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CIGARETTE SMOKING AND SURGICAL WOUND HEALING: A PROSPECTIVE COMPARATIVE COHORT STUDY OF POSTOPERATIVE OUTCOMES AT A TERTIARY CARE CENTRE IN SOUTH INDIA

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ABSTRACT

Background: Cigarette smoking is a well-recognised, modifiable determinant of impaired tissue repair, yet comparative data quantifying its effect on postoperative wound outcomes remain limited in South Asian surgical populations, particularly when weighed against common comorbidities such as diabetes and hypertension. **Objectives:** To compare postoperative recovery, wound healing status, pain trajectory, and complication rates between smokers and non-smokers undergoing clean and clean-contaminated surgery, and to determine whether smoking, diabetes, or hypertension independently predict delayed healing. **Methods:** A six-month prospective observational cohort study was conducted at Basaveshwara Medical College Hospital & Research Centre, Chitradurga, following institutional ethics committee approval. Two hundred and twenty adult postoperative patients were enrolled and allocated to a smoker group (n=110) or a non-smoker group (n=110). Demographic data, comorbidity status, and smoking history were captured with a structured questionnaire, and wounds were assessed serially on postoperative days 4, 7, 10, and 15 using standard clinical wound-grading criteria. Group comparisons used chi-square and independent-samples t-tests, and multivariate logistic regression was used to identify

independent predictors of delayed healing. **Results:** The two groups were age-matched (p=0.747); smoking was confined to male participants. Healthy wound healing was achieved by 83.6% of non-smokers versus 60.9% of smokers, while delayed healing was more than twice as frequent among smokers (39.1% vs 16.4%; p<0.001). Postoperative infection occurred in 10.0% of smokers compared with 2.7% of non-smokers (p=0.050). Smokers reported significantly higher pain scores on postoperative days 4, 10, and 15 (p<0.001 for each), with no significant between-group difference on day 7 (p=0.245). On multivariate logistic regression, smoking was the only independent predictor of impaired healing (odds ratio 0.32, 95% confidence interval 0.17–0.60, p<0.001); diabetes, hypertension, and their coexistence did not reach statistical significance. **Conclusion:** Smoking is a dominant, independent, and modifiable risk factor for delayed surgical wound healing, higher infection rates, and greater postoperative pain, with an effect that outweighs that of diabetes or hypertension in this cohort. Structured preoperative smoking-cessation counselling should be prioritised in surgical care pathways.

KEYWORDS (MESH): *Wound Healing; Smoking; Surgical Wound Infection; Postoperative Complications; Pain, Postoperative; Comorbidity; Nicotine.*

INTRODUCTION

Successful closure and repair of a surgical wound depends on an orderly sequence of haemostasis, inflammation, proliferation, and remodelling, each of which is oxygen- and perfusion-dependent.[1] When this sequence is disturbed, patients face a substantially higher likelihood of surgical site infection, wound dehiscence, delayed discharge, and, in severe cases, tissue necrosis — outcomes that extend hospital stay, escalate treatment costs, and diminish quality of life.[2] Among the many patient-level variables that influence this trajectory, cigarette smoking is unusual in being both extremely common and entirely modifiable, which makes it a natural target for preoperative intervention rather than merely a prognostic label.

The biological case against smoking in the perioperative period is well established. Nicotine is a potent vasoconstrictor that reduces cutaneous and subcutaneous blood flow, limiting the oxygen supply that fibroblasts and endothelial cells require for collagen synthesis and neovascularisation.[3] Independently, the carbon monoxide carried in tobacco smoke binds competitively to haemoglobin, lowering the oxygen-carrying capacity of blood, while hydrogen cyanide and other combustion products interfere with cellular respiration at the

mitochondrial level.[1] The cumulative effect is a wound bed that is relatively hypoxic during precisely the phase in which oxygen-dependent processes — epithelialisation, granulation tissue formation, and bacterial clearance by neutrophils — are most active. Several cohort studies have also demonstrated that smokers mount a blunted inflammatory and immune response at the wound margin, which both slows debris clearance and increases vulnerability to opportunistic pathogens.[3,4] Clinically, this translates into measurable differences: pooled analyses of surgical cohorts have reported that current smokers face a two- to three-fold higher risk of surgical site infection and wound dehiscence relative to never-smokers, alongside a roughly four-fold increase in tissue necrosis.[5]

