of oral antibiotics post-operatively within six months from general practitioners for otorrhoea were considered to have post-operative infection. Fifty-five children who failed to turn up for follow up at various stages, were excluded from the study. The drumhead was divided into two halves, anterior and

posterior, and the incidence of myringosclerosis was noted in each half. The myringosclerosis was termed extensive if it happened in both halves. The duration of grommet *in situ* was calculated from the day of insertion until its extrusion. Attic retraction was classified using the system described by Tos.<sup>11</sup> Statistical analysis was performed using chi-square test and for the duration of grommet *in situ*, the Kaplan-Meier method of survival analysis with 95 per cent confidence interval was used.

## Results

Six hundred and six children were enrolled for the study. Of these, 220 (36 per cent) were girls and 386 (64 per cent) boys, age ranging from one year and six months to 14 years and six months with an average age of 5 years. Thirty-nine per cent were aged four and five (Figure. 1). Table I shows the number of cigarettes smoked by parents per day in the house and inside their car when with children; 166 mothers smoked when they were pregnant. Fifty-one children (Table II) had bilateral narrow ear canals of whom 33 (65 per cent) were exposed to passive smoking in pregnancy. Of these 51 children who had narrow ear canal, all had early extrusion of grommets within a year with a median survival rate of 45 weeks. The median survival rate of grommet for non-smoking parents was 86 weeks. The survival rate of grommet

drops if at least one parent smokes, and also in children with narrow ear canals (Table III).

There was increased incidence of infection after grommet insertion in children who were exposed to passive smoke than those who were not, requiring at least two courses of antibiotics in a six-month period. The infection rate was high if both parents smoked in the house and inside the car ( $p < 0.00001$ ).

There was significant myringosclerosis of tympanic membrane after the grommets were extruded in the smoking group (Figures 2 A–D). Myringosclerosis was 64 per cent if both parents smoked and less than 20 per cent if neither parents smoked, which was statistically highly significant. Nearly 30 per cent of the smoking group had extensive myringosclerosis compared to less than 6 per cent in the non-smoking group ( $p < 0.00001$ ).

The duration of the grommet *in situ* was calculated from the day of operation until its extrusion. Kaplan-Meier method of survival analysis with 95 per cent confidence interval was used to calculate survival of the grommet *in situ* (Table III). The extrusion rate was high if both parents smoked. At the end of one year after grommet insertion, only 43 per cent of the children still had their grommets *in situ* if both parents smoked, compared to 79 per cent in the non-smoking group, as shown in the graph (Figure 3). The early extrusion of grommets is more likely in children from exposure to passive smoking with an odds ratio of 3.1, which is highly significant.

Attic retraction, which is a sequel in major ear

TABLE I

FREQUENCY OF PARENTAL SMOKING IN THE HOUSE AND IN THE CAR

	Mother* n (%)	Father n (%)
Non-smokers	305 (50.3)	328 (55.5)
1–9 cigarettes/day (mild smokers)	47 (7.6)	38 (6.4)
10–19 cigarettes/day (moderate smokers)	139 (22.9)	97 (16.4)
More than 20 cigarettes/day (heavy smokers)	115 (19.0)	128 (21.7)
Total	606 (100)	591 (100)
Smoking in car with closed window	41	47

\* Fifteen mothers were single parents

disease, was high in the smoking group. Out of a total of 1174 ears, 76 ears (6.4 per cent) had attic retraction pre-operatively and 52 ears (4.4 per cent) still had attic retraction post-operatively. Pre-operatively, attic retraction was more predominant in the smoking group (55 out of 76, 72 per cent) than in the non-smoking group (21 out of 76, 28 per cent). Out of 76 ears, 69 had Grade 1 attic retraction and seven had Grade 2 attic retraction. Forty-eight ears with Grade 1 and all Grade 2 retractions were in the smoking group; 21 ears with Grade 1 attic retraction were in the non-smoking group. Grade 1 attic retraction was reversible in 24 ears after grommet insertion, of whom five were in the non-smoking group and 19 were in the smoking group, whilst none

