

Glycerol particle cigarettes: a less harmful option for chronic smokers

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Abstract

In 20 smokers who switched to a new type of virtually tar free cigarette for three days, average nicotine intake was reduced by 44%, carbon monoxide intake increased by 19%, while estimated tar intake was reduced by about 90%. Such cigarettes pose substantially less risk of cancer and chronic obstructive lung disease than conventional cigarettes, and their acceptability and safety could be improved by increasing nicotine yield, reducing carbon monoxide yield, and improving the flavour.

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Strategies to lower the risks of smoking are an important part of the overall programme to reduce smoking related disease. The main objective is to reduce the tar intake of smokers,¹ but tar and nicotine yields are highly correlated (about 0.9) so that greater reductions in tar intake are limited by the reluctance of smokers to tolerate similar reductions in nicotine.² This has led to recommendations for the development of low tar cigarettes with slightly enhanced nicotine yields (up to 1 mg) to improve acceptability to smokers and to reduce compensatory increases in the intensity of smoking.¹

An American tobacco company recently developed a virtually tar free cigarette (brand name Premier) which heats rather than burns tobacco.³ The smoke particles in which nicotine is transported are comprised mainly of glycerol and water rather than tar. Glycerol is harmless, easily absorbed, and metabolised as a source of energy. The yields of all major carcinogens and many other potentially harmful components are far lower than those of conventional cigarettes and the biological activity of its condensate is also greatly reduced.⁴ The yield of nicotine free dry particulate matter is 5.7 mg per cigarette, of which 4.6 mg is glycerol and 0.4 mg is propylene glycol, giving a conventional "tar" yield of about 0.7 mg per cigarette. The nicotine and carbon monoxide (CO) yields are 0.3 mg and 12.0 mg respectively. These compare with sales weighted average yields of current UK cigarettes of 13.1 mg tar, 1.18 mg nicotine and 14.4 mg CO.⁵ To evaluate the potential of the glycerol particle cigarette as a

less harmful form of smoking, we conducted two studies of the blood nicotine and CO levels obtained from these cigarettes and assessed their acceptability to smokers.

Methods

In both studies glycerol particle cigarettes in packs of 20 were used. In the first study four healthy men abstained from smoking for at least 12 hours (confirmed by expired air levels of CO (ECO)) and then smoked a glycerol particle cigarette in a standardised way by puffing at 30 second intervals and inhaling as deeply as possible until the cigarette was finished (mean 13 puffs in six minutes). Venous blood samples to measure nicotine concentration were taken before and 1, 2, 5, 10, 15, 20, 30, and 45 minutes after finishing the cigarette. A second cigarette was then smoked and blood sampled on the same schedule up to 15 minutes. ECO was measured before and 4-5 minutes after each cigarette.

In the second study the intention was to compare cigarette consumption and measures of smoke intake before and after switching to glycerol particle cigarettes for a week. Thirty five smokers (17 women) were recruited to the study. In the afternoon of a day of normal smoking ECO was measured 4-5 minutes after smoking one of their usual cigarettes, and a blood sample was taken two minutes after completing the cigarette for measurement of nicotine and cotinine. Subjects were then instructed to smoke only glycerol particle cigarettes, but as many as they wished, until reattendance for expired air and blood sampling at the same time three days and, in some cases, seven days later. Questionnaire measures of withdrawal symptoms and satisfaction were completed before and after switching to glycerol particle cigarettes.

Results

The blood nicotine profiles of the four subjects in the first study illustrate the rapid absorption of nicotine during smoking (fig). Peak levels were obtained within one minute of the last puff on both occasions. The overall average blood nicotine boost per cigarette was 13.0 (range 10.6-16.0) ng/ml. The ECO increase averaged 7.8 (range 6.0-9.0) ppm per cigarette and was similar on each