The public-health scale of this problem is considerable. The World Health Organization estimates that more than a billion people worldwide use tobacco, a substantial proportion of whom will undergo at least one surgical procedure in their lifetime. In India, where tobacco use — including the locally prevalent bidi form, which carries a higher tar burden than manufactured cigarettes — remains widespread, surgical site infection rates reported across hospitals range from roughly 4% to 30%, appreciably higher than figures typically cited from high-income settings.[6,7] This is compounded by India's dual burden of communicable and non-communicable disease, in which smoking frequently coexists with diabetes mellitus and hypertension, two conditions independently linked to impaired perfusion and delayed tissue repair.[8]

Despite this substantial body of mechanistic and epidemiological evidence, important gaps persist in the clinical literature. Much of the published work on smoking and wound healing is drawn from specific surgical subspecialties — orthopaedic, plastic, or cardiovascular surgery — and comparatively few studies have examined general clean and clean-contaminated surgical cohorts with structured, serial wound assessment extending beyond the immediate postoperative window.[5,9] Furthermore, many existing analyses do not adequately separate the contribution of smoking from that of coexisting comorbidities such as diabetes and hypertension, leaving clinicians without a clear sense of the relative, independent weight that each factor carries once the others are accounted for. Data addressing this question from Indian tertiary care settings, where the smoking–comorbidity overlap is common and the healthcare resource burden of complications is considerable, remain particularly sparse.

This study was therefore designed to address these gaps directly. Using a prospective, serially assessed cohort of patients undergoing clean and clean-contaminated surgery at a tertiary care

centre in Karnataka, India, we aimed to quantify differences in postoperative recovery time, wound healing status, infection incidence, and pain trajectory between smokers and non-smokers, and to determine — using multivariate analysis — whether smoking retains independent predictive value for delayed healing once diabetes, hypertension, and their coexistence are taken into account.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational cohort study conducted in the surgical wards and operation theatre complex of Basaveshwara Medical College Hospital & Research Centre (BMCH & RC), Chitradurga, Karnataka, India, a tertiary care teaching hospital. The study was carried out over a period of six months and is reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guideline for cohort studies.

Participants

Inclusion Criteria: Patient undergoing clean and clean contaminated surgery; Patient from OT and surgery department; Patients above 18 years of age; Both male and female will be included in the study; Patients with other co-morbidities (Diabetes, Hypertension); Patients with social habits such as smoking, alcohol, tobacco.

Exclusion Criteria: Patients below 18 years of age; Patients who do not give consent; Pregnant and lactating mothers; Patients with mental health conditions; Patient with Diabetic Ulcer.

Eligible participants were allocated, on the basis of self-reported current smoking status, to Group A (smokers) or Group B (non-smokers). A total of 220 patients were enrolled, 110 in each group.

Sample Size

The estimated sample size was 182.

The sample size was de d by using formula mentioned below.

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \, [P(1 - P_1) + P_2(1 - P_2)]}{(P_1 - P_2)^2}$$

Where,

$\mathbf{Z_{\alpha/2}}$ = Significance i.e. 5% (0.05) **[α/2 = 1.96]**

$\mathbf{Z_{\beta}}$ = Power i.e. 80% (0.84)

P1 = Prevalence in smokers i.e. 40% (0.40)

P2 = Prevalence in non-smokers i.e. 20% (0.20)