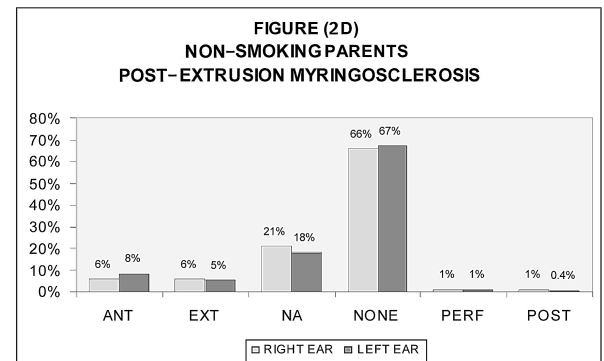
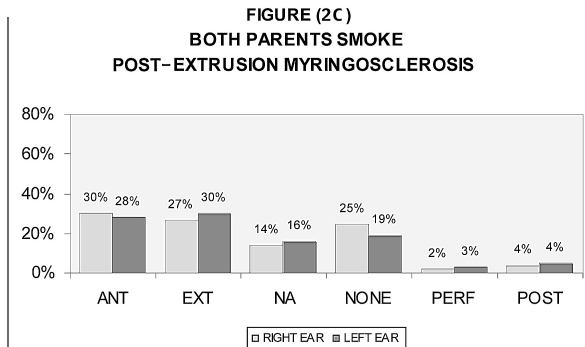
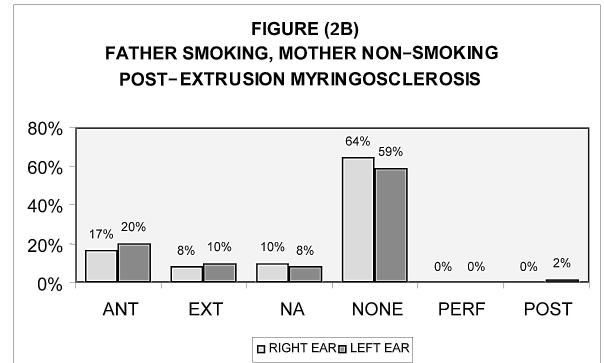
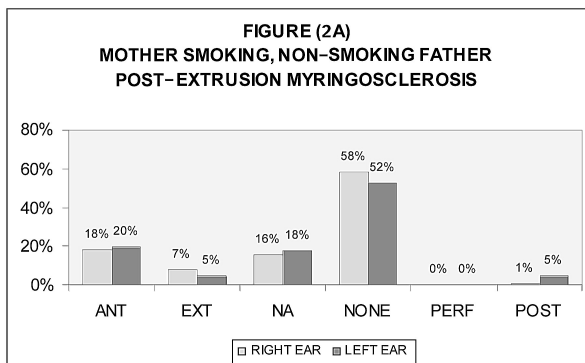


FIG. 2

Post-extrusion myringosclerosis. Thirty per cent of the children had extensive myringosclerosis if both parents smoked, compared to 6 per cent in the non-smoking group. ANT = myringosclerosis in anterior half of tympanic membrane; EXT = extensive myringosclerosis; N/A = patients still having grommets in ear; NONE = no post-extrusion myringosclerosis; PERF = perforated eardrum; POST = myringosclerosis in posterior half of tympanic membrane

TABLE II  
EAR CANAL AND SMOKING BY MOTHER

		Pregnancy		Total
		No smoker	Smoking	
Ear canal	Normal	422	133	555
	Narrow	18	33	51
Total		440	166	606

Thirty-three (65 per cent) out of 51 children who had narrow ear canal were exposed to passive smoking during pregnancy.

of the Grade 2 retractions showed any changes post-operatively and they are being followed up regularly. Attic retraction was more predominant in the left ear (49 out of 76, 64.4 per cent) than in the right ear (27 out of 76, 35.5 per cent).

Thirteen patients (2.1 per cent) had permanent perforations of the tympanic membrane, of whom two had bilateral perforations, four had perforations in the right ear and seven had perforations in the left ear. Nine (69 per cent) of these 13 were in the smoking group and four (31 per cent) were in the non-smoking group.

