



The Effect of Cigarette Smoke vs. Vaporized Nicotine on Healing of a Rat Femur

Jacqueline R. Tucker, BS¹, Andrew McCullen, BS¹, Zachary Koroneos, BS², Hwa Bok Wee, PhD³, Aman Dhawan, MD², Hannah Atkins, DVM, PhD⁴, Gregory S. Lewis, PhD², Matthew R. Garner, MD²



¹ College of Medicine, The Pennsylvania State University, Hershey, PA

²Department of Orthopedics and Rehabilitation, Penn State Bone and Joint Institute, Hershey, PA

³The Pennsylvania State University Center for Orthopedic Research and Translational Science, Hershey, PA

⁴Department of Comparative Medicine, College of Medicine, The Pennsylvania State University, Hershey, PA

Purpose

To characterize and compare the biomechanical, radiologic and histologic changes that occur with femur fracture repair in an established Wistar rat model with vaporized nicotine (“vaping”), combusted tobacco, and controls.

Methods

- 45 adult, male Wistar rats were randomly divided into three cohorts (cigarette, vaping, and control), consisting of 15 rats each.
- Rats were exposed to either two unfiltered University of Kentucky 3R4F research cigarettes daily, an equivalent dose of vaporized nicotine, or placed into containment tubes for the same period of time as the exposures, six days a week.
- All rats received their daily exposures for 4 weeks prior to surgery where femurs were fractured and then repaired using Krirschner wire.
- Following surgery, the rats received 4 additional weeks of exposure. After sacrifice, femurs were harvested and imaged using micro-CT scans.
- Ten (n = 10) specimens from each cohort underwent biomechanical testing using a torsional, rotation-to-failure model.
- Remaining samples were sent for histologic analysis and graded and evaluated for union, spongiosa, compacta, inflammation, neovascularization, and necrosis.