Confounder adjustment = 15%

Variables and Data Collection

A structured, pre-piloted questionnaire was used to record demographic data (age, sex), smoking history (duration and frequency), alcohol use, coexisting diabetes mellitus and hypertension, and the type and classification of surgical wound (clean versus clean-contaminated). Wounds were evaluated at the bedside on postoperative days 4, 7, 10, and 15 by trained members of the study team using standard clinical assessment criteria, cross-referenced against established wound-grading frameworks, and recorded as one of three categories: healthy and clean, redness/swelling, or signs of infection. Postoperative pain was recorded on each assessment day using a numeric pain rating scale. The primary outcome was overall wound healing status (healthy versus delayed healing) at final follow-up; secondary outcomes were incidence of wound infection, postoperative pain scores, and length/cost of hospital stay.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics, version 29. Categorical variables were summarised as frequencies and percentages and compared between groups using the chi-square test. Continuous variables (pain scores) were summarised as mean ± standard deviation and compared using the independent-samples t-test. Multivariate logistic regression was used to evaluate smoking, diabetes, hypertension, and the combined presence of diabetes and hypertension as independent predictors of wound healing status, with odds ratios and 95% confidence intervals reported. A two-sided p-value below 0.05 was considered statistically significant throughout.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of Sri Jagadguru Mallikarjuna Murugharajendra College of Pharmacy, Chitradurga (Reference No. SJMCP/472/2024–2025). Written informed consent was obtained from all participants after the purpose, procedures, and voluntary nature of the study were explained in a language they understood.

RESULTS

Two hundred and twenty patients undergoing clean or clean-contaminated surgery were enrolled and divided equally into a smoker group (n=110) and a non-smoker group (n=110), permitting a balanced, one-to-one comparison across all outcome measures.

Baseline Demographic Characteristics

The two groups were closely matched for age. Non-smokers were most commonly aged 20–40 years (49/110, 44.6%) and 41–60 years (48/110, 43.6%), with a smaller proportion aged 61–80 years (13/110, 11.8%); the corresponding figures among smokers were 44/110 (40.0%), 50/110 (45.5%), and 16/110 (14.5%). This distribution did not differ significantly between groups (p=0.747), indicating that age is unlikely to have confounded the comparison of healing outcomes.

A marked sex disparity was observed in smoking behaviour. Among non-smokers, 90/110 (81.8%) were female and 20/110 (18.2%) were male, whereas the entire smoker cohort (110/110, 100%) was male, with no female smokers identified. This pattern is consistent with broader epidemiological data from South Asia, where tobacco smoking remains overwhelmingly concentrated among men, and it means that any sex-linked physiological differences in healing could not be fully disentangled from smoking status in this cohort.

Table 1: Baseline age and sex distribution of the study cohort (N=220).

Variable	Non-smokers n (%)	Smokers n (%)	p-value
Age 20–40 years	49 (44.6%)	44 (40.0%)	
Age 41–60 years	48 (43.6%)	50 (45.5%)	0.747
Age 61–80 years	13 (11.8%)	16 (14.5%)	
Female sex	90 (81.8%)	0 (0.0%)	<0.001
Male sex	20 (18.2%)	110 (100.0%)	

Wound Classification and Concurrent Alcohol Use

Clean-contaminated wounds predominated in both groups but were numerically more frequent among smokers (83/110, 75.5%) than non-smokers (73/110, 66.4%); clean wounds were correspondingly less frequent among smokers (27/110, 24.5%) than non-smokers (37/110, 33.6%). This difference did not reach statistical significance (p=0.181), so it should be interpreted as a possible trend rather than a confirmed association.

Concurrent alcohol use was reported exclusively within the smoker group. No non-smoker reported alcohol use (0/110, 0.0%), whereas 21/110 (19.1%) of smokers did so; the remaining

89/110 (80.9%) smokers reported no alcohol use. This association between smoking and alcohol use was highly significant (p<0.001), reflecting the well-documented clustering of these two behaviours, and it is a factor that future analyses with larger samples should adjust for independently.

Table 2: Wound classification and concurrent alcohol use by smoking status.

