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# Urinary point-of-care test for smoking in the pre-operative assessment of patients undergoing elective plastic surgery☆

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**Summary** Self-reported information about smoking habit and cigarette consumption can be inaccurate and subject to bias in the clinical setting. Accurate assessment of a given smoking history at point-of-care is valuable. We describe the use of a comprehensive smoking questionnaire and the use of a disposable biomarker test to verify and quantify the exposure to tobacco smoke. This point-of-care test (SmokeScreen®) is a 6-min, easy-to-use urine test that measures nicotine and its breakdown products.

One hundred consecutive patients attending plastic surgery pre-assessment clinic filled in the questionnaire and gave a consented urine sample. Qualitative and semi-quantitative assessment of tobacco consumption was observed by a simple sample colour change set against a standardised colorimetric chart for nicotine metabolite containing urine. The questionnaire self-reported smoking prevalence was 30% with 98% test specificity. The cotinine validated smoking prevalence was 54% with a 26% self-denial rate. Half the patients ($n = 15$) who admitted smoking on the questionnaire underreported the amount they smoked daily, as quantified by biochemical measurement.

Objective biochemical assessment shows that 26% of self-reporting non-smokers via self-completed questionnaire studies are actual smokers attending this pre-assessment clinic. When patients did report smoking there was consistent underreporting of cigarette consumption.

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Cigarette smoking is a significant contributor to preventable surgical morbidity and mortality. Comprehensive investigations have shown the effect of smoking on blood and plasma viscosity,[1]

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tissue hypoxia, cutaneous vasoconstriction,[2] hand[3] and digital blood flow[4,5] producing an overall thrombogenic, peripherally ischaemic state.

Impaired wound healing and poor surgical outcomes in several areas of plastic surgery including abdominoplasties,[6] breast reconstruction,[7,8] digital replantation[9] and face-lifts[10,11] reinforce the fact that cutaneous blood flow is most susceptible to the toxic chemical composition of tobacco smoke. The commonly used reconstructive tissues of skin, muscle, bone and adipofascial tissue all have a low blood flow rate and high vascular resistance responding with greater affinity to the vasoconstrictor effect of nicotine and its metabolites.

Patient smoking histories, smoking education and provision of guidelines are established at the time of consultation but in practice, even with impending medical intervention, many patients continue to smoke.[12,13] The accuracy of self reporting relates to the circumstances – if there are no penalties involved self reporting is more reliable.[14] Increased operative risks and even cancellation is the ultimate deterrent but in truth there is an incentive to falsify information.

The assessment of smoking behaviour is complex as it has to take into account: the yield of cigarettes smoked, the puffing behaviour, depth of inhalation, efficiency of absorption and metabolism. This would be hard to assess from a simple questionnaire. To overcome these problems, biomarkers of tobacco smoke have become increasingly important. These are tested to a high degree of sensitivity with a range of sophisticated laboratory techniques detecting nicotine metabolites in plasma,[15] urine, saliva[16] and hair.[17] Cotinine is a valuable and highly sensitive marker for verifying and quantifying tobacco use.[18]

A point-of-care, non-invasive biochemical test to verify self-reported smoking behaviour preoperatively was used in this study. This gave a qualitative and semi-quantitative assessment of tobacco consumption simply by observing a colour change with reference to a colour chart,[19] which includes a compensation factor for urine dilution. Our aim, in this audit, was to determine if the subjective assessment of smoking status using a comprehensive questionnaire correlated to the more accurate biochemical analysis.

## Methods

A total of 100 patients (62 females, aged 27–78 years, 38 males, aged 18–81 years) attending preadmission clinic for elective surgery at a large inner-city hospital plastic surgery unit were asked to fill in a comprehensive smoking questionnaire. This was followed by a consented urine sample. All questionnaires were given out and the urine samples were collected by the nursing staff to prevent bias. It has been demonstrated that if the investigator administers the self-report they can identify smokers due to sensory cues, such as nicotine stains, facial skin changes and odour.[14] This audit was undertaken with full patient consent and an understanding that this would have no influence to their overall management.

### Questionnaire

The 27-point questionnaire was specifically and simply worded to obtain critical information on current, previous and passive smoking status. The current smoker section determined how many cigarettes the patient had consumed over the preceding 48 h, how many they usually consume and if the patient had used any alternative nicotine source such as gum or patches. The other sections of investigation highlighted in the questionnaire were concerned with ex-smokers, exact exposure to passive smoking and some general patient and operative information.

