

Vaporized Versus Combusted Nicotine: A Biomechanical Comparison of Achilles Tendon Healing in a Rat Model

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Purpose: The negative effects of smoking have been well documented following orthopaedic injury. Although nicotine has been shown to be detrimental to musculoskeletal tissue healing, nicotine in the form of “vaping” is being increasingly used as a perceived healthier alternative to actual smoking and may theoretically obviate many of the harmful volatiles and chemicals contained within combusted tobacco that are additionally harmful to musculoskeletal healing. Our objective was to evaluate the biomechanical and histological effects on Achilles tendon repair between rats that inhaled combusted tobacco, versus those with isolated nicotine exposure via vaping, versus a control group.

Methods: 54 Sprague-Dawley rats were randomly placed in a control, vaping, or cigarette cohort. Each group contained 18 rats and exposure occurred 6 days per week. The smoking cohort was exposed to 2 unfiltered University of Kentucky research cigarettes in a previously validated smoking chamber. The vaping group was exposed to e-cigarette vapor with equivalent nicotine exposure over 10 minutes at a flow rate of 2.4 L/min. The control group was placed in the smoking chamber with room air flow. All rats received their respective daily exposures for 4 weeks prior to surgery when surgical transection and repair of the Achilles tendon was performed. Following surgery, the rats continued 2 additional weeks of smoking, vaping, or control exposure. After sacrifice, Achilles tendons were harvested and tested with controlled tension to failure (n = 15 per group). Histological samples were sent for analysis (n = 2-3 per group). One rat expired prior to sacrifice.

Results: Tensile testing evaluated maximum force to rupture and tissue stiffness. The control group demonstrated highest mean tensile strength of 41.0 N (standard deviation [SD] 10.4 N), with the cigarette cohort having the second highest mean tensile strength at 37.3 N (SD 11.1 N), and finally the vaping group had the lowest at 32.8 N (SD 8.4 N). One-way analysis of variance with heterogeneity of variance was used for evaluation. There was a significant difference detected in load to failure when comparing controls to e-cigarettes (P = 0.026). No statistically significant difference was seen between controls versus cigarettes (P = 0.35). Histological analysis demonstrated no difference among groups.

Conclusion: Our investigation demonstrates that, in a rat model, isolated nicotine exposure via “vaping” significantly impedes biomechanical healing properties of Achilles tendon surgical repair. Although smoking resulted in a lower maximum force to failure as compared to control in these samples, this difference was not significant. While e-cigarettes are often utilized as a perceived “safer” alternative to smoking combusted tobacco, this study suggests that use of e-cigarettes may be more detrimental to tendon healing than combusted tobacco in a rat Achilles model.