

Finite Element Analysis of Tendon-loop Tension Band Fixation in Simple Patellar Fractures Using Cannulated Screws and FiberWire

Kanaphat Rattananithikul¹; Chatchanin Mayurasakorn¹; Technin Seechaipat²; Vajara Phipobmongkol¹



Kanaphat Rattananithikul

¹ Bangkok Orthopedic Center, Bangkok International Hospital, Bangkok, Thailand.

² Center of Excellence in Biomechanics Medicine, Suranaree University of Technology, Nakhon Ratchasima, Thailand.

*Address Correspondence to author:
Chatchanin Mayurasakorn, MD
Bangkok Orthopedic Center,
Bangkok International Hospital,
2 Soi Soonvijai 7, New Petchburi Road,
Huaykwang, Bangkok 10310, Thailand
email: upkanaphat@gmail.com

Received: October 23, 2025
Revision received: June 29, 2026
Accepted after revision: July 19, 2026
BKK Med J 2026;22(2): 97-103.
DOI: 10.31524/bkkmedj.2026.21.003
www.bangkokmedjournal.com

Abstract

OBJECTIVES: To compare the biomechanical performance of stainless steel and FiberWire in a tendon-loop tension band wiring (TBW) construct with cannulated screws using finite element analysis.

MATERIALS AND METHODS: A three-dimensional finite element analysis model of a mid-pole transverse patellar fracture was reconstructed from CT data. Two models combined stainless steel cannulated screws with a figure-of-eight tendon loop made of either 1.25-mm stainless steel wire or 0.75-mm FiberWire No. 5. Under a 400-N load at 45° of knee flexion, von Mises stress and maximum deformation were evaluated for the complete fixation assembly (“cannulated construct”) and the isolated loop component (“figure-of-eight tendon-loop construct”).

RESULTS: Both fixation models demonstrated stable behavior under the simulated loading condition. Peak von Mises stresses in the cannulated constructs were 435.87 MPa for stainless steel and 451.55 MPa for FiberWire, whereas the corresponding values in the figure-of-eight tendon-loop constructs were 329.18 and 319.03 MPa, respectively. Maximum deformation remained below 0.3 mm in all analyses. FiberWire demonstrated stress distribution and deformation patterns comparable to those of stainless steel.

CONCLUSION: The finite element analysis indicated that FiberWire provides fixation stability comparable to that of stainless steel in tendon-loop TBW constructs combined with cannulated screws. By modeling the tendon-loop technique rather than screw-loop modifications, this study reflects the most common surgical practice and supports FiberWire as a clinically relevant alternative to stainless steel. However, the clinical significance of these findings requires further investigation.

Keywords: patellar fracture, tension band wiring, FiberWire, stainless steel, finite element analysis, tendon-loop

Patellar fractures account for approximately 1% of all skeletal injuries and frequently compromise the knee extensor mechanism, thereby necessitating surgical fixation to restore function and achieve reliable union.¹⁻⁵ Among the available surgical methods, tension band wiring (TBW) has become the standard treatment for simple transverse fractures. The principle underlying TBW is the conversion of tensile forces acting on the anterior surface of the patella into compressive forces at the fracture site during knee flexion.⁶

The conventional TBW technique involves placing a figure-of-eight wire loop around the quadriceps and patellar tendons, secured with parallel implants such as Kirschner wires or cannulated screws to maintain alignment.⁷⁻¹⁰ This construction is widely employed because of its technical simplicity and dependable biomechanical stability. However, complications associated with stainless steel (SS) wire—including migration, breakage, and soft-tissue irritation—remain a frequent cause of morbidity and secondary surgical intervention.¹¹⁻¹⁵

Prior studies have introduced screw-loop configurations, in which the wire is threaded through cannulated screws.¹⁶⁻¹⁹ Although these

models offer biomechanical appeal, they differ fundamentally from the tendon-loop technique, which remains the most commonly used method in clinical practice. This difference is not merely technical but also biomechanical, as tendon-loop fixation involves soft-tissue loading and transmits stresses differently from screw-loop constructs.

FiberWire, a high-strength braided polyester suture, has attracted attention as a potential alternative to stainless steel. Previous biomechanical and clinical investigations have suggested that FiberWire provides equivalent or superior stability, with the added benefit of reducing complications related to metallic implants.¹⁹⁻²³ Despite these promising results, few finite element analyses have evaluated FiberWire specifically in the tendon-loop figure-of-eight construct combined with cannulated screws, leaving a gap in evidence relevant to standard surgical practice.