Variable	Non-smokers n (%)	Smokers n (%)	p-value
Clean wound	37 (33.6%)	27 (24.5%)	
Clean-contaminated wound	73 (66.4%)	83 (75.5%)	0.181
Alcohol use — No	110 (100.0%)	89 (80.9%)	
Alcohol use — Yes	0 (0.0%)	21 (19.1%)	<0.001

Serial Wound Status Assessment

Wound appearance was assessed on postoperative days 4, 7, 10, and 15 and classified as healthy and clean, showing redness/swelling, or showing signs of infection. Across these assessments, non-smokers consistently showed more favourable wound appearance: 92/110 (83.6%) were classified as healthy and clean, compared with 67/110 (60.9%) of smokers. Redness and swelling were noted in 15/110 (13.6%) non-smokers versus 32/110 (29.1%) smokers, and overt signs of infection were present in 3/110 (2.7%) non-smokers versus 11/110 (10.0%) smokers. The between-group difference in wound appearance was statistically significant at each assessment point (p=0.001), indicating a persistent, rather than transient, disadvantage for smokers across the postoperative course. (Figure 1).

Table 3: Wound status on clinical assessment (consistent pattern across postoperative days 4, 7, 10, and 15).

Wound status	Non-smokers n (%)	Smokers n (%)	p-value
Healthy and clean	92 (83.6%)	67 (60.9%)	
Redness / swelling	15 (13.6%)	32 (29.1%)	0.001
Signs of infection	3 (2.7%)	11 (10.0%)	

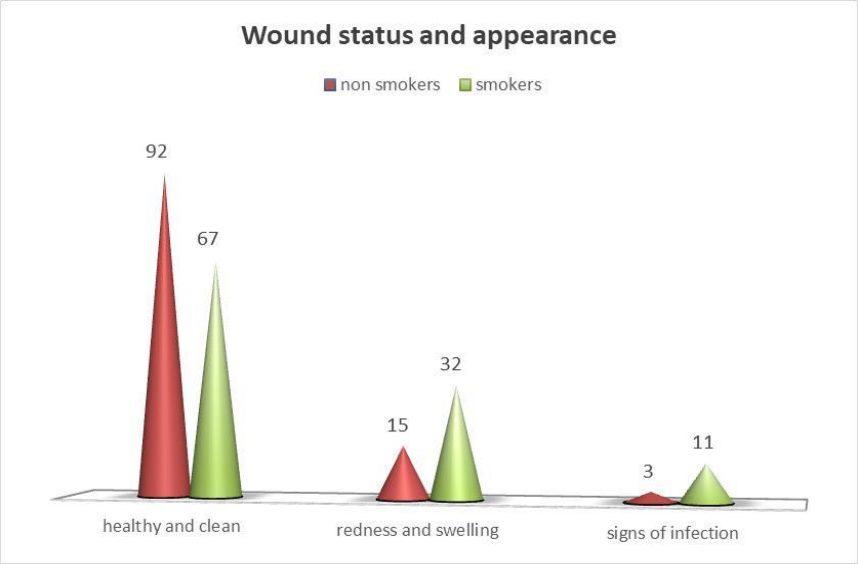


Figure 1: Wound status and appearance among smokers and non-smokers during postoperative assessment.

Postoperative Pain

Mean pain scores fell progressively in both groups over the follow-up period, but smokers reported significantly higher pain than non-smokers at three of the four assessment points. On day 4, smokers scored 8.35 ± 0.549 against 7.50 ± 0.955 for non-smokers ($p<0.001$). By day 7, scores had converged somewhat (smokers 5.92 ± 1.174 vs non-smokers 5.73 ± 1.256), and this difference was not statistically significant ($p=0.245$). The gap widened again thereafter: on day 10, smokers scored 3.29 ± 1.710 versus 2.45 ± 1.352 for non-smokers ($p<0.001$), and on day 15, smokers scored 4.45 ± 1.431 versus 3.62 ± 1.299 for non-smokers ($p<0.001$). The persistence of higher pain scores among smokers at later time points, after the initial postoperative peak had subsided in both groups, is consistent with ongoing impaired tissue perfusion rather than simple surgical trauma. (Figure 2).

Table 4: Comparison of postoperative pain scores (independent-samples t-test).