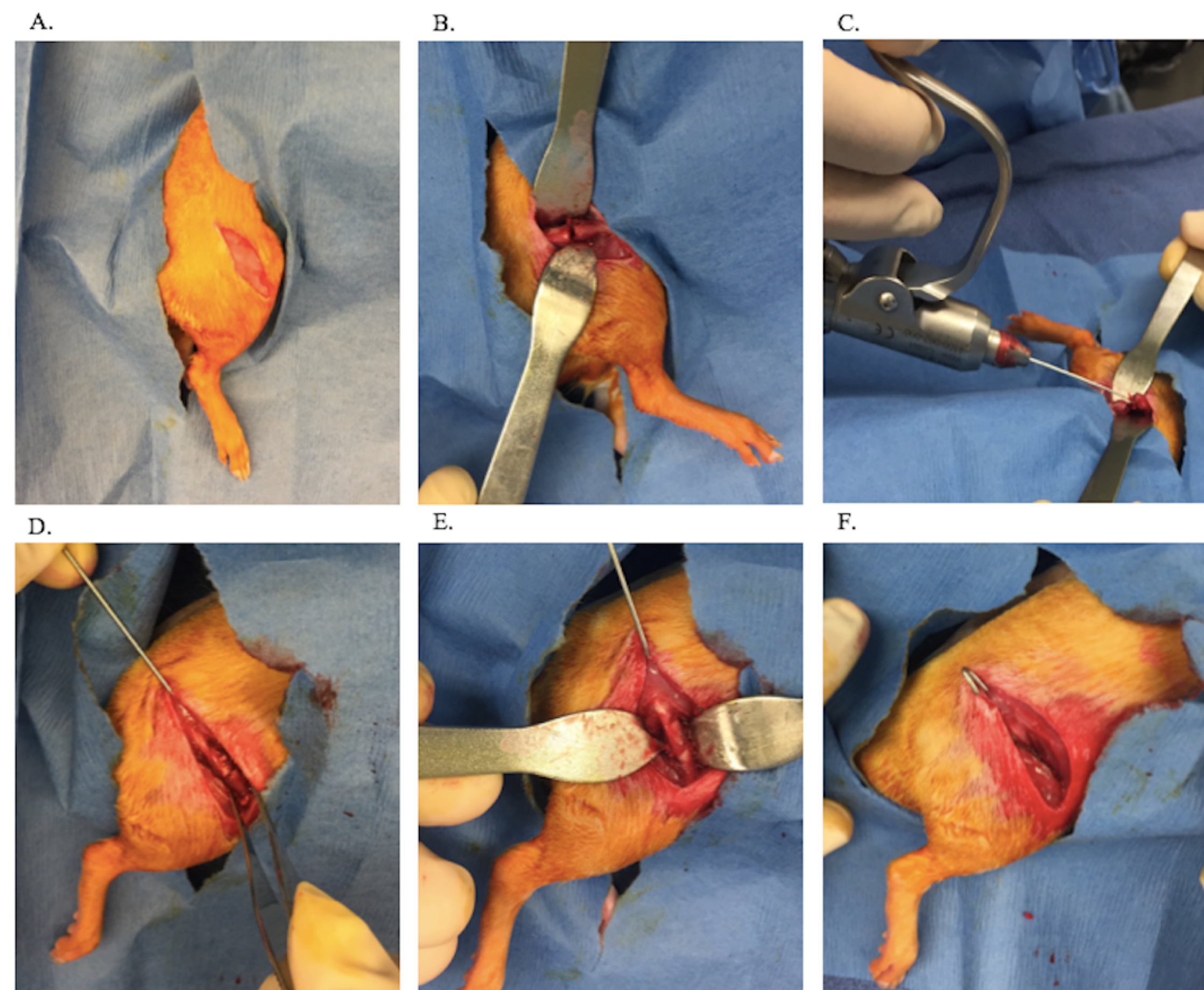


Figure 1: The surgical procedure of breaking and fixing the femur.

Results

Table 1: Micro-CT imaging results

Total Callus Volume mm ³				
Group	N	Mean mm ³	Std Dev	p-value
Control	10	210.30	39.84	0.14
Combusted	10	224.10	33.49	
Vaporized	10	195.10	17.65	
Immature Bone (mg HA/ccm 250-1000) Volume mm ³				
Group	N	Mean mm ³	Std Dev	p-value
Control	10	162.80	44.69	0.15
Combusted	10	168.30	36.05	
Vaporized	10	138.70	20.35	
Mature Bone (mg HA/ccm > 1000) Volume mm ³				
Group	N	Mean mm ³	Std Dev	p-value
Control	10	47.50	11.78	0.12
Combusted	10	55.80	22.37	
Vaporized	10	56.40	6.02	
Immature Bone (mg HA/ccm 250-1000) BMD (mg HA/ccm)				
Group	N	Mean mm ³	Std Dev	p-value
Control	10	563.50	26.72	0.14
Combusted	10	561.40	23.65	
Vaporized	10	580.10	13.60	
Mature Bone (mg HA/ccm > 1000) BMD (mg HA/ccm)				
Group	N	Mean mm ³	Std Dev	p-value
Control	10	1135.80	21.94	0.05
Combusted	10	1123.10	25.55	
Vaporized	10	1149.00	13.51	
Combusted vs. Vaporized				0.04
Combusted vs. Control				0.45
Vaporized vs. Control				0.47

Table 2: Biomechanical testing results

Maximum Torque				
Group	N	Mean N·m	Std Dev	p-value
Control	8	0.21	0.06	0.31
Combusted	10	0.24	0.05	
Vaporized	10	0.20	0.04	
Torsional Stiffness				
Group	N	Mean	Std Dev	p-value
Control	8	0.38	0.21	0.92
Combusted	10	0.38	0.12	
Vaporized	10	0.36	0.09	

Table 3: Histology results for assessment of union

	Histology Table of Union		
	Control	Combusted Tobacco	Vaporized Nicotine
No sign of union	0	0	0
Fibrous union	1	1	0
Osteochondral union	3	2	4
Bone union	0	0	1
Complete union with reorganization	0	0	0



Figure 2: An example of the radiograph that was taken after surgery to make sure the fracture was fixed correctly and the pin was in the correct place.