The present study addresses this gap by directly comparing stainless steel and FiberWire in tendon-loop TBW constructs using finite element analysis. By replicating the conventional surgical technique rather than the screw-loop variation, this investigation provides biomechanical insights that are directly translatable to clinical application.

Material and Methods

CT Image Acquisition and Reconstruction

CT imaging was first used to acquire the anatomical geometry of the patella. High-resolution scans of an uninjured right patella were obtained from a 46-year-old man (70 kg, 165 cm). The Digital Imaging and Communications in Medicine (DICOM) dataset was imported into Mimics 10.01 (Materialise, Leuven, Belgium), where segmentation was performed to isolate cortical and cancellous bone regions. Adjacent soft tissues such as capsule, cartilage, and ligaments were excluded. Using reverse engineering techniques, a triangulated three-dimensional (3D) surface mesh of the patella was generated and exported as an STL file.^{19, 24}

Solid Model Preparation

The STL file was then processed in Geomagic Studio (Morrisville, NC, USA) to remove image artifacts, smooth irregularities, and generate a watertight solid geometry. A standardized transverse mid-pole fracture was introduced in accordance with AO/OTA classification 34-C1, with a 0.5 mm gap created at the mid-height of the patella to replicate a clinical fracture pattern. The finalized solid CAD model was then exported to SolidWorks (Dassault Systèmes, Vélizy-Villacoublay, France) for implant modeling and assembly.

Implant Modeling and Assembly

Two fixation models were designed. Model 1 consisted of two 4.0-mm stainless steel cannulated cancellous screws combined with a 1.25-mm stainless steel wire arranged as a figure-of-eight tendon loop. Model 2 employed the same stainless steel cannulated screw configuration but used 0.75-mm FiberWire No. 5 arranged as an identical figure-of-eight tendon loop. Screw positioning was standardized at one-third and two-thirds of the patellar width, perpendicular to the fracture line.

In both fixation models, the wire or suture was looped around the quadriceps and patellar tendons in accordance with the tendon-loop technique rather than passed through the screw cannulations. Anatomical fidelity was preserved, with superior widths measured at 38.02 mm anteriorly and 21.56 mm laterally, and inferior widths at 28.74 mm anteriorly and 20.34 mm laterally. For simulation purposes, the tendon-loop was positioned close to the bone surface. The quadriceps and patellar tendons were not modeled as separate deformable structures. Instead, the wire or suture trajectory was positioned according to anatomical tendon insertion sites to approximate the tendon-loop configuration used clinically. This simplification was adopted to facilitate comparison between fixation materials while maintaining computational efficiency.^{25,26} (Figure 1)

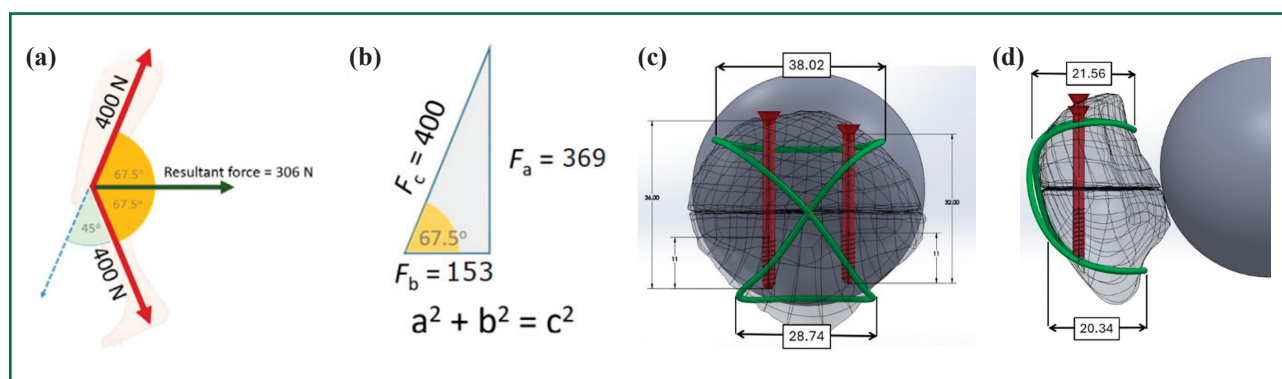


Figure 1: (a) Knee flexion at 45° was simulated by applying a pulling force at 67.5° to each fragment, perpendicular to the patellofemoral joint. The resultant joint reaction force of 306 N was derived from two 153-N force components acting in the same vector direction. (b) Trigonometric calculation of the force vectors. (c, d) Graphic representation of the patellar model with a transverse 0.5-mm fracture gap, two 4.0-mm cannulated cancellous screws, and tendon-loop tension band wiring; the sphere represents the femoral condyle.