Postoperative day	Non-smokers Mean ± SD	Smokers Mean ± SD	p-value
Day 4	7.50 ± 0.955	8.35 ± 0.549	<0.001
Day 7	5.73 ± 1.256	5.92 ± 1.174	0.245
Day 10	2.45 ± 1.352	3.29 ± 1.710	<0.001
Day 15	3.62 ± 1.299	4.45 ± 1.431	<0.001

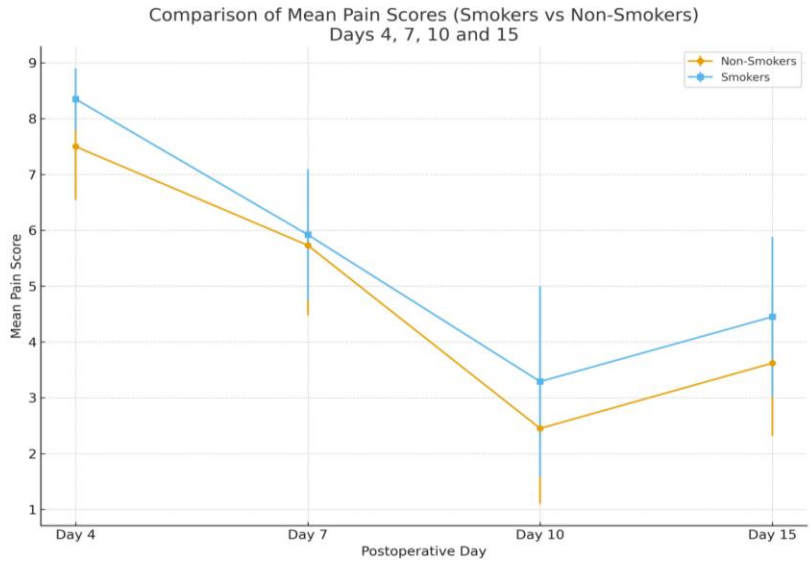


Figure 2: Comparison of mean postoperative pain scores between smokers and non-smokers on postoperative days 4, 7, 10, and 15.

Overall Wound Healing Outcome and Complications

At final follow-up, healthy healing was documented in 92/110 (83.6%) non-smokers compared with 67/110 (60.9%) smokers, while delayed healing occurred in 18/110 (16.4%) non-smokers versus 43/110 (39.1%) smokers — a rate more than twice as high in the smoker group. This difference was highly significant ($p<0.001$) (Figure 3). Postoperative wound infection, considered separately as a discrete complication, occurred in 3/110 (2.7%) non-smokers and 11/110 (10.0%) smokers, a difference that reached borderline significance ($p=0.050$) (Figure 4).

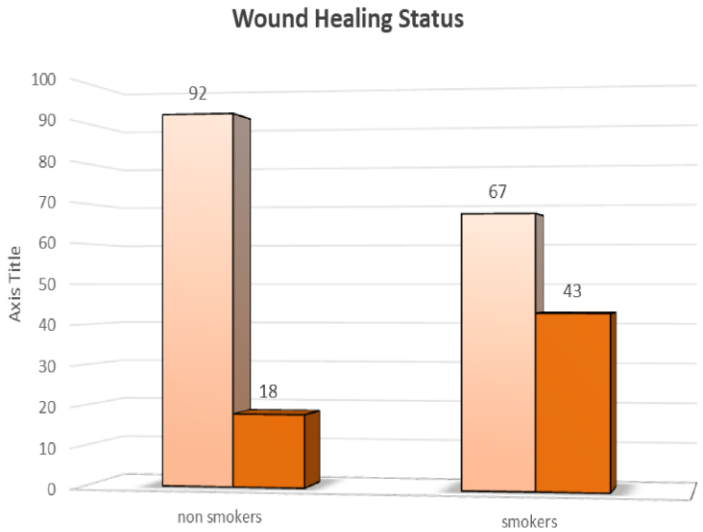


Figure 3: Wound healing status by smoking status at final follow-up.

