

Motion During Total Knee Cementing Significantly Decreases Tibial Implant Fixation Strength

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1. Introduction

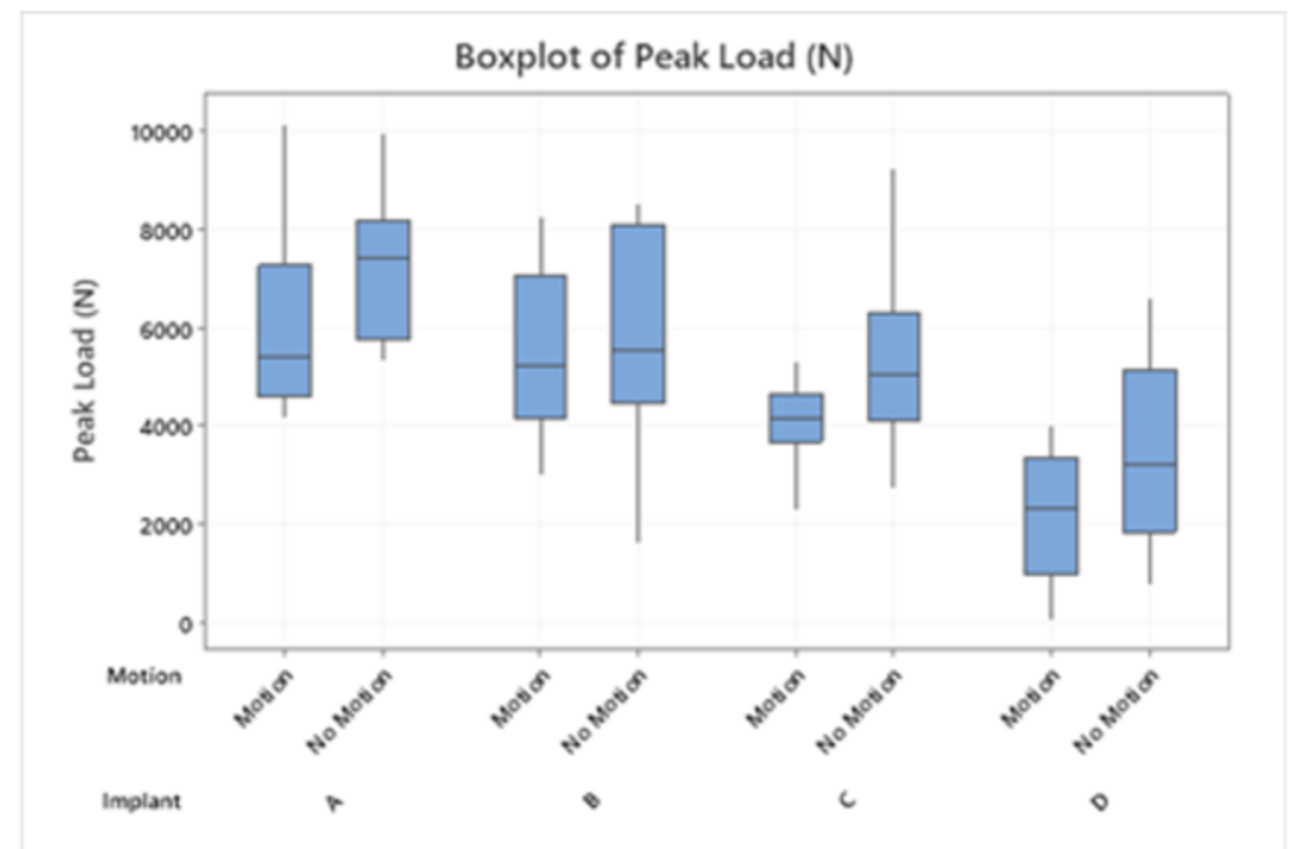
- Aseptic tibial loosening following primary total knee persists despite technique and device related advancements. The mechanisms for this mode of failure are not well understood.
- We hypothesized that knee movement while the cement was curing dispersed lipids at the implant cement interface and would result in decreased tibial fixation strength.



Cemented Tibial Implantation

2. Results

- The average pull-out strength for the no-motion cohort (5462N) exceeded the motion cohort (4473N)(p=0.001).
- The mean pull-out strength between implant designs in the no motion cohort varied significantly [Implant A - 7230N; B - 5806N; C - 5325N; D - 3486N] (p=0.007)



Boxplot of Peak Load (N) by Implant and Motion.