Material Properties

Mechanical properties of the materials were defined as isotropic, homogeneous, and linearly elastic, consistent with previous finite element studies (Table 1).¹⁹ Biomechanical properties of bone²⁷⁻²⁹ and implant materials³⁰⁻³² were assigned to the model. The specifications of the 4.0-mm cannulated cancellous screws were based on Synthes screws (Synthes GmbH, Oberdorf, Switzerland) with a 2.6-mm core diameter and a 1.2-mm cannulated diameter. For braided polyester, we used biomechanical properties of FiberWire No.5 (Arthrex, Naples, FL, USA).³³

Boundary Conditions and Loading

The figure-of-eight loop was modeled close to the anterior bony surface of the patella, reflecting the clinical technique where the wire or suture contacts bone to improve construct stability through compression at the fracture site.³⁴ The sphere acting as femoral condyle contacted the posterior surface of the patella. The patellofemoral joint reaction force peaks at approximately 45° of knee flexion.¹⁸ A quadriceps force of ~400 N is typically required to achieve full extension.³⁵ Therefore, the simulation was performed at 45° of flexion with a 400 N load applied to the superior pole of the patella. The distal pole was fixed at the patellar tendon attachment to represent the in vivo anchorage. Contact conditions were defined as follows: the screw–bone interface was bonded, with no relative motion; the wire–bone interface was defined as a no-separation contact to allow load transfer; and the fracture surfaces were defined as no-separation contacts to represent stable fragment apposition without gap closure (Figure 1).

Meshing and Analysis

The reconstructed CAD assembly was discretized using 4-node tetrahedral elements, which are well suited for modeling complex bony geometries. Mesh density was refined in regions of interest (around the fracture site, screws, and wire/suture loops) to improve accuracy of stress distribution results. A mesh convergence test was performed by progressively refining element size until the variation in peak von Mises stress was less than 5%, ensuring a balance between computational efficiency and numerical accuracy. Static structural analysis was carried out in ANSYS Workbench (ANSYS Inc., USA). Boundary conditions and loading were applied as described above, and the solver was set to linear elastic mode with isotropic material properties.¹⁹

Outcome Measures

The following outcome measures were extracted from the simulations:

1. von Mises stress distribution (MPa) to identify stress concentration zones in implants and bone
2. maximum implant deformation (mm) and qualitative assessment of stress distribution patterns

For each fixation model, von Mises stress and maximum deformation were evaluated for the complete screw–loop assembly, referred to as the “cannulated construct.” The figure-of-eight loop component was subsequently isolated and analyzed separately, referred to as the “figure-of-eight tendon-loop construct,” to compare the mechanical behavior of stainless steel wire and FiberWire.

Results

Stress Distribution

Stress concentration was primarily observed at the wire–screw junction and the anterior surface of the patella (Figure 2). Both stainless steel and FiberWire constructs demonstrated stable stress distributions under the simulated loading condition.

- **Cannulated construct:** peak von Mises stress was 435.87 MPa for stainless steel and 451.55 MPa for FiberWire.
- **Figure-of-eight tendon-loop construct:** peak stresses were 329.18 MPa (stainless steel) and 319.03 MPa (FiberWire).

These findings indicate that FiberWire showed a slightly higher peak stress in the cannulated configuration but demonstrated lower peak stresses than stainless steel in the tendon-loop figure-of-eight construct.

Implant Deformation

Maximum implant deformation was minimal in all simulations, remaining under 0.3 mm (Figure 3).

- **Cannulated construct:** 0.268 mm for stainless steel vs. 0.272 mm for FiberWire.
- **Figure-of-eight tendon-loop construct:** 0.265 mm for stainless steel vs. 0.260 mm for FiberWire.

The close similarity between materials suggests comparable fixation stability under the tested loading condition.

Comparative Assessment

Both stainless steel and FiberWire constructs demonstrated comparable mechanical performance. Differences in peak stress were observed, while differences in deformation between the two materials were less than 0.01 mm, suggesting similar fixation stability under the applied loading condition.