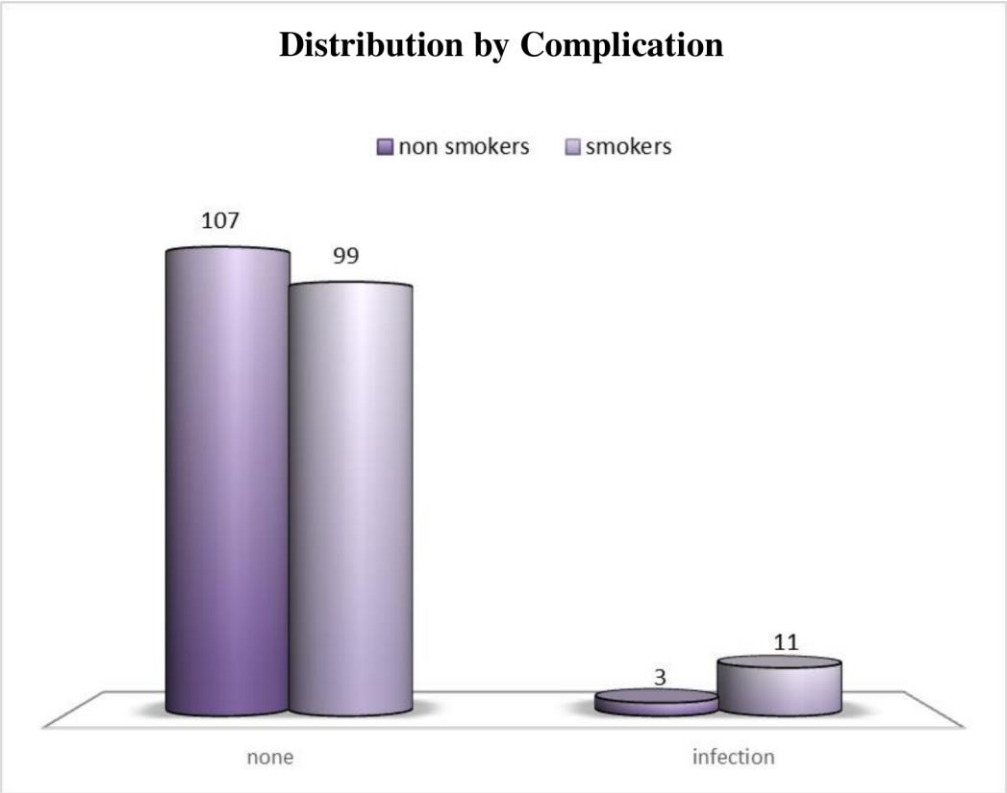


Figure 4: Distribution of postoperative complications by smoking status.

Table 5: Overall wound healing status and postoperative complications by smoking status.

Outcome	Non-smokers n (%)	Smokers n (%)	p-value
Healthy healing	92 (83.6%)	67 (60.9%)	
Delayed healing	18 (16.4%)	43 (39.1%)	<0.001
No complication	107 (97.3%)	99 (90.0%)	
Wound infection	3 (2.7%)	11 (10.0%)	0.050

Multivariate Predictors of Delayed Wound Healing

On multivariate logistic regression incorporating smoking status, diabetes, hypertension, and the combined presence of diabetes and hypertension, smoking emerged as the only statistically significant independent predictor of wound healing outcome. Smokers had markedly lower odds of healthy healing relative to non-smokers (odds ratio 0.32, 95% confidence interval 0.17–0.60, p<0.001), equivalent to roughly a three-fold reduction in the likelihood of favourable healing. Diabetes alone was associated with a numerically higher odds of impaired healing (odds ratio 1.73, 95% confidence interval 0.60–5.01) but did not reach significance (p=0.314). Hypertension alone showed no meaningful association (odds ratio 0.99, 95% confidence interval 0.47–2.11, p=0.988). The combined presence of diabetes and hypertension was also associated with a non-significant increase in odds of impaired

healing (odds ratio 1.64, 95% confidence interval 0.68–3.93, p=0.268). (Figure 5).

