Biomechanical Comparison of Fixation Methods for Patella Fracture: Evaluating Anterior Locking Plate and Traditional Tension Band Wiring with Cannulated Screws

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Introduction: This study delves into the biomechanical aspects of treating transverse patella fracture, a significant orthopedic concern involving the most prominent sesamoid bone in human body, the patella, which is crucial for knee function. The research explores the biomechanical analysis of hybrid constructs, combining cannulated screws with tension band wiring (TBW) cerclage and cannulated screws with anterior VA (Variable Angle) locking neutralization plates (LNP). The study aims to bridge knowledge gaps by analyzing a hybrid construct's biomechanics, hypothesizing superior load-bearing capacity and fracture reduction retention compared to conventional methods, especially for patients with excessive body weight or muscle mass. The underlying hypothesis poses that these augmentations exhibit an enhanced capacity to withstand greater loads and more effectively preserve the integrity of the repaired patella in contrast to conventional methodologies.

Methods: 16 fresh frozen human cadaver patellas, divided into two groups of 8 each, were utilized. Transverse fractures were induced using a sagittal saw. Fixation methods included Cannulated Screw Fixation added with either TBW or Anterior VA Locking Plate Fixation Technique. A 16G stainless-steel wire was inserted through cannulated screws for the TBW group. In contrast, the plate group used anterior VA LNP contoured for a flush fit on the anterior patella cortex, fixed with 7 locking screws. Cyclic loading simulations (500 cycles) were conducted to mimic knee motion, tracking fracture displacement with Optotrak (Fig 1). The Data was collected after every 100 cycles. After that, the constructs were secured over a servohydraulic testing machine (MTS) to determine the load-to-failure.

Results: In this study, two distinct augmentation methods for patella transverse fractures were compared after fixing it with two cannulated screws: anterior VA LNP and TBW. Catastrophic failures due to compromised bone quality led to the exclusion of certain specimens. The investigation revealed significant biomechanical differences between the two methods. After 500 cycles, the average fracture displacement for the anterior VA LNP group was 0.09 ± 0.12 mm, compared to 0.77 ± 0.54 mm for the TBW with cannulated screw group (Fig 2). Additionally, the load-to-failure analysis showed a significant difference, with the anterior VA LNP and cannulated screw group exhibiting a mean load-to-failure of 1267.20 ± 393.30 N and the cannulated screw with TBW group showing 820.00 ± 233.00 N. These findings emphasize the biomechanical superiority of anterior VA LNP over TBW.

Discussion: Anterior VA LNP are very low profile and adjustable according to the morphology of patella. It is also exhibiting higher load-to-failure capabilities [1]. Conventional strategies, such as cannulated screws or K wires and TBW, have addressed patella fractures in the average population. Notably, cannulated screws have emerged as a superior treatment option, providing enhanced biomechanical support compared to K- wires and TBW. However, the need to augur simple transverse patella fracture is not well explored in contemporary literature. The biomechanical advantage of anterior VA LNP has been repeatedly demonstrated, showcasing improved support and reduced fracture gap widening compared to TBW. So, it is wise to use anterior VA LNP to augment the fixation rather than TBW if needed. However, little data is available on the effectiveness of anterior VA LNP versus TBW in simple transverse patella fractures. The study's results reveal displacement rates within acceptable limits for both constructs, with the anterior plate showing statistical superiority but possibly marginal clinical significance. Load-to-failure data supports these findings, highlighting the substantial load-bearing capacity of both constructs.

Significance / Clinical Relevance: This research highlights the superior biomechanical advantage of anterior VA LNP over TBW for treating simple transverse patella fractures with two cannulated screws. Further rigorous randomized trials are essential to validate these findings, assess clinical viability, and consider financial implications. This significance is particularly pronounced for patients with elevated body weight, BMI, implant quality uncertainty prompting post-fixation augmentations, and cases involving patients with mental illnesses such as acute mania, delirium, or psychosis, necessitating leniency in post-surgical immobilization protocols. Successful implementation of these advanced techniques could enable earlier knee rehabilitation, substantially reducing the risk of post-surgery knee contracture.

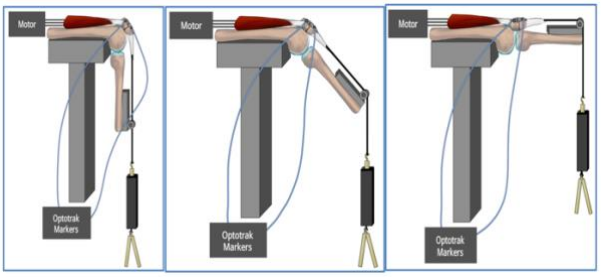

Fig 1: This illustrative depiction captures the cyclic load distribution spanning the range from 90-degree flexion to full extension in a controlled biomechanical setting. Notably, precise Optotrack markers have been strategically affixed to the superior and inferior poles of the patella, serving as instrumental points for the meticulous quantification of fracture displacement

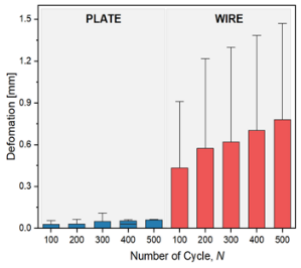

Fig 2. A comparison of average deformation values between plate and wire fixation methods across cycles 100 to 500. Plate fixation consistently exhibited lower deformation, with an average of 0.060 mm at cycle 100, gradually increasing to 0.099 mm at cycle 500. In contrast, wire fixation displayed higher deformation, starting at an average of 0.433 mm at cycle 100 and rising to 0.778 mm at cycle 500.

References

1. Stoffel, K., Zderic, I., Pastor, T. *et al.* Anterior variable-angle locked plating versus tension band wiring of simple and complex patella fractures – a biomechanical investigation. *BMC Musculoskelet Disord* **24**, 279 (2023). https://doi.org/10.1186/s12891-023-06394-x