### Discussion

The health effects of passive smoking have received widespread attention in recent years because of the increasing public awareness about the risks of tobacco smoking. The term 'passive smoking' usually refers to the inhalation of smoke that is either exhaled by a smoker or released as sidestream smoke from a burning cigarette. Passive smoking is

also referred to as 'involuntary smoking' because the person who inhales often has no choice in the matter, like the foetus in a smoking mother.<sup>12</sup> Environmental tobacco smoke (ETS) is made up of exhaled mainstream smoke and sidestream smoke. Mainstream smoke is smoke inhaled and exhaled by smokers directly from tobacco products. Sidestream smoke is a mixture of smoke emitted from the smouldering tobacco, contaminants emitted during puffs and contaminants that diffuse through cigarette paper and the mouth end of the cigarettes between puffs.<sup>13</sup> ETS is a complex mixture of some 4000 compounds, containing more than 40 known or suspected human carcinogens<sup>14</sup> like 4-aminobiphenyl, 2-naphthylamine, benzene, nickel, and a variety of polycyclic aromatic hydrocarbons and N-nitrosamines.<sup>13</sup> A number of irritants and toxins like ammonia, nitrogen oxides, sulphur dioxide, various aldehydes, nicotine and carbon monoxide are also present in ETS.<sup>13</sup> Several studies in literature have shown a positive link to parental smoking and middle-ear effusion,<sup>10,13,14,16-19</sup> and Kraemer *et al.*<sup>20</sup>