Table 1: Material properties

Material	Density (kg/mm ³ ×10 ⁻⁶)	Young's Modulus (MPa)	Poisson's Ratio
Patella (bone)	1.80	5,000	0.30
Stainless steel 316L	7.95	186,400	0.31
FiberWire No. 5	5.50	190,000	0.39

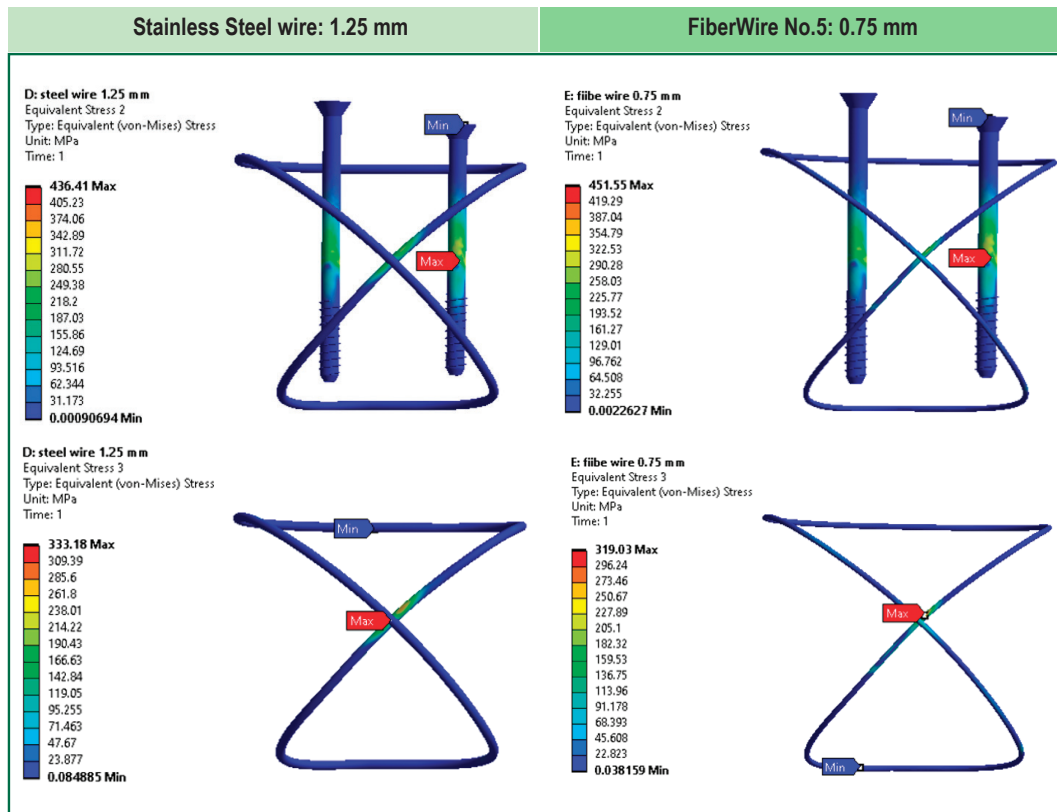


Figure 2: Cannulated construct: peak von Mises stress was 435.87 MPa for stainless steel and 451.55 MPa for FiberWire. Figure-of-eight tendon-loop construct: peak stresses were 329.18 MPa (stainless steel) and 319.03 MPa (FiberWire).