### Measurement of urinary nicotine metabolites

The point-of-care test (SmokeScreen®, Surescreen Diagnostics, Derby, UK) is a disposable colorimetric assay, based on the König reaction and measures the presence of a pyridine ring, a common feature of nicotine metabolites. The plastic testing device consists of a 2-ml sampling device and a reaction chamber (Fig. 1). The chamber holds the dry reagents sodium citrate, citric acid, potassium cyanide and 2,2-dimethyl-1,3-dioxane-4,6-dione. The other main reagent, Chloramine-T, is isolated in a washer-like annulus between two tightly fitting plastic discs. The chamber is sealed as the urine sample is introduced through these discs into the reaction chamber. The urine is mixed thoroughly with the reagents and the colour was allowed to develop.[20]

If the sample contained nicotine or its breakdown products, the reaction produced a pink/red end-point in a concentration-dependant manner. A colour change was observed after 6 min for adequate and reproducible colour development. The SmokeScreen® test is also semi-quantitative as the change in colour is proportional to the nicotine metabolite concentration, set out in a laboratory cotinine concentration calibrated colour wheel giving four panels of graduated colour density

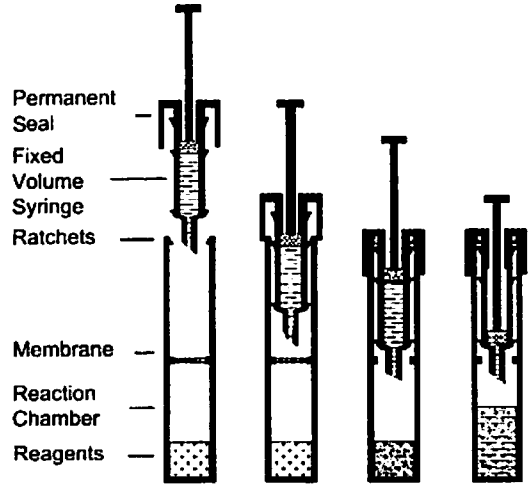


**Figure 1** Diagram of the point-of-care test for smoking showing the two-part device, the upper sampling unit and the lower reaction chamber where the urine sample mixes with the reagents and changes in colour if a sample is positive for nicotine metabolites. The depth of colour is proportionate to the nicotine intake.

(Fig. 2). Urine dilution is compensated for by independent laboratory measurement using gas-chromatography and is represented as the six inner sectors on the colorimetric wheel.

The point-of-care test results were compared to the subjective answers on the questionnaire. The semi-quantitative analysis compared the degree of colour change in the smoking test with reported daily cigarette consumption. All biochemical analyses were carried out by the same clinician without the prior knowledge of the questionnaire answers or any direct contact with the test subjects.

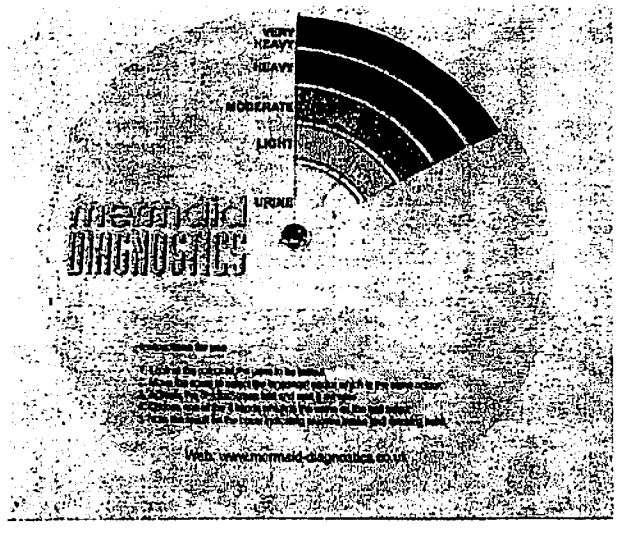


**Figure 2** The colour chart for semi-quantitative assessment of the point-of-care test result. The chart is a roundel divided into six segments, each divided into five sectors. The inner sector of different shades of yellow relates to different urine dilutions. The pink/orange sectors above this are analogous to light, moderate, heavy and very heavy nicotine intake.

## Results

Patients attending pre-assessment clinic ($n = 100$), were recruited to the study, between April and July 2004. No patient refused the urine test post completion of the questionnaire. Eighty-five patients were assessed for general anaesthetics and 15 for local or with a block. The majority were admitted for hand operations (41), 35 for breast and/or abdominal operations and 24 for general plastic surgery procedures.