Implant	Implant. Cement failures (#)	Average pull-out strength (N)	Bone Failures (#)	Average pull-out strength (N)	Mixed failures (#)	Average pull-out strength (N)
A	5	6783	10	6314	1	9957
B	8	4692	6	6391	2	7268
C	1	2753	6	4938	9	4739
D	16	2841	0	N/A	0	N/A

Implant Pull-out Strength For Each Failure Pattern

4. Discussion

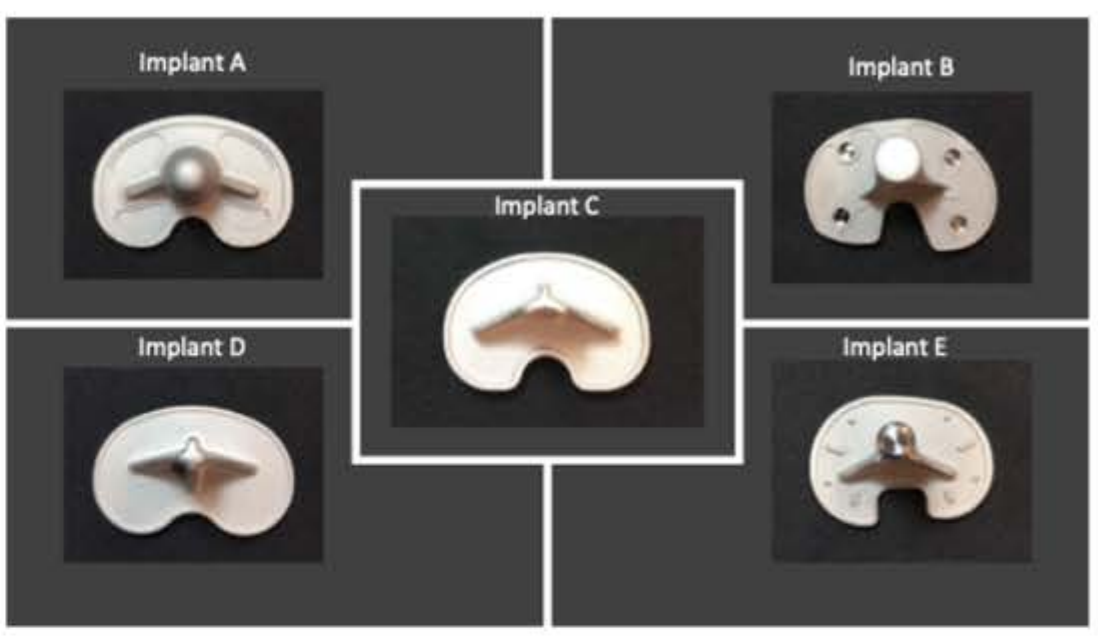
- Knee motion during cement polymerization is associated with significant decreases in tibial implant fixational strength.
- Reduction in implant pull-out strength was identified with each implant design with motion and varied between designs.
- Across all tested designs, we recommend limiting motion while cementing the tibial implant to improve fixation strength.



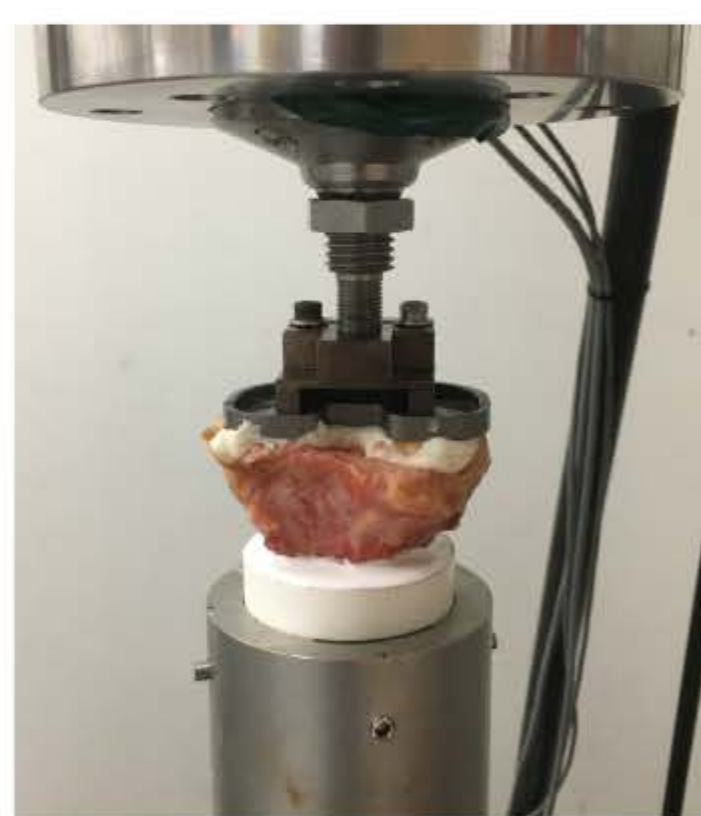
2. Methods

Experimental Protocol

- A cadaveric study was performed utilizing 32 torso-to-toe specimens (64 knees). Four contemporary total knee arthroplasty designs were evaluated.
- Each implant design was randomly assigned to a cadaveric specimen pair with side-to-side randomization. Specimen densitometry was recorded. Each tibial implant was cemented using standard technique. On one side, the tibial component was held without motion following impaction until complete cement polymerization. The contralateral knee tibial implant was taken through gentle range of motion and stability assessment seven minutes after cement mixing. Axial tibial pull-out strength and interface failure examination was performed on each specimen.