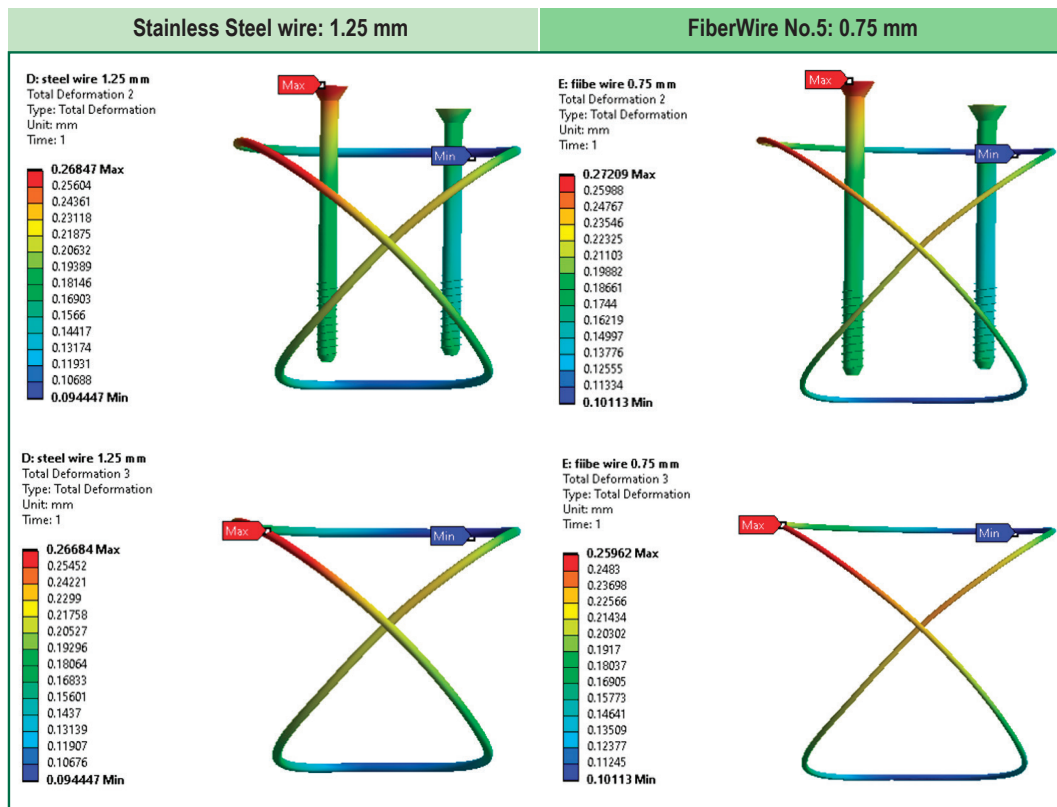


Figure 3: Cannulated construct: 0.268 mm for stainless steel vs. 0.272 mm for FiberWire. Figure-of-eight tendon-loop construct: 0.265 mm for stainless steel vs. 0.260 mm for FiberWire.

Stress Distribution Characteristics

Although differences in stress distribution were observed between fixation materials, both constructs maintained stable biomechanical behavior under loading. Interpretation of these differences should be limited to the modeled conditions and should not be extrapolated directly to clinical outcomes.

Failure Mode

No numerical instability or excessive deformation was observed under the modeled linear-elastic conditions. Both constructs demonstrated stable stress and deformation patterns under the simulated static loading condition.

Table 2: Comparative results of finite element analysis

Construct	Peak Stress (MPa)	Maximum deformation (mm)
Cannulated construct + stainless steel wire	435.87	0.268
Cannulated construct + FiberWire	451.55	0.272
Figure-of-eight tendon-loop construct + stainless steel wire	329.18	0.265
Figure-of-eight tendon-loop construct + FiberWire	319.03	0.260

Note: The cannulated construct represents the complete screw-loop assembly, whereas the figure-of-eight tendon-loop construct represents the isolated loop analysis. Stainless steel cannulated screws were used in both fixation models.

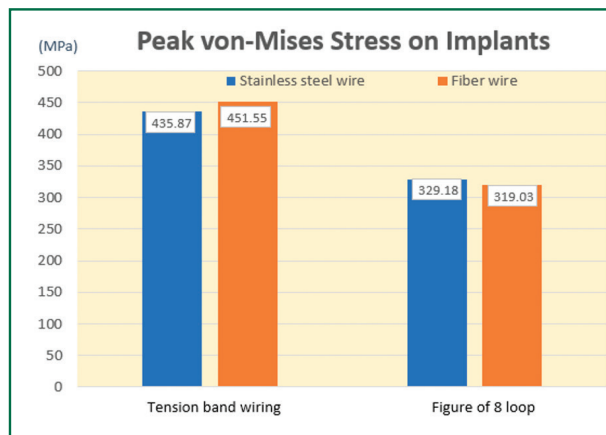


Figure 4: Cannulated construct: peak von Mises stress was 435.87 MPa for stainless steel and 451.55 MPa for FiberWire. Figure-of-eight tendon-loop construct: peak stresses were 329.18 MPa (stainless steel) and 319.03 MPa (FiberWire)

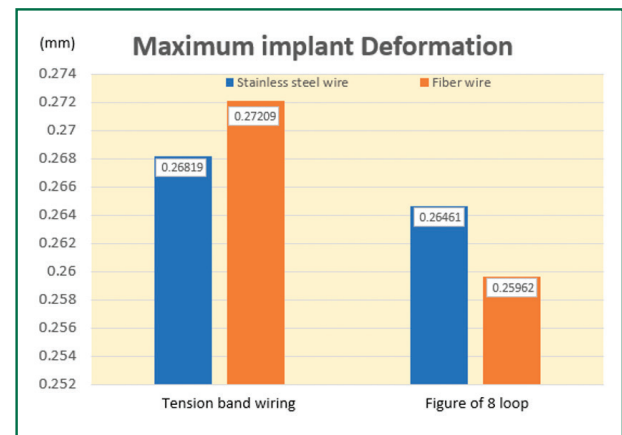


Figure 5: Cannulated construct: 0.268 mm for stainless steel vs. 0.272 mm for FiberWire. Figure-of-eight tendon-loop construct: 0.265 mm for stainless steel vs. 0.260 mm for FiberWire.

