



Blowing Smoke: A Meta-Analysis of the Effects of Smoking on Fracture Healing and Postoperative Infection

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Introduction

Worldwide, over 1.3 billion individuals smoke tobacco. An estimated six million deaths are caused annually due to the multiple unwanted effects of cigarette smoke.^{1,2} While cigarette use may be decreasing in some areas of the industrialized world, nearly one-in-five Americans still uses tobacco. In the developing world, the use of tobacco continues to rise at a rate of nearly 3.4 percent annually.^{3,4} While the deleterious effects of smoking on many organ systems have garnered significant attention, its effects on the musculoskeletal system, including on fracture healing and postoperative infection after long-bone fracture surgery, have not been well characterized. The aim of this study was to systematically review the association between smoking, fracture healing, and postoperative infection.

Materials and Methods

Medline, EMBASE, and Cochrane literature databases were queried and a manual search

of bibliographies was performed. Randomized controlled trials and cohort studies, both retrospective and prospective, evaluating the associations between smoking and long bone fracture healing, as well as smoking and infection were included. Descriptive and quantitative data were extracted. A meta-analysis was performed using a random effects model for nonunion, superficial infections, and deep infections in smoking and non-smoking cohorts. Time to healing was evaluated using frequency-weighted means and group-weighted standard deviations. Three sensitivity analyses were performed to evaluate the effects of tibia fractures, open fractures, and level of evidence. Study heterogeneity, criteria of methodological quality, and publication bias were also evaluated; these factors were adjusted for using trim and fill analysis.

Results

Our initial search identified 7,110 references. Of the 237 articles further inspected by title, 20

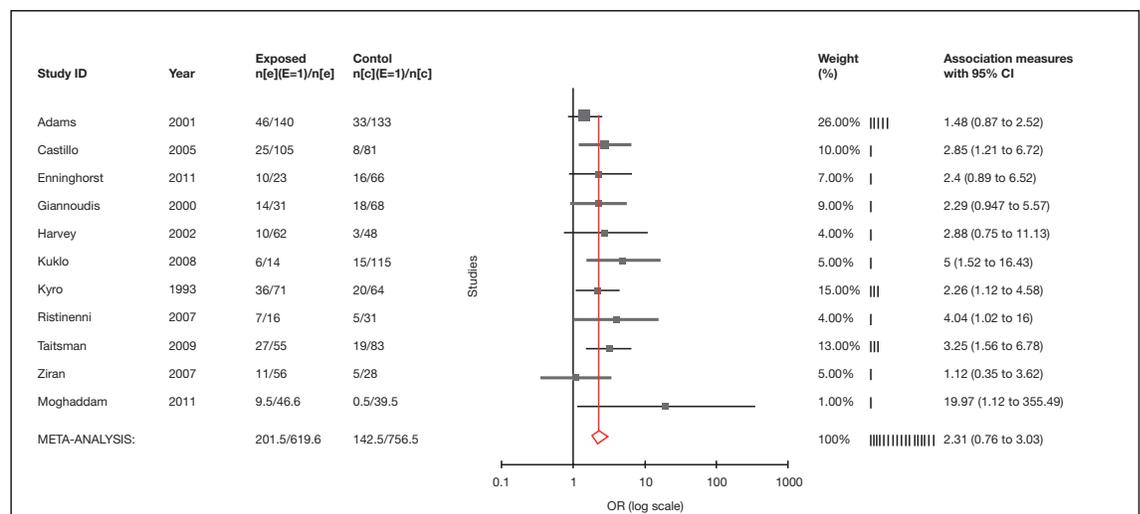


Figure 1. Forest plot demonstrating meta-analytic adjusted odds of nonunion among smokers with tibia fractures.

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were included (7 prospective and 13 retrospective cohort studies), and 18 offered sufficient data for meta-analysis. The adjusted odds of nonunion was 2.3 times in the smoking group compared to the non-smoking group (95% confidence interval: 1.8-3.0; $p < 0.01$; Figure 1). Risk difference calculation revealed a 15 percent higher risk of overall long bone nonunion in smokers (95% CI: 10-19%). There were increased rates of nonunion in smokers with tibia fractures (OR 2.42, 95% CI: 1.7-3.4; $p < 0.01$), and with open fractures (2.42, 95% CI: 1.7-3.4; $p < 0.01$). For all fracture types, the mean healing time was longer for smokers (30.2 weeks, 95% CI: 22.7-37.7 weeks) than non-smokers (24.1 weeks, 95% CI: 17.3-30.9 weeks). For tibia fractures, the mean healing time was longer for smokers (32.0 weeks, 95% CI: 23.2-41.0 weeks) than non-smokers (25.1 weeks, 95% CI: 16.4-33.9 weeks). There was no difference in post-operative superficial and deep infections between smokers and non-smokers undergoing long bone fracture surgery ($p = 0.13$). Publication bias was noted in the small studies showing a larger effect size than larger studies. Trim and fill analysis was performed which resulted in similar results to the original meta-analysis.

Discussion

This study provides a systematic review of the evidence in the literature regarding the effects of smoking on fracture healing and postoperative infection. Smoking was associated with increased nonunion for all fractures, tibia fractures, and open fractures. Additionally, smokers trended towards longer mean healing times. These potential risks should be discussed with all fracture patients. Further studies are warranted to determine the potential benefits of smoking cessation programs on outcomes following fracture fixation.

References

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