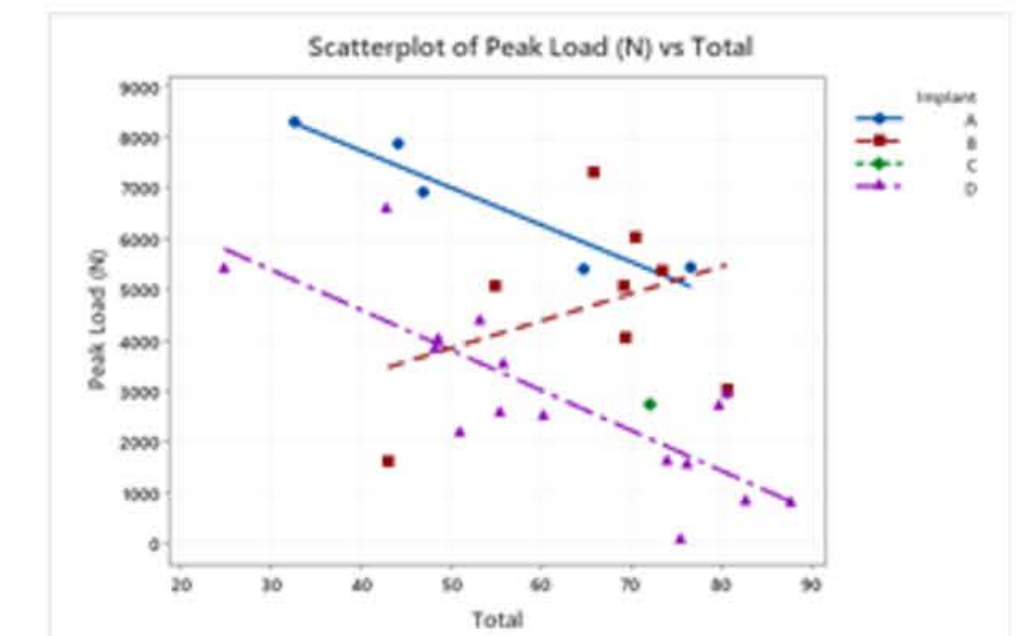
Implants tested (E later excluded)



Axial tibial pullout fixture

2. Results (Cont.)

- Similarly, the motion cohort inter-implant variance was significant (p<0.001).
- Intra-implant pull-out strength was significantly higher in Implant A than D.
- Tibial pull-out strength was significantly less for implants that failed at the implant-cement interface compared to failures of the bone.



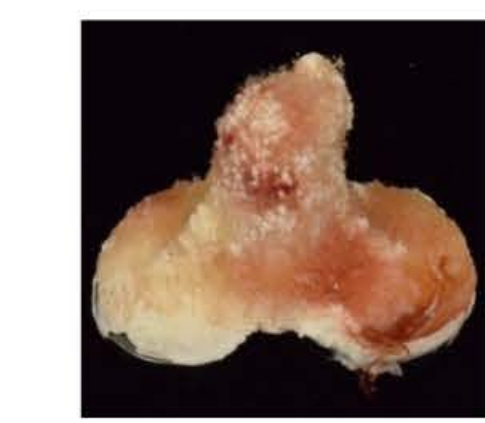
Scatterplot which correlates the percentage of lipid contamination of the tibial base plate and the peak load to failure for each implant. Lipid contamination inversely correlates with peak pull-out strength.



The above image demonstrates a failure of fixation at the implant-cement interface. The undersurface of the tibial tray is completely devoid of cement and there appears to be lipid contamination of the tray.



The above image demonstrated a mixed pattern of failure. There are areas where the implant-cement interface has failed adjacent to areas where the bone has failed. Lipid contamination of the tibial tray is also present.



The above image demonstrates a failure of the bone. The entire implant, cement-mantle, and surrounding bone was pulled out from the cadaveric specimen.

5. Conclusion

- **Knee motion during cement polymerization is associated with significant decreases in tibial implant fixational strength.**
- Reduction in implant pull-out strength was identified with each implant design with motion and varied between designs.
- Across all tested designs, **we recommend limiting motion while cementing** the tibial implant to improve fixation strength.
- Additionally, the three-dimensional undersurface design features of the tibial tray were significantly associated with pull-out strength. Therefore, **optimizing the undersurface tibial tray geometry appears advantageous.**