Discussion

Biomechanical Interpretation

This study suggests that FiberWire provides fixation stability comparable to that of stainless steel when paired with cannulated screws for transverse patellar fractures. Both materials demonstrated stable stress patterns, with maximum deformation remaining below 0.3 mm under the modeled loading condition. As a braided suture material, FiberWire offers greater handling flexibility and conformability than stainless steel wire; however, these practical characteristics were not directly evaluated in the present finite element model. Although stainless steel is mechanically robust, metallic fixation has been associated with implant-related complications, including implant migration and irritation.^{12,13} A central contribution of this study is the use of the tendon-loop figure-of-eight construct, in contrast to screw-loop models commonly reported in finite element analysis studies.^{8,19,23,36} Since the tendon-loop technique is the standard in clinical practice, our findings provide biomechanical evidence more directly applicable to everyday surgical decision-

making. These findings suggest that FiberWire may provide practical handling advantages while maintaining biomechanical performance comparable to that of stainless steel under the modeled conditions.

Interpretation of Stress Distribution

Differences in stress distribution were identified between fixation materials. However, because the present study employed a static finite element model, no conclusions can be drawn regarding fatigue performance, cyclic durability, or long-term mechanical behavior. Additional experimental studies are required to investigate these aspects.

Comparison with Previous Studies

Mayurasakorn et al.¹⁹ and Xiang et al.²³ reported biomechanical performance comparable to that of stainless steel in screw-loop models. Our results extend this knowledge to the traditional tendon-loop construct, showing that FiberWire maintains biomechanical reliability in the technique

most familiar to surgeons. Similarly, Demirtaş et al.^{6,22} and Lin et al.¹⁶ highlighted the importance of construct geometry; our findings reinforce that geometry plays a decisive role in fixation mechanics, and FiberWire performs effectively in the tendon-loop arrangement.

Clinical Relevance

The clinical implications of this work are considerable. Stainless steel tension bands, while effective, are prone to hardware-related complications including cut-out, breakage, and symptomatic irritation that often require secondary removal.^{11-13,20} FiberWire eliminates the metallic tension-band wire, potentially reducing these complications and improving patient comfort. The present findings demonstrate biomechanical feasibility under simulated conditions. Whether these findings translate into differences in patient outcomes, complication rates, or reoperation rates remains unknown and requires clinical investigation. Because the tendon-loop technique remains a standard surgical approach, our findings support FiberWire as a potentially viable alternative to stainless steel under the simulated conditions.

Limitations

This study has several limitations. First, the finite element model assumed isotropic and homogeneous material properties for bone, excluding natural anisotropy. Second, only static loading at 45° knee flexion was simulated, whereas in vivo loading involves multi-angle, cyclic forces. Third, tendon elasticity and soft tissue properties were excluded; the tendon loop was modeled closest to the bone surface based on anatomical references, which may not exactly replicate clinical placement. Finally, the quadriceps and patellar tendons were not modeled as separate deformable structures, and the simplified representation of FiberWire may not fully capture the complex mechanical behavior of braided suture materials.

Furthermore, knot formation and FiberWire conformability, as well as twisting of the stainless steel wire, were not explicitly modeled. Cyclic loading, fatigue behavior, biological healing, and patient-specific variability were also not incorporated into the present analysis.

Conclusion

Finite element analysis demonstrated comparable biomechanical performance between FiberWire and stainless-steel tendon-loop tension band constructs combined with cannulated screws under the simulated loading condition. By modeling the tendon-loop configuration commonly used in clinical practice, this study provides biomechanical information relevant to contemporary surgical techniques. Further biomechanical and clinical studies are required to validate these findings and determine their clinical significance.