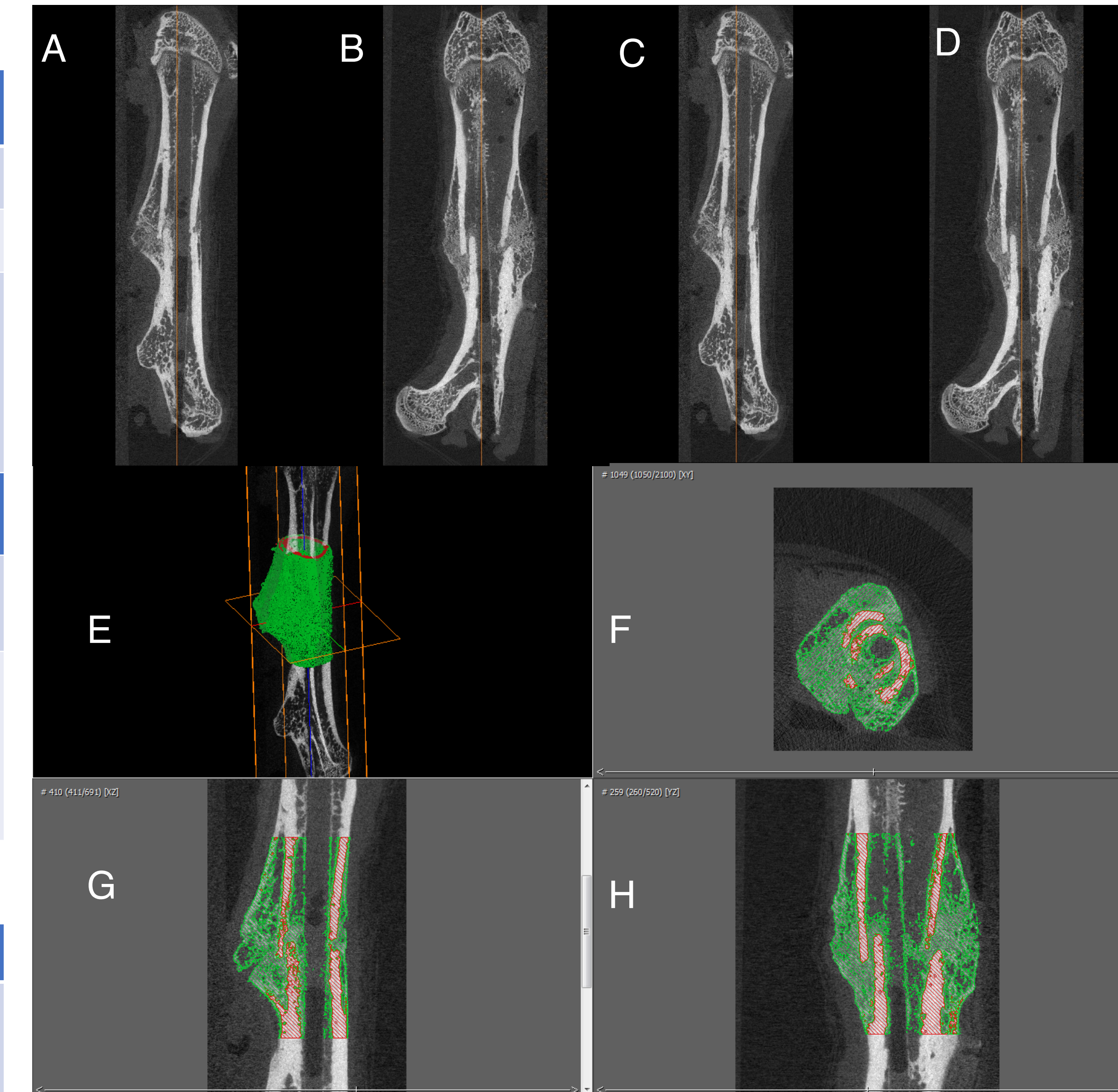


Figure 3: Representative micro-computed tomography scan of rat femur (A-B) and reformats demonstrating area of interest (C-D). Peripheral (Green) bone represents immature callus (BMD < 1000 mgHA/ccm) while central (Red) bone represents mature bone (BMD > 1000 mgHA/ccm) (E-H).

Conclusions

- This study compared smoking cigarettes, vaping and a control group by using CT scans, torsion testing, and histology.
- This animal fracture repair model found significance only in mean BMD of mature bone.
- No significant differences were seen in remaining CT imaging variables, biomechanical testing, or histology between the three groups.
- Larger studies must be completed for further understanding.

References

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