3D Imaging of the Bone-Implant Interface After Cementless TKA Using Weight-Bearing CT

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DISCLOSURES: none.

INTRODUCTION: Cementless total knee arthroplasties (TKA) use porous metal implants that encourage the patient's bone to grow directly into the components. This forms a more permanent bond between the bone and implant, and avoids potential complications such as cement breakdown, compared to traditional cemented TKA. Cementless implants are thought to have longer survivorship and lower the risk of aseptic loosening, but further studies are required to support their long-term effectiveness. Coronal alignment, such as hip-knee-ankle angle (HKAA) and joint line obliquity (JLO), is also an important factor to consider in TKA, and may have an impact on implant fixation. This study aims to explore whether the bone-implant interface is influenced by the implant design or by the change in the coronal alignment of the patient post-TKA. We hypothesize that the interface characteristics will be affected by coronal alignment changes, but not implant design.

METHODS: This project was approved by an ethics committee. Patients who received the Attune or Triathlon Tritanium cementless TKA were eligible for inclusion. Forty patients (n = 40) were recruited, twenty for each implant system. Patients with the Attune implant were matched with the Triathlon group based on sex, age (+/- 5 years), and coronal alignment (HKAA +/- 1.5°). Coronal alignment was measured from the most recent postop hip-to-ankle Xray on the patient's electronic medical record. The bone-implant interface was examined using weight-bearing CT. Image analysis was performed using 3D Slicer. To assess the bone-implant interface, bone density and radiolucent lines were examined as markers of implant fixation. Density was obtained from five regions: under the four pegs (anterolateral, posterolateral, posteromedial, anteromedial) and the keel of the tibial component. Statistical analysis was performed using GraphPad Prism.

RESULTS: When examining bone quality, the anterolateral density is significantly lower ($p < 0.05$, n = 40, Friedman test) than the posterolateral, posteromedial, and anteromedial density (*Figure 1*). The density under the keel is significantly lower ($p < 0.001$, Friedman test) than the density under the pegs, except for the anterolateral peg. This trend was observed in both the Attune and Triathlon groups, and there was no significant difference ($p > 0.05$, Mann-Whitney test) between the groups. No radiolucent lines were appreciated beyond the zone that could be attributable to metal artifact in both groups. There is a significant difference between preop and postop HKAA ($p < 0.001$, n = 40, paired t-test) and JLO ($p < 0.001$, paired t-test) (*Figure 2*). *Table 1* shows the results of Spearman correlation analysis between change in coronal alignment (ΔHKAA and ΔJLO) and bone density. There is a weak but not significant correlation ($p > 0.05$) between ΔHKAA and density under the anterolateral and posterolateral peg, in opposite directions. There is no significant correlation ($p > 0.05$) between ΔHKAA and bone density under the posteromedial peg, anteromedial peg, and keel. There is no significant correlation ($p > 0.05$) between ΔJLO and bone density.

DISCUSSION: The results have showed that there is no difference in the bone-implant interface when comparing the Attune and Triathlon groups. This is consistent with the findings from *Bendich et al*, where they found stress shielding at the tibial bone-implant interface did not differ between Attune and Triathlon groups. The general trend observed in both groups is highest bone density medially, followed by laterally, while lowest density under the keel. The higher density under the pegs can be explained by the fixation in the epiphysis, whereas the keel is fixed in the medullary canal. However, the region under the anterolateral peg has significantly lower density than the other pegs. This may be due to poorer bone quality on the lateral side, since most loading in varus knees occur on the medial side. Bone density is an important marker for implant fixation as higher density suggests better quality bone due to force being transmitted through the implant to the bone with resultant increase bone growth around the implant. *Stadler et al* found that radiolucent lines were only observed in 8 out of 91 post-TKA, and lines disappeared within one year postop in five cases. Although radiolucent lines were not appreciated in this study, this may be due to metal artifact around the implant, smaller sample size, or disappearance of the lines years after surgery. Overall, these data are consistent with the second hypothesis that implant design does not impact implant fixation, and thus support the use of both Attune and Triathlon implants. There is a significant difference between preop and postop coronal alignments, which suggest that ΔHKAA and ΔJLO are substantial and may contribute to implant fixation. However, the Spearman correlation analysis shows that there is no significant correlation between coronal alignment and bone density, which is contrary to the first hypothesis. Changes in HKAA and JLO will result in changes in knee kinematics and loading, which should theoretically have an impact on bone density. There are a few limitations of this study. First, the patients' postop standing Xrays were obtained at different times, which may have an impact on the measured coronal alignments, yet the differences should be insignificant. Next, patient experiences, such as pain or functional ability, were not explored. This may be considered for future work in order to correlate bone-implant radiographic findings with clinical outcomes. To conclude, there are many factors that can affect fixation of the implant to the bone, yet the changes in coronal alignment and the cementless implant design do not seem to play a significant role. Though bone quality patterns were found under different locations of the implant, these trends did not seem to be affected by changes in coronal alignment or implant design.

SIGNIFICANCE/CLINICAL RELEVANCE: Cementless TKA has recently gained greater interest in orthopaedic surgery, yet long term studies are still needed for this technology. Examining and measuring the bone-implant interface may help to characterize the survivorship or predict clinical outcomes, and future studies such as comparisons between cemented vs cementless TKA may be beneficial to justify whether cementless is superior to cemented TKA.

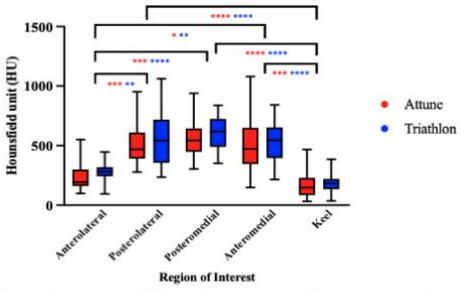

Figure 1. Bone density of different locations under Attune vs Triathlon implants.

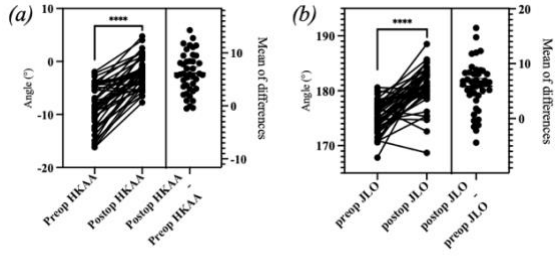

Figure 2. Estimation plots for preop vs postop HKAA (a) and JLO (b)

r/p	*Anterolateral Density*		*Posterolateral Density*		*Posteromedial Density*		*Anteromedial Density*		*Keel Density*	
	ΔHKAA	ΔJLO	ΔHKAA	ΔJLO	ΔHKAA	ΔJLO	ΔHKAA	ΔJLO	ΔHKAA	ΔJLO
r	-0.2713	0.1259	0.2907	-0.03801	0.1321	0.002513	0.1438	0.07157	0.00536	-0.01256
p	0.0822	0.4270	0.0618	0.8111	0.4045	0.9874	0.3635	0.6524	0.9731	0.9371

Table 1. Correlation analysis between changes in coronal alignment (ΔHKAA, ΔJLO) and density.