

# Higher bone mineral density correlates with the Surgeon selection of cementless fixation in total knee arthroplasty

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**Disclosures:** Quevedo González (LimaCorp: 1; Zimmer Biomet: 6), Borsinger (N), Lipman (Exactech: 1; LimaCorp: 1; Mathys: 1; Ortho Development: 1; Wishbone: 1; Extremity Medical: 3C; EvolveOrtho: 4), Wright (Exactech: 1; LimaCorp: 1, 6; Mathys: 1; Zimmer Biomet: 6; AJRR: 9; OREF: 9; Knee Society: 9), Sculco (Depuy: 2, 3B; Intellijoint: 3B, 4, 6; EOS: 2, 3B; Parvizi Surgical Innovation: 4, LimaCorp.: 3B; Zimmer Biomet: 3B), Kahlenberg (N), Debbi (Ortho Development: 1,2; Depuy: 3B; Think Surgical: 4), Karasavvidis (N), Pagan (N), Mayman (OrhoAlign: 1, 4; Smith Nephew: 1; Stryker: 3B; CyMedica: 4; Imagen: 4; MiCare: 4; Wishbone: 4; Hip Society: 9; Knee Society: 9), Vigdorchik (Depuy: 1, 3B; Intellijoint: 3B; Aware: 4; Corin: 4; Motion Insights: 4; Ortho AI: 4; Polaris: 4; JBJS: 8; AAHKS: 9)

**INTRODUCTION:** To achieve successful fixation of total knee arthroplasty (TKA) implants, the underlying bone must provide a strong foundation to avoid bone catastrophic early collapse [1] and aseptic loosening, one of the most frequent modes of failure of TKA [2]. This is particularly critical for cementless TKA implants that have the potential of achieving long lasting biologic fixation conditional if an initial stable fixation is ensured to allow bone ingrowth. Bone mineral density (BMD) is one of the main determinants of bone strength [3]; however, our knowledge of the normative distribution of BMD in TKA patients remains limited. Consequently, the surgeon's decision to cement is often based on surrogate metrics, like age, sex, or preoperative alignment. Therefore, the goal of this study was to characterize the tibial BMD in patients undergoing TKA and to quantify the differences in tibial bone density between patients who received cemented and cementless fixation of the same implant design. We hypothesized that patients who received a cementless tibial fixation would have denser bone than patients managed with cemented implants, especially in the medial compartment of tibia.

**METHODS:** Under IRB approval, we retrospectively identified 98 patients (45 females, age 50-86 years, BMI 20.5-49.1 kg/m<sup>2</sup>) that underwent robotically assisted TKA (Stryker, Mahwah, NJ) at our institution between September 2022 and July 2023. These patients received a standard of care CT scan including a K2HPO4 bone density reference phantom (Mindways Software, Austin, TX). All patients received the same cruciate retaining implant design (Triathlon, Stryker, Mahwah, NJ), with either cemented fixation (N=16) or cementless fixation (N=82), based on the intraoperative decision of the surgeon. We manually segmented the bone from the CT-scans (Mimics, Materialise, Leuven, Belgium) and used the phantom to convert the Hounsfield Units to BMD, in mg/cm<sup>3</sup>. We identified the anatomic landmarks from the robotic plan to virtually reproduce the cut performed during surgery. For each patient, we then computed the average BMD from 2mm above the cut to 10 mm below the cut for the entire tibial surface, the medial half, and the lateral half. We compared the bone density at the tibial cut for all three regions between patients who received cemented and those who received cementless implants using T-tests with a significance of 0.05.