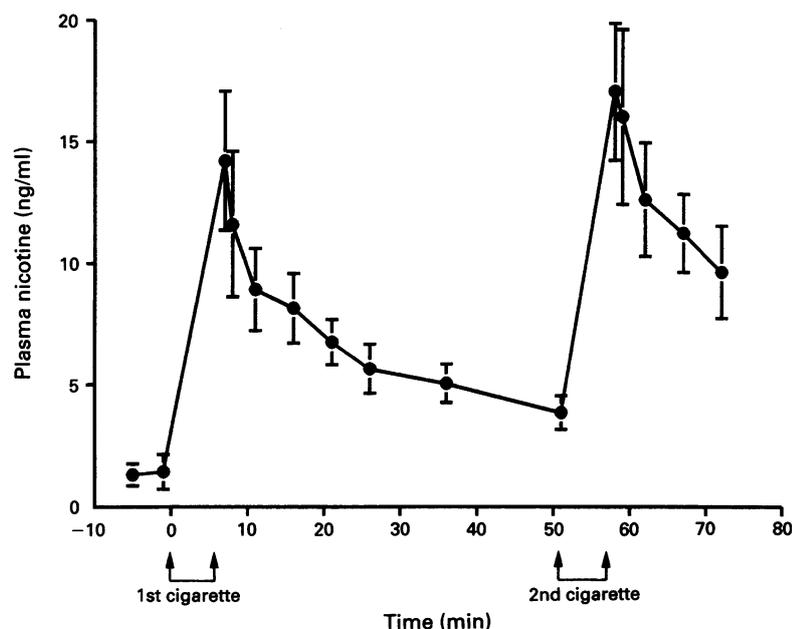
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Mean (SD) plasma nicotine concentrations of four subjects who smoked a single glycerol particle cigarette followed by a second one after 45 minutes (1 ng/ml nicotine \approx 6.25 nmol/l).

occasion (means 8.3 and 7.8 ppm).

As a result of low acceptability of the glycerol particle cigarette, only five of the 35 subjects in the second study were able to tolerate it for a week, 15 persisted for three days and 15 dropped out earlier or were withdrawn having smoked at least one of their usual brand of cigarettes. Measures of smoke intake from the usual brand and the changes after switching to glycerol particle cigarettes did not differ significantly between those who switched for three rather than seven days, or those who dropped out, and pooled data of the 20 subjects before and after switching are shown in the table.

Nicotine intake was significantly reduced by 44.1% after switching to glycerol particle cigarettes. This reduction was substantially

less than the 72.2% decrease in nicotine yield of glycerol particle cigarettes compared with the usual brand, indicating that the subjects were partially compensating by inhaling more deeply since the number of cigarettes smoked remained unchanged. Although the CO yield of the glycerol particle cigarette was less than that of the usual brands, average CO intake was increased by about 19% after switching, again reflecting the compensatory increase in inhalation. Despite smoking harder to obtain sufficient nicotine, estimated tar intake from the glycerol particle cigarette was decreased by about 90%.

Acceptability of the glycerol particle cigarette was a problem and 15 of the 35 subjects dropped out of the study complaining about its sweet taste and smell. Glycerol particle cigarettes were rated by the 20 subjects who persisted as significantly ($p < 0.001$) less satisfying, harder to puff, weaker, and as having a "bad" taste compared with each subject's usual brand. Although 12 subjects described at least moderate craving for their usual brand, there were no changes after switching in any other measures of tobacco withdrawal symptoms. Seven subjects thought that they could switch permanently to glycerol particle cigarettes.

Discussion

Despite its low nicotine yield, the average blood nicotine boost of 13.0 ng/ml from the glycerol particle cigarette was similar to the 14.3 ng/ml boost reported for conventional cigarettes smoked under similar laboratory conditions.⁶ Had the subjects in our second study puffed and inhaled as hard as those in the first study, they could have maintained their usual nicotine levels. The results show that compensation was only partial, although sufficient to raise the CO intake above that on the usual brand. The excessive puffing and inhalation required to maintain adequate

Mean (SD) cigarette yields and measure of smoke intake in 20 subjects who used glycerol particle cigarettes for at least three days

