Research Article

FastFrame Knee Spanning External Fixation Associated With Lower Cost Than Modular Frame Configurations: A Comparative Cohort Study

Luke A. Myhre, MD
Elleanor H. Sato, MD
Lillia Steffenson, MD
Zachary Olsen, BS
David L. Rothberg, MD
Lucas S. Marchand, MD
Justin Haller, MD

ABSTRACT

Introduction: External fixation costs have been identified as a primary driver of initial cost in the care of tibial plateau fractures. Because hospital systems and institutions pursue value-based care, external fixation choices become a uniquely surgeon-dependent driver of cost. Our objective was to determine differences in cost in a prepackaged, single-use, external fixation system compared with standard, modular, knee spanning frames. Secondary objectives were to determine differences in surgical time and loss of distraction between the two types of fixation.

Methods: This was a retrospective cohort study at an academic level 1 trauma center. Fifty-nine patients were treated with knee spanning external fixation over a 7-year period (Arbeitsgemeinschaft fur Osteosynthesefragen/Orthopedic Trauma Association 41-B/C). Patients received either the Zimmer FastFrame external fixator or a conventional-style, modular, external fixator. The primary outcome was implant and supply cost. The secondary outcomes were operating room facility cost, surgical time, and percent of distraction lost.

Results: The FastFrame cohort demonstrated a 24.9% decrease in surgical times (29.2 vs. 38.9 minutes, $P = 0.002$), with a 37% decrease in supply and implant cost of conventional cohort (0.63x vs. 1x, $P < 0.001$). Operating room facility cost was less than the conventional cohort (0.72x vs. 1x, $P = 0.41$), and total cost was 21.8% less (0.78x vs. 1x, $P = 0.07$), although these did not reach statistical significance. The Fastframe cohort lost less distraction (72.6% vs. 62.8%, $P = 0.02$).

Conclusion: The FastFrame demonstrates a lower supply and implant cost, faster surgical times, and demonstrated clinical equivalence in regard to loss of distraction when compared with conventional, modular, external fixator.

Level of Evidence: Diagnostic—Level III

From the Department of Orthopedic Surgery, University of Utah Health Sciences, Salt Lake City, UT.

Correspondence to Dr. Myhre: luke.myhre@gmail.com

J Am Acad Orthop Surg 2025;33:e1423-e1428

DOI: 10.5435/JAAOS-D-24-00372

Value-based care has been an important priority in health care over the past decade.[1] Health care represented 17.6% of the United States Gross Domestic Product in 2016.[2] This cost can be particularly difficult in the trauma population where there is a high proportion of underinsured patients.[3] There is a professional responsibility in orthopaedic surgical care to pursue value-based care, which includes an understanding of implant cost.[4] Yet many surgeons are unaware of the costs of devices they implant.[5] It is highly likely that future methods, such as gain sharing, comanagement, and bundled payments, will incentivize surgeons toward value-based care.[6,7] Value is also affected by the barriers companies and institutions in North America face to recycling external fixator components.[8] Numerous factors contribute to optimal value-based care in the perioperative management of orthopaedic trauma patients. Implant selection is an aspect of the total cost of care that can be dictated by surgeons and is therefore of interest to orthopaedic trauma surgeons, as they make decisions to maximize value.

Tibial plateau fractures represent a wide spectrum of severity requiring a variety of surgical interventions, including the potential need for staged approaches. Temporizing external fixation is often required to maintain length and alignment during the acute inflammatory stage after high-energy injuries. These frames are left in place while surgeons monitor the soft tissues in preparation for definitive internal fixation. Patients often require a period of 7 to 15 days with a fixator in place before they undergo definitive surgery.[9] Costs associated with external fixation can be notable, although the procedure is relatively straight forward and requires less surgical time than the definitive surgery. Knee spanning fixators can reach more than $10,000 in implant costs,[10] which represents a notable cost to the patient and the healthcare system. External fixation component selection has been identified as the largest contributor to overall cost in the first 30 days of care in tibial plateau fractures.[11]