Acknowledgements

The authors gratefully acknowledge the support of Dr. Suthorn Bavonratanavech, Chief of the Bangkok Dusit Medical Services Orthopedic and Trauma Care Network, Thailand, and Chief of Faculty at the Center of Excellence in Orthopedics Institute. The authors also acknowledge the contributions of the research team, particularly Mr. Techin Seechaipat from the Center of Excellence in Biomechanics Medicine, Suranaree University of Technology, Thailand.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- Boström A. Fracture of the patella. A study of 422 patellar fractures. *Acta Orthop Scand Suppl.* 1972;143:1-80. doi: 10.3109/ort.1972.43.suppl-143.01.
- Weber MJ, Janecki CJ, McLeod P, et al. Efficacy of various forms of fixation of transverse fractures of the patella. *J Bone Joint Surg Am.* 1980;62(2):215-20.
- Carpenter JE, Kasman R, Matthews LS. Fractures of the patella. *Instr Course Lect.* 1994;43:97-108.
- Melvin JS, Mehta S. Patellar fractures in adults. *J Am Acad Orthop Surg.* 2011;19(4):198-207. doi: 10.5435/00124635-201104000-00004.
- Gwinner C, Mardian S, Schwabe P, et al. Current concepts review: Fractures of the patella. *GMS Interdiscip Plast Reconstr Surg DGPW.* 2016;5:Doc01. doi: 10.3205/ips000080.
- Demirtaş Y, Emet A. The comparison of the two different patella fracture fixation technique: finite element analysis. *Int J Pioneer Technol Eng.* 2022;1(2):95-8. doi: 10.56158/jpte.2022.35.1.02.
- Wright PB, Kosmopoulos V, Cote RE, et al. FiberWire is superior in strength to stainless steel wire for tension band fixation of transverse patellar fractures. *Injury.* 2009;40(11):1200-3. doi: 10.1016/j.injury.2009.04.011.
- Chen CH, Chen YN, Li CT, et al. Roles of the screw types, proximity and anterior band wiring in the surgical fixation of transverse patellar fractures: a finite element investigation. *BMC Musculoskelet Disord.* 2019;20(1):99. doi: 10.1186/s12891-019-2474-7.
- Lack WD, Karunakar MA. Patellar fractures and dislocations and extensor mechanism injuries. In: Tornetta P 3rd, Ricci WM, editors. *Rockwood and Green's fractures in adults.* 9th ed. Philadelphia: Wolters Kluwer; 2019. p. 2152-74.
- Rudloff MI. Fractures of the lower extremity: patella. In: Azar FM, Beaty JH, editors. *Campbell's operative orthopaedics.* 14th ed. Philadelphia: Elsevier; 2021. p. 2873-9.

