INTRODUCTION Allograft tissue remains a valuable option for ACL reconstruction due to the decreased surgical morbidity, improved cosmesis and decreased surgical time. There have been several animal studies evaluating the effects of low-dose irradiation on bone-patellar tendon-bone (BTB) allograft tissue in an effort to optimize the mechanical properties of the transplanted graft and improve outcomes. To our knowledge, there are no studies investigating the effect of 1.0-1.2 MRad dose of irradiation on graft properties. While the central third of the patellar tendon remains the gold standard for autograft surgeries, there is no definitive scientific rationale for selecting the central third for allograft surgery. Hence we compared the regional characteristics of irradiated and non-irradiated human patellar tendons. There are also no studies to date that correlate the effect of bone mineral density (BMD) on the mechanical properties of these grafts. In our previous study, we demonstrated no correlation between donor age and BMD. However significantly greater BMD on the patella compared to the tibial side was noted. Using human patellar BTB allografts, the current study investigated (1) the effect of low-dose irradiation on biomechanical properties and BMD, (2) quantified biomechanical differences among the central, medial, and lateral thirds, and (3) examined potential correlation between BMD with biomechanical indices.

METHODS Twenty BTB allografts were harvested according to American Association of Tissue Banks standards from 10 donors (9 male, 1 female, Age: 52±11 Range: 27-65). Bilateral knees were randomized to either no radiation or a standard low-dose (1.0-1.2MRad) irradiation (n=32, 16 samples per group paired analysis). The samples were then divided, using digital caliper measurements, into approximately equal width medial, central, and lateral thirds yielding 60 specimens in total. BMD analysis was performed on the tibial and patellar bone plugs. Samples were then potted for biomechanical analysis using an electromechanical testing system (MTS Insight 5, Eden Prairie, MN, USA). Following a preload of 10N, samples were cyclically loaded at 0.5Hz for 100 cycles (50N to 200N), followed by a load to failure test at strain rate of 10%/s. Cyclic creep strain was computed by taking the difference of peak elongation from the first cycle to the last cycle, and normalizing it to the initial, pre-cycling length. Structural and material properties were determined from the failure test. Analyses included paired t-tests to compare properties of irradiated to non-irradiated contralateral tendons, ANOVA with Tukey’s post-hoc testing to compare tendon regions, and Pearson’s correlation coefficient with significance for all set at p<0.05.

RESULTS The average tendon width before preparation was 28.2±1.8 mm (n=20) and 8.9±0.9 mm (n=60) after separation into thirds. The central portion of the BTB graft (4.9±0.4 mm) was significantly thicker than the medial (4.4±0.5 mm) or lateral (4.3±0.6 mm) thirds. The mean length of the lateral portion (59.0±8.7 mm) was significantly greater than that of the medial (50.3±8.4 mm) or central (47.4±8.9 mm) portions. The average BMD of the patella (0.37±0.1 g/cm²) was significantly larger than the tibia (0.26±0.05 g/cm²) and showed no regional difference. Age did not correlate with the BMD of patellar or tibial bone plugs (R² = -0.11 and 0.02 respectively). The lateral region showed a higher relative elongation compared to the central region during cyclic testing. The lateral region was the only portion significantly affected by the irradiation, as the irradiated lateral graft elongated more than the non-irradiated graft.

DISCUSSION AND CONCLUSION While low-dose irradiation does not affect the BMD of human BTB grafts, it does increase the percentage of creep during the cyclic testing for the lateral region. However there were no significant differences in the failure test’s biomechanical properties due to irradiation. Since tibial BMD correlates with tendon strength, we may need to consider conducting preoperative tests to obtain grafts with higher tibial BMD values. Though usage of the lateral third could be beneficial in a graft mismatch situation, the surgeon should be mindful that its biomechanical properties might be compromised relative to the central portion. Given these new results on regional differences among tendon thirds, it appears worthwhile to further investigate hemi-grafts. The present study reinforces the clinical practice of utilizing the central third of the BTB graft along with validating the usage of low dose irradiation.

SIGNIFICANCE Using the tibial BMD, one can predict the quality of the patellar tendon graft.

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REFERENCES

Table 1 (Failure Properties): A: No difference in elongation to maximum load, maximum load, or maximum stress with low-dose irradiation (n=32, 16 samples per group paired analysis) B: The central third of the BTB construct is superior with regard to maximum load and stress but not elongation (N=42 with 16 samples per group).

Figure 1: Relative graft elongation during cyclic testing. Bars indicate significant difference.

Figure 2- Correlation graph of Maximum Load and tibial BMD.