**RESULTS:** For all patients, the BMD in the medial half of the tibia was higher than on the lateral half, and in all cases, decreased from proximal to distal, especially between 2 mm proximal to 4 mm distal to the tibial cut (Fig. 1). Patients who received cementless implants had denser bone (Fig. 2) than patients with cemented implants at the total cut (210 mg/cm<sup>3</sup> vs 184 mg/cm<sup>3</sup>, p=0.02) and the medial half (231 mg/cm<sup>3</sup> vs 202 mg/cm<sup>3</sup>, p=0.03) of the tibial cut, but not for the lateral half (171 mg/cm<sup>3</sup> vs 154 mg/cm<sup>3</sup>, p=0.4). No difference was found in age (p=0.5) or BMI (p=0.4) between patients with cemented and cementless implants. Of the 16 patients who received cemented implants, 15 (94%) were female and 2 (13%) had preoperative valgus alignment. Of the 82 patients who received cementless implants, 30 (37%) were female and 14 (17%) had preoperative valgus alignment. Female patients had lower density than males in the total cut (190 mg/cm<sup>3</sup> vs 220 mg/cm<sup>3</sup>, p<0.001) and the medial half of the cut (203 mg/cm<sup>3</sup> vs 245 mg/cm<sup>3</sup>, p<0.001). Patients with preoperative varus or neutral alignment had denser bone in the medial aspect of the knee (237 mg/cm<sup>3</sup> vs 172 mg/cm<sup>3</sup>, p<0.001) and less dense bone in the lateral aspect of the knee (155 mg/cm<sup>3</sup> vs 239 mg/cm<sup>3</sup>, p=0.002) than patients with preoperative valgus alignment.

**DISCUSSION:** Incorporating BMD in the presurgical planning for TKA has the potential to implement data driven decision making regarding bone quality and type of implant fixation. Surgeons had no a-priori knowledge of the bone density distribution of patients and based their decision on surrogate metrics, like age, sex, or preoperative alignment; nonetheless, we found that patients who received cementless implants had denser bone than patients with cemented implants, particularly in the medial aspect of the tibia. Despite these differences in BMD between cemented and cementless implants, all patients included in the study continue to have, to our knowledge, successful TKAs. Therefore, the threshold for an acceptable BMD for cementless implants remains unknown.

**SIGNIFICANCE/CLINICAL RELEVANCE:** (1-2 sentences): Our results provide normative values for the bone density distribution of TKA patients that could help decide the implant fixation method.

**REFERENCES:** [1] Pitta, et al., J Arthroplasty. 2018; [2] AJRR, 2022; [3] Morgan, et al., J Biomech. 2004

## IMAGES AND TABLES:

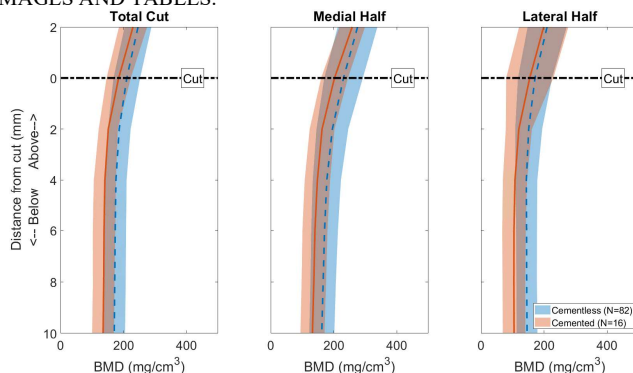


Fig. 1 – Distribution of bone density above and below the tibial cut for cementless (blue dashed line) and cemented (red solid line) implants.  
Translucent areas represent 1 standard deviation

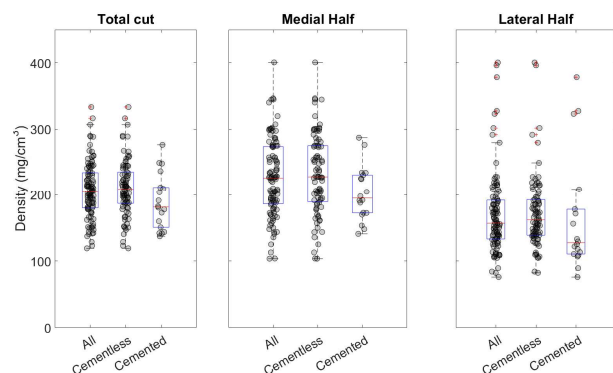


Fig. 2 – Bone density at the tibial cut for all patients, patients with cementless implants, and patients with cemented implants.