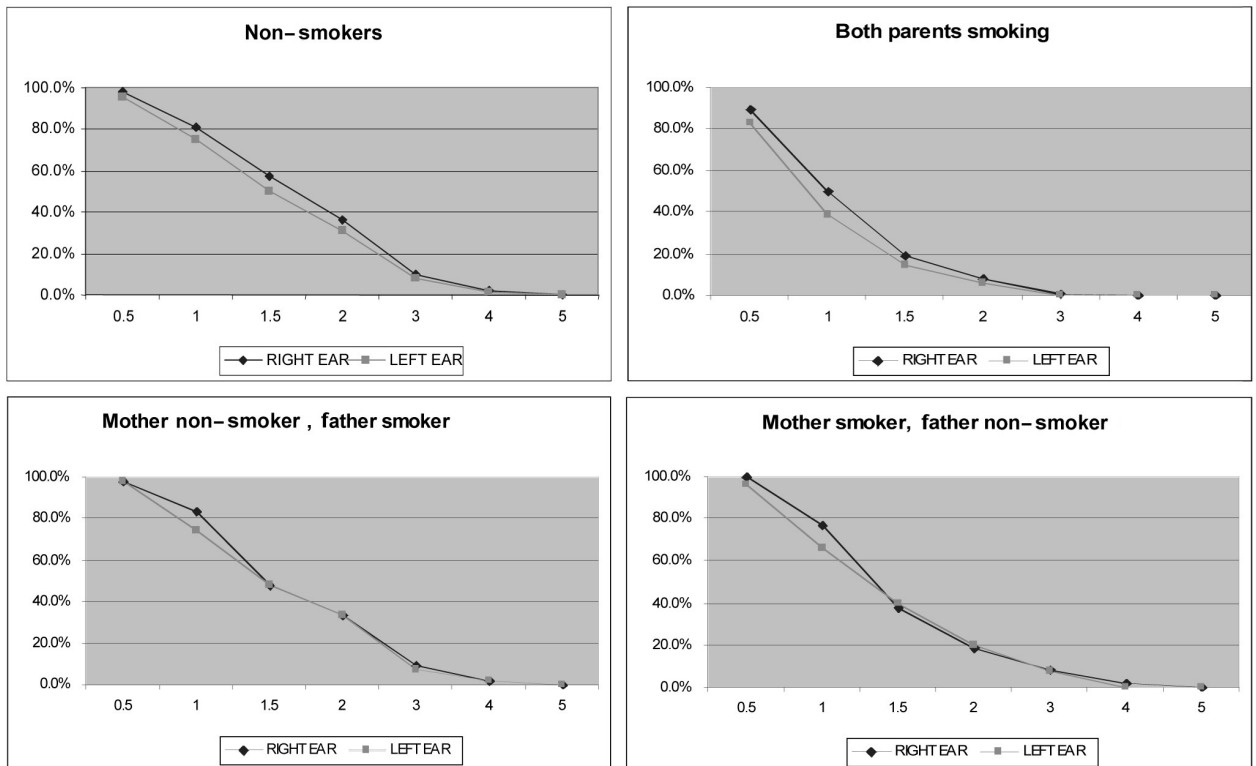


FIG. 3

Extrusion rate of grommets (in years) At the end of one year, 57 per cent of children had their grommets extruded if both their parents smoked as opposed to 21 per cent if both their parents were non-smokers.

TABLE III  
 MEDIAN SURVIVAL OF GROMMETS IN WEEKS. THE EXTRUSION RATE INCREASES IF BOTH PARENTS SMOKE

	Median survival of grommet (in weeks)	95% confidence interval
Both parents smoke	59.9	53.9 to 65.9
At least one parent smokes	69.9	66.0 to 73.7
Neither parent smokes	86.0	78.7 to 93.3
Narrow ear canals	45.0	36.7 to 53.3

were the first to report this positive association in 1983. Our study shows an adverse effect of passive smoking by parents on children causing high incidence of myringosclerosis, narrow ear canals, attic retraction, permanent perforation of tympanic membrane, post-operative infection requiring antibiotics and early extrusion of grommet.

Tympanosclerosis is an abnormal condition of the middle-ear cleft in which there are calcareous deposits in the tympanic membrane, tympanic cavity, ossicular chain and occasionally in mastoid.<sup>21</sup> Myringosclerosis is tympanosclerosis limited to tympanic membrane. Myringosclerosis is more common than tympanosclerosis, the incidence ranging from 24 per cent to 51 per cent in chronic otitis media<sup>22</sup> to 61 per cent after grommet insertion.<sup>21</sup> The exact aetiology and pathology of tympanosclerosis is not known; several factors influence its pathogenesis and inflammation, otitis media with effusion and autoimmune factors have all been postulated.<sup>22</sup> Hinton<sup>10</sup> addresses post-extrusion myringosclerosis in passive smokers and does not report any statistically significant finding with passive smoking. We found a high incidence of statistically significant post-extrusion myringosclerosis in passive smokers and the incidence increases if both parents smoke.

The present study found significant narrowing of the ear canal in children when their mothers smoked during pregnancy. This finding has not been reported in English literature. Narrowing of the ear canal makes the surgery difficult and increases the duration of surgery. The foetus of a smoking mother is an involuntary smoker and is a captive recipient of tobacco chemicals passed across placenta from the mother.<sup>12</sup> There are reports which suggest that smoking during pregnancy causes generalized retardation in intrauterine growth, resulting in babies with low birth weight,<sup>15,23</sup> shorter lengths<sup>12</sup> and smaller head circumference.<sup>24</sup> The narrow ear canals in children whose mother smoked during pregnancy that we found in our study may be due to intrauterine growth retardation and small head circumference but needs more study in this area. Narrow ear canals were also associated with early extrusion of

grommets and needed repeated surgical intervention.

Maternal smoking in pregnancy also causes effects on child development. Studies have shown an effect on mental development, a reduction in cognitive functioning by the age of three and a reduction in vigilance in the young child.<sup>25-27</sup> We found significant increase in post-operative infection causing otorrhoea in children exposed to passive smoking and receiving at least two courses of antibiotics from general practitioners over six months. Ey *et al.*<sup>17</sup> found an increased risk for recurrent otitis media and maternal smoking during pregnancy and during infancy. Ilicali *et al.*<sup>18</sup> did not find any statistically significant difference in children exposed to passive smoke for post-operative otorrhoea, but their study group was very small compared to ours. Passive smoking could promote eustachian tube dysfunction by increasing secretion of mucus, causing tissue congestion near the eustachian tube, compromising phagocytic defences against bacteria, and decreasing ciliary motility in middle-ear mucosa.<sup>28,29</sup> The middle-ear mucociliary system plays an important role in clearing middle-ear effusions. ETS affects middle-ear effusion in children in two ways:<sup>16</sup>