Previous research has demonstrated high cost variability in temporizing external fixation both in laboratory and clinical settings.[10,12,13] In addition, surgical costs between similarly trained traumatologists is highly variable in both ankle and tibial plateau fractures.[14] Standard external systems rely on pin-rod connectors and carbon fiber rods that can be assembled in a variety of constructs (Figure 3). A preassembled single-use external fixator in a single sterile package (FastFrame) was designed to increase operating room (OR) efficiency and reduce cost.[15] The system includes telescoping tubes and triplanar spheres that allow adjustment of length and alignment for a fixed cost (Figure 4). Although standard system's cost varies with construct choices, the FastFrame does not.

There are no published studies that investigate whether the FastFrame system affected surgical costs as compared with standard external fixation systems. The purpose of the study was to analyze the cost difference between the Fast Frame and standard external fixator systems to allow surgeons to optimize value to their patients.

Methods

Institutional review board approval was obtained under IRB 00071850, "Value of the Treatment of traumatic musculoskeletal injuries at the University of Utah." Patients treated with knee spanning external fixation at a single, academic, level 1 trauma center were identified retrospectively by Current Procedural Terminology codes (20690, 27535, 27536, 27556, 27557, 27558) from 2015 to 2022. All medical records of patients with the above codes were reviewed to determine eligibility by the following criteria.

Inclusion Criteria

Inclusion criteria for this study included patients older than 18 years, who were treated with acute knee spanning external fixation for traumatic tibial plateau fracture or traumatic knee dislocation.

Exclusion Criteria

Patients were excluded if they underwent a revision of a previously placed external fixator or application of a fixator spanning multiple joints. Patients were excluded from the cost analysis if they had another procedure performed simultaneously with the placement of external fixation. Therefore, any patients with simultaneous irrigation and débridement, compartment release, internal fixation, revascularization, or treatment of other injuries were excluded. Patients who had definitive fixation during their initial hospitalization were also ineligible for cost analysis.

Patients meeting criteria were included and queried for cost information through the value-Driven Outcome (VDO) database. The VDO database is a proprietary tool developed at the University of Utah that allows generation of encounter level cost in the following areas: facility utilization, imaging, implant, laboratory, pharmacy, supply direct costs, and other services.[16] Because of variance in billing, surgical implants can fall in to

either the supply or the implant costs, and so these cost buckets were combined in our analysis. Costs reflect institutional costs and are not dependent on patient payments or insurance company reimbursements. The VDO database has been shown in previous publications to be an important tool in the optimization of value-based care.[17-19] Because of compliance with vendor contracts, cost data from the VDO is published as a relative percentage instead of dollar amounts.

Imaging Review

Routine care at this institution includes anterior-posterior and lateral intraoperative fluoroscopy views of the knee after placement of the spanning frame. The distraction of the joint and fracture fragments, where applicable, were compared between intraoperative fluoroscopy and routine postoperative flat plates in the radiology suite. Given inaccuracies arising from magnification differences, all measurements were calibrated off the diameter of the external fixation bars. The ratio of the diameter of the bars to the joint space was then compared between intraoperative images and postoperative images to determine the amount of "settling" or shortening that naturally occurs with all frames (Figure 1 and 2). A small decrease in the level of distraction may normally lack clinical relevance; however, any differences in the utility of the fixators being compared was known to also be of interest to surgeons seeking to compare value.

Statistical Analysis

Patient demographic information, injury characteristics, and external fixator types were tabulated and placed in our two cohorts, the FastFix Cohort and the Conventional Cohort. Costs between the cohorts were compared using a student two-tailed *t*-test. Categorical values were compared using the chi-square test. Statistical analysis was done using Excel 2016. Standard statistical significance of $P < 0.05$ was set for all comparisons Figures 3 and 4.