### Qualitative assessment

Thirty patients declared smoking on the questionnaire validated by a 28% positive biochemical test result. Two patients declared smoking but at such an infrequent rate that the urine nicotine metabolite level was insufficient to give a colour change (98% sensitivity).

With respect to the self-reported smoking via the questionnaire, 70% declared that they did not smoke, 29% of these disclosed that they were ex-smokers. No patients at the time of the test were using nicotine replacements according to the questionnaire answers. Biochemical validation by the SmokeScreen® test indicated that 26 self-declared non-smokers were positive and the true number of ex-smokers was actually only seven (Table 1).

Seventeen of these 26 self-declared non-smoker patients were females, but this reflects the overall gender ratio seen in this study. This is in keeping with the previous studies that show there does not tend to be any gender differences in self-reported smoking practices.[21] Importantly, 88% of these female patients were pre-admitted for elective breast and/or abdominal surgery such as free tissue transfer, abdominoplasties or breast augmentation/reduction. Cigarette consumption equates to a similar cotinine equivalent concentration in

**Table 1** Results revealing the concordance between the subjective questionnaire answers and the objective point-of-care SmokeScreen® test outcomes

| Patient smoking responses | SmokeScreen® | |
|---|---|---|
| | Negative | Positive |
| Questionnaire negative | 44 | 26 |
| Questionnaire positive | 2 | 28 |

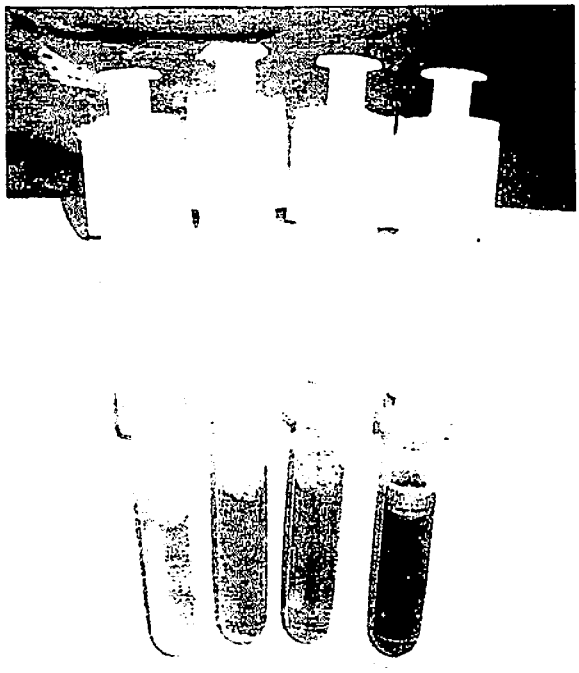

Figure 3 SmokeScreen® Safetubes showing the range of colour change from pale pink to deep orange after 6 min. Semi-quantitative assessment of tobacco consumption is read from the colour wheel; pale pink relates to an average of five cigarettes/day to the deep orange indicating over 20 cigarettes/day.

μg/ml reflected in the graduated calibrated colour wheel (Fig. 3, four tubes). Hence, on data analysis 10 of these self-denial patients were light smokers, 13 medium, two heavy and one very heavy tobacco consumer (Table 2).

## Semi-quantitative assessment

Of the true 28 smokers on questionnaire data, 50% gave accurate daily cigarette consumption validated by the SmokeScreen® test result (±5 cigarettes). Of the other 14 patients there was a 195% overall increase between declared and actual consumption with one patient declaring three per day but with a cotinine level on biochemical testing at over 20 per day (Table 3).

## Passive smoking

Fifty-six patients on questionnaire response advised they had no passive smoking exposure, 19 were non-smokers. Thirty-five estimated their exposure as little (18 non-smokers) and nine patients said they were exposed to heavy passive smoking. Of these, seven were non-smokers and all biochemical urine tests on these patients were negative for nicotine metabolites.

# Discussion

There is growing pressure on smokers to increasingly underestimate consumption, or even to deny smoking altogether. Society has evaluated the true cost of smoking and it is deemed in many countries now to be an anti-social behaviour with bans in public houses, bars and restaurants. In most of the developed world, smoking is the leading preventable cause of morbidity and death despite advances in clinical knowledge and treatment. These facts are true in patients undergoing surgery, but there are great emotional and physical strains so that smoking cessation, with clinically proven reduction in elective operative risk, often does not outweigh the benefit they feel on continuing smoking.

