

# Comparative Analysis of Fixation Methods for Patella Fracture: An Experimental and Finite Element Analysis

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**Introduction:** Patellar fractures, constituting approximately 1% of orthopedic injuries, present intricate challenges due to their indispensable role in knee kinematics [1, 2]. Our study delves into the biomechanics of treating the most common patella fracture type—transverse fractures—by investigating hybrid constructs those cannulated screws with tension band cerclage wiring (TBW) and cannulated screws with variable anterior (VA) locking neutralization plates (LNP) targeting challenges posed by these fractures, notably in patients with obesity or heightened muscle mass [3]. Distinct from traditional methods, our study comprehensively analyzes these unique combinations of fixation approaches. Furthermore, by harnessing Finite Element Analysis (FEA) to delve into intricate mechanics, the study provides the stress pattern and deformation associated with the two fixation methods. The primary objective is to evaluate the biomechanical benefits of an FEA model validated through experimental data. We also assessed the durability and tensile strength of the hybrid approach—integrating cannulated screws with a VA LNP versus TBW.

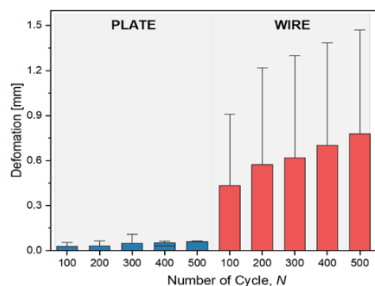
**Methods:** A total of 16 human cadaveric patellae were acquired and transversely fractured. Half of the specimens were repaired using the cannulated screw and VA LN. In contrast, the other half was fixed using TBW—cyclic testing apparatus allowing for precise flexion and extension motion simulation. Optotrak markers were placed on both sides of the fracture for precise spatial measurements. Cyclic testing consisting of 500 flexion and extension cycles evaluated the stability and durability of the fixation constructs. The fracture gap size was measured by analyzing the difference in distance between the Optotrak markers before and after cycling. Load-to-failure tensile testing was conducted, applying forces directly to the proximal and distal tendons. FEA simulations were also performed to analyze the mechanical behavior of the two fixation constructs. FEA models of the fractured patella with the respective fixation constructs were created based on CT scan images, mimics software, and ANSYS. The FEA models and Boundary conditions followed the experiment testing and loading for load-to-failure conditions.

**Result:** At the endpoint of 500 cycles, the patella fixed with the cannulated screw with VA LNP exhibited an average fracture site gap of 0.09mm (SD=0.12mm). This gap was significantly smaller than the average gap of 0.77mm (SD=0.54mm) observed in the group treated with cannulated screws and TBW (**Fig 1**). The load to failure of the plate was, on average, 1359N (SD=393.30), significantly higher than the load to failure of 780.1N (SD=233) observed for the TBW group. FEA simulations supported the experimental findings, showing that the VA LNP could withstand higher loads than the TBW. In the VA LNP group, the maximum stress of 1317.1 MPa was located at the patella's base. In contrast, for the TBW group, the maximum pressure of 347.15 MPa was located at the apex of the lateral side (**Fig 2**).

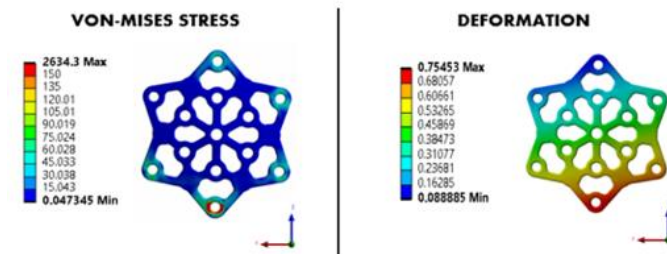
**Discussion:** The study compares the effectiveness of combining cannulated screws with VA LNP versus TBW through biomechanical assessment. The plate construct notably displayed smaller, minor deformation and greater load-to-failure capacity compared to TBW. However, the practical significance of this discrepancy might be constrained by associated expenses. Conventional strategies, such as cannulated screws or K wires and TBW, have addressed patella fractures in normal populations. Notably, cannulated screws have emerged as a superior treatment option, providing enhanced biomechanical support compared to K- wires and TBW. However, the need for augmentation of simple transverse patella fracture are not well explored in the 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 locking plates 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.

## Significance/Clinical Relevance:

The study emphasizes the biomechanical superiority of anterior VA LNP compared to TBW in managing uncomplicated transverse patella fractures using cannulated screws. This advancement shows potential in specific demographics, like obese individuals, facilitating early-phase physiotherapy. Further robust randomized trials are crucial to authenticate these results, evaluate clinical feasibility, and address other considerations. The significance is particularly prominent for patients with higher body weight, uncertain implant quality necessitating additional support post-fixation, and cases involving conditions like ADHD that require flexibility in post-surgical immobilization protocols. Integrating these advanced techniques could allow for accelerated knee rehabilitation, considerably decreasing the risk of post-operative motion constraints.



**Fig 1.** 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.



**Fig 2.** Mechanical analysis results for plate and wire fixation: von-Mises stress distribution of (a) plate (b) wire and along with deformation of (c) plate and (d) wire.

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