Results

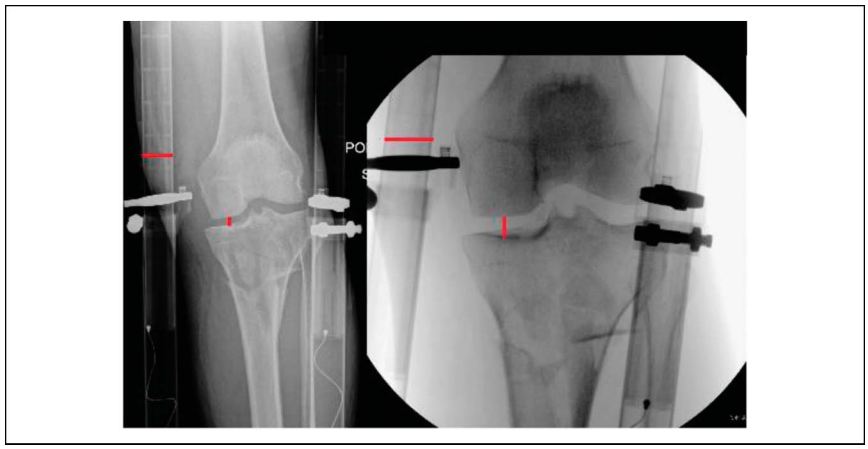
Seventy-seven patients met inclusion criteria and were included in our initial analysis. Of these, 18 patients underwent another surgical procedure after their spanning external fixation in the same hospitalization and were therefore excluded from the final cost analysis. Therefore, 59 patients were ultimately included in the cost analysis with 32 patients in our conventional cohort and 27 patients in our Fastframe cohort. Demographics, insurance characteristics, and injury characteristics were similar between the cohorts (Table 1).

The supply and implant costs of the Fastframe cohort were 0.63x compared with the conventional cohort ($P < 0.001$; Table 2). No statistically significant difference was found in costs between the Fastframe and conventional cohorts in OR facility cost (0.72x, $P < 0.41$) or the sum total cost (0.78x, $P = 0.07$). In addition, the Fastframe cohort had faster surgical times (29.2 vs. 38.9 minutes, $P = 0.002$) and a decreased loss of distraction ratio (0.628 vs. 0.726, $P = 0.02$).

Discussion

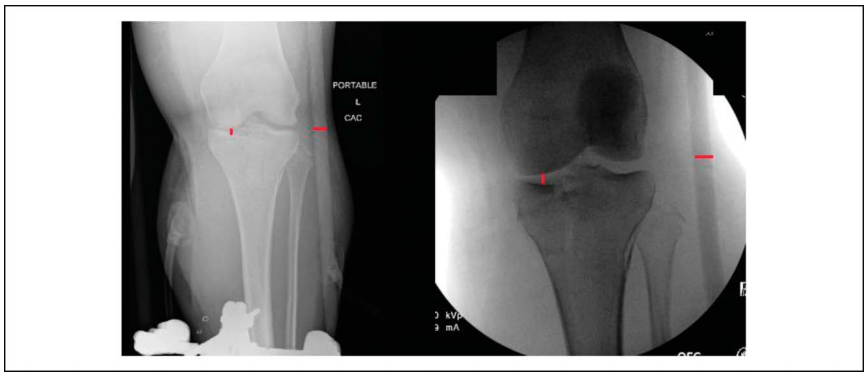
The purpose of this study was to evaluate the difference in cost between the Zimmer FastFrame Knee Spanning External Fixation System and conventional modular

Figure 1



Intraoperative and postoperative radiographs demonstrating maintenance of distraction.