- (1) It directly causes an irritant effect on middle-ear mucosa and the eustachian tube, and it damages the mucociliary clearance mechanism. Passive smoking can impair ciliary function and cause persistent otitis media;<sup>29</sup> this may explain a high incidence of post-operative otorrhoea in children exposed to passive smoking.
- (2) It indirectly causes irritation of adenoid tissue and increased release of histamine, which in turn leads to production of middle-ear effusion. ETS is also thought to depress immune function and render an individual more susceptible to bacterial and viral infection.<sup>14</sup>

Bonham and Wilson<sup>24</sup> report that ETS could directly affect the susceptibility of children to respiratory disease by decreasing their lung function. Collet *et al.*<sup>30</sup> found heavy smoking to be a significant risk factor for four or more episodes of otitis by the age of four. They also found the risk of otitis media

TABLE IV  
 ATTIC RETRACTION WAS MORE COMMON IN THE SMOKING GROUP AND IN THE LEFT EAR

	Attic retraction present				No attic retraction	
	Pre-op		Post-op		Pre-op	Pre-op
	R	L	R	L	R	L
No smoking	6	15	3	13	226	241
At least one parent smokes	21	34	13	23	335	296
Total	27	49	16	36	561	537

R = right ear; L = left ear

progressively increased with the amount smoked by mothers. Collet *et al.*<sup>30</sup> also report increased incidence of otitis media in boys than girls, which is similar to what we found in our study.

- **Previous studies have identified passive smoking as a significant aetiological factor in otitis media with effusion (OME)**
- **This study investigates the influence of passive smoking in children having undergone ventilation tube insertion**
- **Post-operative infection rate, attic retraction, myringosclerosis and residual tympanic membrane perforation were all more common in children exposed to passive smoking**
- **This study provides further evidence of the harmful effect of passive smoking on children with OME**

Our findings are consistent with the findings of Kitchens<sup>31</sup> who reports early extrusion of grommets in children exposed to passive smoke. Ilicali *et al.*<sup>18</sup> did not find any difference in early extrusion rate in their study, however their patient group was small compared to ours. Early extrusion increases the chances of recurrence of glue, revision surgery and more economic burden on the health service.

Cotinine is a major metabolite of nicotine, is the most suitable marker to measure passive exposure to tobacco smoke and can be found in body fluids. Strachnan *et al.*<sup>33</sup> found abnormal tympanometric findings in seven-year-old children with high concentration of cotinine in their saliva. They showed a relationship between abnormal tympanometric findings with maternal smoking, the number of smokers in the house, the type of accommodation, and they attribute about one-third of cases of middle-ear effusions to passive smoking. Ilicali *et al.*<sup>32</sup> measured urinary cotinine by radioimmunoassay method and found increased incidence of otitis media in children exposed to passive smoke. Unfortunately, because of lack of funds, we were unable to measure cotinine in our study.

These results show that 'second hand smoking' has a significant effect on the outcome of grommet insertion. Since 'glue ear' is the most common reason for hospitalization for surgery in children, it imposes a heavy financial burden on the healthcare system and thus has an enormous economic impact. ETS adds to this economic impact in so many ways, by increasing antibiotic prescription post-operatively, by increasing early extrusion of grommets, by increasing the rate of perforation of tympanic membrane requiring further surgery, by increasing attic retraction needing long-term follow up, and by an increased rate of tympanosclerosis.

The important highlight of this study is the

significant post-extrusion myringosclerosis and narrow ear canals in children exposed to passive smoking during pregnancy, hitherto not reported in English literature. In this study heavy smoking was found to be a significant factor in causing post-operative otorrhoea and early extrusion of grommets. The effect was greatest when both parents smoked and also smoked in their car. The study provides further support to professional and governmental advice that parental smoking is harmful to children. Cessation of smoking may reduce the number of surgical procedures required in the long term.

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