DIABETES ALTERS TRABECULAR BONE STRUCTURE IN A RAT FEMORAL IMPLANT MODEL

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INTRODUCTION: Diabetes is common in orthopedic surgery patients, affecting one quarter of the US population above 65 years of age [1] and increases the risk for aseptic loosening, the most common indication for joint replacement surgery [2]. Beyond increases in hospital stays [3], and overall complication rate [4], diabetes is thought to directly alter bone structure but it is unknown if or how peri-implant bone is affected. In the present study, we describe the peri-implant bone morphology in the intramedullary femoral implant model in Zucker Diabetic Fatty rats as compared to Sprague-Dawley rats.

METHODS: 14 week-old female outbred Sprague-Dawley (n=11) and Zucker Diabetic Fatty (n=11) rats were compared. The Zucker Diabetic Fatty (ZDF) rats were given high-fat rat chow as a model of type 2 diabetes (T2D) while the Sprague-Dawley (SD) rats were given normal chow and served as controls. Both groups were allowed *ad libitum* access to food and water. All animals had bilateral titanium implants placed into the femoral canal. Groups were then randomly selected for sacrifice at 2 weeks, 6 weeks, or 10 after surgery. Blood glucose measured in the 6 and 10 week groups confirmed that SD rats had normal glycemic levels while ZDF rats were hyperglycemic (data not shown). Right femora were scanned with μCT (Scanco μCT50nd 14.8 μm isotropic voxels, 90 kVp, 88 μA, 750 ms integration, 1600 projections/180°, 0.5mm Al filter). Measurements were made proximal to the distal growth plate for trabecular bone endpoints and in the midshaft diaphysis for cortical bone endpoints. Two-way analysis of variance (ANOVA) tests was performed to assess the effects of group, time to sacrifice, and the group-by-time interaction. When main effects were significant, group differences were compared to age-matched SD group using student's t-test. Animal procedures were approved by the Rush University Animal Care and Use Committee.

RESULTS: Tb. BV/TV and Tb. N was significantly decreased (0.41 fold and 0.52 fold respectfully) in ZDF group at week 10. Tb. Sp was increased (2.1 fold) in ZDF group at week 10 that resulted in a significant group effect for these measures. There was also a significant time effect and interaction as ZDF animals showed progressive decline starting at 6 weeks while trabecular measures in SD animals remained relatively constant overtime. Tb. Th was not significantly altered when comparing age-matched SD group. Ct. Area and thickness increased significantly over the experimental time but no changes were observed in any cortical measurements among ZDF group versus the SD group.

DISCUSSION: In the present study, we compare Sprague-Dawley and Zucker Diabetic Fatty rats to assess how T2D affects peri-implant bone morphology. As compared to SD, ZDF animals had significant decrease in trabecular bone volume and trabecular number as well as increased trabecular spacing. This suggests that the altered glucose regulation had significant impact on the more metabolically active trabecular bone. These findings may help explain the higher implant failure rate in diabetic compared to non-diabetic patients. Future studies are needed to assess other likely effects of T2D on peri-implant bone material properties, bone-implant contact and implant fixation mechanics to more thoroughly understand how diabetes alters the bone-implant interface.

SIGNIFICANCE/CLINICAL RELEVANCE: Alterations in peri-implant bone remodeling may explain the increased risk for revision surgery in diabetic patients compared to non-diabetic patients following joint replacement.

REFERENCES:[1] American Diabetes Association. Classification and diagnosis of diabetes. Diabetes Care. 2017;40(suppl 1):S11–S24. [2] Sadoghi P, Liebensteiner M, Agreiter M, Leithner A, Böhler N, Labek G. Revision surgery after total joint arthroplasty: a complication-based analysis using worldwide arthroplasty registers. J Arthroplasty. 2013 Sep;28(8):1329-32. doi: 10.1016/j.arth.2013.01.012. Epub 2013 Apr 18. Review. [3] Ahmann A: Reduction of hospital costs and length of stay by good control of blood glucose levels. *Endocr Pract* 2004;10:53-56. [4] Bushnell BD et al. Perioperative medical comorbidities in the orthopaedic patient. J Am Acad Orthop Surg. 2008 Apr;16(4):216-27. Review.

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