Stedman's paper[22] reveals that tobacco smoke contains over 3800 toxic and carcinogenic compounds and gases. Sophisticated laboratory-based measurements of these metabolites in various body constituents provide biochemical information on smoking behaviour but these are time-consuming, expensive and sometimes invasive.

Urinary cotinine is a sensitive derivative of nicotine with an extended plasma and urine elimination ($t½ = 16–20$ h).[23] This property, with non-invasive specimen collection, renders it ideal as the biochemical verification of a self-reported smoking history at the pre-assessment stage. The longer half-life has the advantage of a positive

Table 2 Cotinine equivalent nicotine consumption as shown on the colour wheel and translated into quantity per day. Daily consumption estimation of the 26 self-denial patients via the SmokeScreen® test, from five to 20+ cigarettes/day

| Smoking habit | Light | Medium | Heavy | Very heavy |
|---|---|---|---|---|
| Average cigarettes/day | 5 | 10 | 15 | 20+ |
| Twenty-six self-denial patients' SmokeScreen® consumption | 10 | 13 | 2 | 1 |

Table 3 Fourteen questionnaire self-reported smokers with an overall 195% discrepancy of disclosed consumption to actual consumption validated biochemically by the SmokeScreen® test

| 14 Smokers | |
|---|---|
| Self-disclosed cig/day | SmokeScreen® predicted cig/day |
| 3 | 10–15 |
| 3 | 10–15 |
| 4 | 10–15 |
| 6 | 10–15 |
| 5 | 10–15 |
| 4 | 15–20 |
| 8 | 15–20 |
| 7 | 15–20 |
| 8 | 15–20 |
| 5 | 15–20 |
| 3 | 15–20 |
| 10 | 20+ |
| 6 | 20+ |
| 3 | 20+ |

SmokeScreen® test 2–3 days after the last cigarette smoked, especially in a heavy smoker (Cope, 2004 personal communication).

The 26% self-denial patients could only have been positive if they smoked tobacco, as dietary nicotine-like substances are found in the nightshade family (Solanaceae) (i.e. tomatoes, potatoes, aubergines and peppers) and in various teas but only at a consumption level of about 1.4 μg/day.[24] Passive smoking was declared high in seven of the 26 questionnaire responses. This can be assumed irrelevant as subjective visual analysis could not determine a positive SmokeScreen® test even in the non-smoking/high passive exposure group. Colorimetric analysis at 490 nm does allow quantification of environmental smoke exposure using this bed-side test.[20]

Interestingly, the questionnaire allowed analysis on the validity of self-declared daily cigarette consumption by correlating it to the urine concentration of nicotine metabolites and referenced to the cotinine standard colour wheel. The test is semi-quantitative as nicotine and cotinine concentration are influenced by age, gender, type of cigarette, puff topography, inhalation and heterogeneity of metabolism. Out of the self-declared smokers in our study, half underreported their smoking consumption. This exact level of information deception using plasma cotinine was reported in a study of pregnant women.[25] It may be that this denial behaviour is enforced by adverse media attention, the global knowledge that smoking is detrimental to health and now, an anti-social label. Forces acting on pre-operative patients to underreport their consumption are due to the intensity of the anti-smoking environment and the suspicion that if they admit to heavy smoking their operation will be cancelled.

Denial and underreporting are important factors when considering the severe manifestations of circulating tobacco compounds in skin and soft-tissue. Maximum nicotine vasoconstriction occurs after only one cigarette and last 90 min. There is a high chance that a smoker of greater than 10 cigarettes a day will have had another before the end of this period producing a permanently constricted state. These are major concerns to the operative surgeon and to the observer may appear less threatening than the acknowledged cardiovascular, pulmonary and neoplastic outcomes of tobacco use. Compromised wound healing in reconstructive surgery post neoplasm excision, aesthetic surgery or limb trauma is 20–50% higher in smokers than in non-smokers,[6,7,9,10] but these figures have little publicity.

Several health-orientated smoking studies using a questionnaire as the subjective data on smoking habits and verified by an objective biochemical analysis show similar self-denial results.[13,25] Meta-analysis of 26 studies on self-reported behaviour and biochemical measurement showed an overall sensitivity of 87% and a specificity of 89% on self-reporting.[14] This is probably true in general population studies where there is no motive to deny smoking or consequence if smoking is continued.[26]

These findings have implications to health professionals who may only have a patients' self-reported smoking status pre-operatively. There is a real need for smoking validation using biochemical tests not only to accurately assess the pre-operative smoking status but also to help people reduce or abstain from smoking as part of a cessation programme.

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