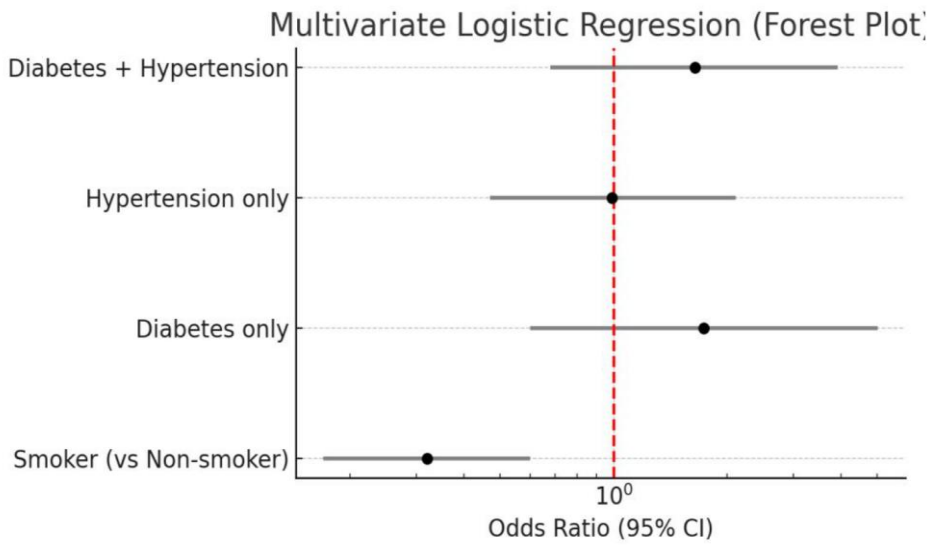


Figure 5: Multivariate logistic regression analysis of predictors of wound healing outcome.

Table 6: Multivariate logistic regression analysis of predictors of impaired wound healing.

Predictor	Odds ratio	95% CI	p-value
Smoker (vs non-smoker)	0.32	0.17–0.60	<0.001
Diabetes only	1.73	0.60–5.01	0.314
Hypertension only	0.99	0.47–2.11	0.988
Diabetes + Hypertension	1.64	0.68–3.93	0.268

DISCUSSION

In this prospective cohort of 220 patients undergoing clean and clean-contaminated surgery, smoking was associated with a consistently worse postoperative course: lower rates of healthy healing, more than double the rate of delayed healing, higher infection incidence, and significantly greater pain at three of four assessment points. On multivariate analysis, smoking remained the sole independent predictor of impaired healing once diabetes and hypertension were accounted for, reducing the odds of favourable healing to roughly one-third that of non-smokers (odds ratio 0.32, 95% confidence interval 0.17–0.60, p<0.001).

These findings are concordant with the broader literature on tobacco and surgical recovery. Sørensen's systematic reviews of smoking and postoperative wound complications reported a consistent excess risk of healing problems and infection among current smokers relative to non-smokers and former smokers, attributing this to nicotine-mediated vasoconstriction, blunted inflammatory signalling, and impaired collagen deposition.[2,3] Liu et al., in a meta-

analysis pooling more than 218,000 postoperative patients, similarly found significantly higher rates of wound healing problems and surgical site infection among smokers regardless of surgical subspecialty.[9] Within an Indian hospital-based cohort, Sharma et al. likewise concluded that preoperative smoking cessation was necessary to optimise abdominal surgical wound healing, a recommendation directly echoed by the present findings.[10]

The pain findings merit specific comment. Smokers in this cohort reported significantly higher pain on days 4, 10, and 15, with convergence only on day 7. This pattern is plausible mechanistically: nicotine-induced vasoconstriction and relative tissue hypoxia are known to sensitise peripheral nociceptors and prolong the inflammatory phase of healing, which could account for both the early peak and the failure of pain to resolve as quickly as in non-smokers.[3] The absence of a significant difference on day 7 alone should not be over-interpreted, since it sits between two time points at which the gap was clearly significant, and may reflect a transient overlap in the pain trajectories of the two groups during the early proliferative phase rather than a true attenuation of the smoking effect.