11. Dy CJ, Little MTM, Berkes MB, et al. Meta-analysis of re-operation, nonunion, and infection after open reduction and internal fixation of patella fractures. *J Trauma Acute Care Surg*. 2012;73(4):928-32. doi: 10.1097/TA.0b013e31825168b6.
12. Hoshino CM, Tran W, Tiberi JV, et al. Complications following tension-band fixation of patellar fractures with cannulated screws compared with Kirschner wires. *J Bone Joint Surg Am*. 2013;95(7):653-9. doi: 10.2106/JBJS.K.01549.
13. Monaco E, Del Duca A, Cardarelli S, et al. Fixation of patella fractures with metallic implants is associated with a significantly higher risk of complications and re-operations than non-metallic implants: a systematic review and meta-analysis. *Int Orthop*. 2022;46(12):2927-37. doi: 10.1007/s00264-022-05565-0.
14. LeBrun CT, Langford JR, Sagi HC. Functional outcomes after operatively treated patella fractures. *J Orthop Trauma*. 2012;26(7):422-6. doi: 10.1097/BOT.0b013e318228c1a1.
15. Baid M, Narula S, Manara JR, et al. Evolution in the management of patella fractures. *J Clin Med*. 2024;13(5): 1426. doi: 10.3390/jcm13051426.
16. Lin T, Liu J, Xiao B, et al. Comparison of the outcomes of cannulated screws vs. modified tension band wiring fixation techniques in the management of mildly displaced patellar fractures. *BMC Musculoskelet Disord*. 2015;16:282. doi: 10.1186/s12891-015-0719-7.
17. Zderic I, Stoffel K, Sommer C, et al. Biomechanical evaluation of the tension band wiring principle. A comparison between two different techniques for transverse patella fracture fixation. *Injury*. 2017;48(8):1749-57. doi: 10.1016/j.injury.2017.05.037.
18. Amirouche F, Mzeihem M, Hoag J, et al. Finite element analysis of patellofemoral contact pressure with varying fixation of transverse patella fractures. *JB JS Open Access*. 2025; 10(3):e25.00032. doi: 10.2106/JBJS.OA.25.00032.
19. Mayurasakorn C, Phiphobmongkol V, Kosuwon W, et al. Cannulated screws and braided polyester tension band as an alternative for fixation of transverse patella fracture: a finite element analysis study. *BKK Med J*. 2017;13:11-8. doi:10.31524/bkkmedj.2017.09.003.
20. Camarda L, La Gattuta A, Butera M, et al. FiberWire tension band for patellar fractures. *J Orthop Traumatol*. 2016;17(1): 75-80. doi: 10.1007/s10195-015-0359-6.
21. Bric JD, Martin JM, McGrady LM, et al. Biomechanical evaluation of transverse patella fracture fixation using headless screws: a comparison of suture versus cable as a tension band. *J Orthop Trauma*. 2023;37(6):e253-e257. doi: 10.1097/BOT.0000000000002556.
22. Demirtaş Y, Katı YA. A novel patella fracture fixation technique: finite element analysis. *Arch Orthop Trauma Surg*. 2023;143(9): 5105-15. doi: 10.1007/s00402-023-04910-1.
23. Xiang F, Xiao Y, Li D, et al. Tension band high-strength suture combined with absorbable cannulated screws for treating transverse patellar fractures: finite element analysis and clinical study. *Front Bioeng Biotechnol*. 2024;12:1340482. doi: 10.3389/fbioe.2024.1340482.
24. Liu Y, Zhang X, Yu S, et al. Finite element analysis of a novel patellar fracture fixation method. *BMC Musculoskelet Disord*. 2024;25(1):1073. doi: 10.1186/s12891-024-08235-x.
25. Oikawa R, Tajima G, Yan J, et al. Morphology of the patellar tendon and its insertion sites using three-dimensional computed tomography: A cadaveric study. *Knee*. 2019;26(2):302-9. doi: 10.1016/j.knee.2018.12.002.
26. Nakano G, Tajima G, Maruyama M, et al. Morphology of the quadriceps tendon and its patella insertion site on three-dimensional computed tomography and magnetic resonance imaging: A cadaveric study. *Knee*. 2023;43:136-43. doi: 10.1016/j.knee.2023.06.001.
27. Pal S. Mechanical properties of biological materials. In: Pal S. Design of artificial human joints & organs. Boston (MA): Springer; 2014. p. 23-40. doi: 10.1007/978-1-4614-6255-2_2.
28. Gargiulo P, Helgason T, Reynisson PJ, et al. Monitoring of muscle and bone recovery in spinal cord injury patients treated with electrical stimulation using three-dimensional imaging and segmentation techniques: methodological assessment. *Artif Organs*. 2011;35(3):275-81. doi: 10.1111/j.1525-1594.2011.01214.x.
29. Reilly DT, Burstein AH. The elastic and ultimate properties of compact bone tissue. *J Biomech*. 1975;8(6):393-405. doi: 10.1016/0021-9290(75)90075-5.
30. Sommerich R, DeCelle M, Frasier WJ. Mechanical implant material selection, durability, strength, and stiffness. In: Cheng BC, editor. Handbook of spine technology. Cham: Springer; 2021. p. 151-62. doi: 10.1007/978-3-319-44424-6_30.
31. Disegi J. Implant materials: wrought titanium–15% molybdenum. 2nd ed. West Chester (PA): Synthes; 2009.
32. Najibi S, Banglmeier R, Matta J, et al. Material properties of common suture materials in orthopaedic surgery. *Iowa Orthop J*. 2010;30:84-8.
33. Turker M, Kilicoglu O, Salduz A, et al. Loop security and tensile properties of polyblend and traditional suture materials. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(2):296-302. doi: 10.1007/s00167-010-1186-1.
34. Baran O, Manisali M, Cecen B. Anatomical and biomechanical evaluation of the tension band technique in patellar fractures. *Int Orthop*. 2009;33(4):1113-7. doi: 10.1007/s00264-008-0602-3.
35. Bryant TL, Anderson CL, Stevens CG, et al. Comparison of cannulated screws with FiberWire or stainless steel wire for patella fracture fixation: A pilot study. *J Orthop*. 2015;12(2): 92-6. doi: 10.1016/j.jor.2014.04.011.
36. Kim S, Mungalpara N, Wangikar R, et al. Comparative study of locking neutralization plate construct versus tension band wiring with a cannulated screw for patella fractures: experimental and finite element analysis. *J Orthop Surg Res*. 2024;19(1):77. doi: 10.1186/s13018-024-04538-w.