	Usual brand	Glycerol particle cigarette	Difference between glycerol particle cigarette and usual brand			
			Mean	95% CI	% change	<i>p</i>
Cigarette yields:						
Nicotine yield (mg/cigarette)	1.08 (0.19)	0.3	-0.78	(-0.86, -0.69)	-72.2	0.001
CO yield (mg/cigarette)	13.5 (2.52)	12.0	-1.52	(-2.70, -0.34)	-11.1	0.014
Tar yield (mg/cigarette)	12.6 (2.44)	0.7	-11.9	(-13.1, -10.8)	-94.4	0.001
Intake measures:						
Cigarettes/day	23.2 (7.27)	22.0 (7.64)	-1.16	(-4.22, 1.90)	-5.17	NS
Plasma nicotine (ng/ml)	36.7 (16.6)	20.5 (12.2)	-16.2	(-23.1, -9.28)	-44.1	0.001
Plasma cotinine (ng/ml)	280 (176)	195 (120)	-84.9	(-142, -27.5)	-30.4	0.006
ECO (ppm)						
Before cigarette	28.0 (16.4)	32.2 (20.1)	4.28	(0.12, 8.4)	17.5	0.044
After cigarette	34.0 (17.2)	39.7 (22.0)	5.78	(1.10, 10.5)	19.0	0.018
Boost/cigarette	6.0 (4.2)	7.5 (5.4)	1.50	(-1.4, 4.4)	25.0	NS
Index of tar intake:						
TI (nicotine)	435 (209)	47.9 (28.6)	-387	(-487, -296)	-89.0	0.001
TI (cotinine)	3340 (2210)	455 (281)	-2884	(-3334, -1941)	-86.4	0.001
TI (CO)*	31.9 (16.0)	2.32 (1.29)	-29.6	(-36.6, -22.6)	-92.8	0.001

CO—carbon monoxide; ECO—expired air carbon monoxide; TI—tar index.

Percentage change in CO intake was calculated after subtracting 4 ppm to correct for background level in non-smokers. Index of tar intake derived from a measured intake marker (nicotine, ECO) and the ratio of the tar to marker yields of the cigarette—for example, tar index (nicotine) = plasma nicotine \times tar/nicotine yield ratio.⁷ Probability values based on a paired sample *t* test between usual brand and glycerol particle cigarette.

*Based on CO value after cigarette.

Nicotine, 1 ng/ml \approx 6.25 nmol/l; cotinine, 1 ng/ml \approx 5.68 nmol/l.

nicotine levels is likely to have been mildly aversive and this, coupled with the rather unpleasant sweet taste and smell, would have deterred subjects from greater perseverance.

Although it would be far better to give up smoking altogether, there is no question that the risks of tobacco related cancers and chronic obstructive lung disease would be substantially reduced, possibly by as much as 90%, for the average smoker who switched to glycerol particle cigarettes. As CO may play a part in cardiovascular risk, the increased intake shown in our study is cause for concern. It should be technically possible, however, to reduce the CO yields and, with a doubling of the nicotine yield to 0.6 mg, compensatory increases in inhalation would be reduced. To the extent that nicotine itself is implicated in cardiovascular disease, our study indicates that intake is reduced despite partial compensation.

In its present form the glycerol particle cigarette is marred by lack of acceptability because of low nicotine yield and poor taste. After modification to increase nicotine yield, reduce CO yield, and improve flavour, it could provide an alternative to conventional

cigarettes that is almost free of the risk of cancer and chronic obstructive lung disease while carrying a risk of cardiovascular disease that is no greater. It could be particularly valuable for patients with chronic pulmonary disease who continue smoking despite all efforts to persuade them to stop.

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- 1 *Third report of the independent scientific committee on smoking and health*. London; HMSO, 1983.
- 2 Wald N, Froggatt P, eds. *Nicotine, smoking and the low tar programme*. Oxford; Oxford University Press, 1989.
- 3 *Chemical and biological studies on new cigarette prototypes that heat instead of burn tobacco*. Winston-Salem, North Carolina: RJ Reynolds Tobacco Co, 1988.
- 4 DeBethizy JD, Borgerding MF, Doolittle DJ, Robinson JH, McManus KT, Rahn CA, *et al*. Chemical and biological studies of a cigarette that heats rather than burns tobacco. *J Clin Pharmacol* 1990;30:755-63.
- 5 Department of Health. Survey 29. In: *The London Gazette*, 52247, 20 August 1990. London: HMSO.
- 6 Benowitz NL, Porchet H, Sheiner L, Jacob P. Nicotine absorption and cardiovascular effects with smokeless tobacco use: comparison with cigarettes and nicotine gum. *Clin Pharmacol Ther* 1988;44:23-8.
- 7 Russell MAH, Jarvis MJ, Feyerabend C, Saloojee Y. Reduction of tar, nicotine and carbon monoxide intake in low tar smokers. *J Epidemiol Community Health* 1986;40:80-5.