The regression findings — that diabetes and hypertension did not retain independent significance once smoking was accounted for — should be interpreted cautiously rather than as evidence that these comorbidities are clinically unimportant. Only a minority of participants carried a diagnosis of diabetes or hypertension, and many of these individuals were also smokers, which limits the statistical power available to detect an independent comorbidity effect and raises the possibility of residual confounding between smoking and comorbidity status. Prior work has repeatedly shown that hyperglycaemia impairs leukocyte function and vascular supply,[11] and that hypertension independently delays healing after major orthopaedic surgery,[12] so the non-significant estimates reported here (diabetes: odds ratio 1.73, 95% CI 0.60–5.01, p=0.314; hypertension: odds ratio 0.99, 95% CI 0.47–2.11, p=0.988) most plausibly reflect this cohort's limited power for these subgroups rather than a true absence of biological effect.

The exclusively male distribution of smoking in this cohort — a pattern well documented in Indian tobacco-use surveys[7,8] — means that any physiological differences in wound healing between the sexes could not be separated from the effect of smoking itself in this dataset. This is a structural feature of the study population rather than a study design choice, and it is a limitation that should be addressed in future work through purposive sampling or statistical adjustment where female smokers are available.

Strengths

The principal strengths of this study are its prospective design with serial, standardised wound assessment at four fixed postoperative time points; its balanced one-to-one allocation of smokers and non-smokers, which minimises the risk of group-size-driven bias; its adequately powered sample relative to the pre-specified calculation; and its use of multivariate regression to isolate the independent contribution of smoking from that of diabetes and hypertension, rather than relying on unadjusted comparisons alone.

Limitations

Several limitations should be considered when interpreting these results. The sample was drawn from a single tertiary care centre over a six-month period, which may limit generalisability to other settings and does not capture seasonal variation. Follow-up was limited to 15 days postoperatively, precluding assessment of longer-term outcomes such as scar quality, late dehiscence, or hernia formation. Smoking status was based on self-report without biochemical confirmation (for example, urinary cotinine), which may be subject to recall or reporting bias. The number of participants with diabetes and hypertension was relatively small, limiting the power available to detect independent comorbidity effects, and the complete absence of female smokers precluded any sex-stratified analysis of the smoking effect.

Clinical Implications

These findings support the routine incorporation of smoking status into preoperative risk assessment for patients undergoing clean and clean-contaminated surgery. Given the magnitude of the observed effect — a roughly three-fold reduction in the odds of healthy healing among smokers — structured smoking-cessation counselling ahead of elective surgery represents a low-cost, high-yield intervention that surgical and pharmacy teams are well placed to deliver jointly. Closer postoperative pain monitoring and a lower threshold for wound review may also be warranted in smokers, given their measurably higher and more persistent pain scores.

Future Recommendations

Future studies should extend follow-up beyond 15 days to capture longer-term healing and scar outcomes, incorporate biochemical verification of smoking status, recruit multicentre cohorts of sufficient size to permit adequately powered subgroup analysis of diabetes and hypertension, and, where feasible, include female smokers to allow sex-stratified analysis.

Interventional trials evaluating structured preoperative smoking-cessation programmes against standard care, with wound healing and infection as primary endpoints, would provide the strongest evidence base for changing perioperative practice.

CONCLUSION

In this prospective cohort study, cigarette smoking was independently and significantly associated with delayed surgical wound healing, higher infection rates, and greater postoperative pain, an effect that persisted after adjustment for diabetes and hypertension and that outweighed the contribution of either comorbidity. These findings reinforce smoking as a dominant, modifiable determinant of surgical recovery and support the systematic integration of preoperative smoking-cessation counselling into routine surgical care pathways.

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Conflict of Interest

The authors declare no conflict of interest.

Informed Consent

Written informed consent was obtained from all individual participants included in the study.

Data Availability Statement

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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