Figure 2



Intraoperative and postoperative radiographs demonstrating loss of distraction.

systems for acute trauma requiring a temporizing tibiofemoral frame. The data demonstrate a 36.6% decrease in supply and implant costs in the FastFrame cohort compared with the conventional cohort, and a 24.9% decrease or 9.7-minute decrease in surgical time. This cost difference is similar to the expected percentage difference in previously published conventional fixators and the negotiated cost of the FastFrame at this institution. Unfortunately, any specific cost differences are institution dependent due to institutional contract negotiations. Although specific cost variability will be dependent on the treating institution, it is reasonable to infer that the data reflects real trends in the national market. It is also reasonable to be skeptical of industry bias given the unique nature of the implant in question. However, no discussion exists between the authors and implant companies during this retrospective research project or with the design surgeons who are from a different institution. In addition, our hospital does not have a unique financial relationship with Zimmer.

Figure 3

Image showing conventional knee spanning external fixator. Conventional frames all include two bars crossing the knee; however, some use small carbon fiber bars, and some employ multipin clamps. Most frames use two 5-mm pins in the tibia and two in the femur. As seen in Figures 3 and 4, sometimes a third pin can be added if purchase or bone quality is questionable.

The cost of a conventional external fixator has been demonstrated in the literature to vary widely, and the FastFrame benefits from a consistent cost without variability in drill bits, pins, connectors, and bars that can vary by surgeon and construct choice. Okelana et al[20] retrospectively reviewed the cost of external fixators in tibial plateau and pilon fractures in 319 patients. They found that the mean plateau construct cost was $5,372 and that the clamps contributed to 69.9% of the cost of the construct. They concluded that cost drivers include surgeon bias and implant preference. Similarly, Hayek et al retrospectively reviewed 221 tibial plateau fractures

Figure 4

Image showing Fastframe external fixator.

Table 1. Cohort Demographics

Factor or Variable	FastFrame Cohort	Conventional Cohort	*P*
Number	27	32	—
Age, yr	47.1	48.8	0.34
Injury severity score	4.3	3.9	0.53
% male	62.96%	65.60%	0.83
% federal insurance	25.90%	25%	—
% private insurance	66.70%	59.40%	—
% self-pay	7.40%	15.60%	—
Full-time employed	57.70%	55.00%	—
Time to conversion (d)	9.48	14.1	0.13
AO OTA 41B (%)	5 (18.5%)	5 (15.6%)	—
AO OTA 41C (%)	22 (81.5%)	25 (78.1%)	—
Knee dislocation	0	2 (6.25%)	—

AO = Arbeitsgemeinschaft fur Osteosynthesefragen, OTA = Orthopedic Trauma Association

and found a mean fixator construct cost of $4,947 with a range of $1848 to $11,568. They did not find any correlation with the fellowship training of the surgeon, the injury characteristics, or the patient demographics. Neither of these studies included FastFrame constructs.

Surgical time has not been studied in external fixation to our knowledge. All surgical times were calculated from procedure start and stop times as recorded by the OR nurse in the OR case log. The drilling of pins and tightening of clamps is assumed to be similar between the cohorts; however, the Fastframe allows pin insertion through the frame, and immediate distraction with tab removal once adequate length is restored. This forgoes the need to preplan bar length, adjust clamps, and design the modular construct before securing the frame in place. Consequently, although only 27 frames were placed between four surgeons, the lack of familiarity does not seem to have markedly affected the efficiency benefit to the FastFrame.

The maintenance of distraction analysis was a secondary question in our project and was included to provide some evaluation of the efficacy of the different fixator cohorts. Return to the OR for revision of the fixators would be a definitive end point but is quite uncommon in general. Outside of knee dislocations, there is rarely ongoing radiographic evaluation because most patients are not routinely imaged between postoperative radiographs and definitive fixation. In our cohorts, only one return was reported to the OR for a revision of conventional external fixator in one of the knee dislocation patients, who spent a much longer time in the fixator.

There are several limitations to this work, including sample size, patient variation, and complexities of cost reporting. This study did also not research the effect of recycling processes or reprocessing associated with conventional implants. The Fastframe was designed as a single use implant, which both enabled cheaper materials and eliminates the possibility of recycling. The ability of an institution to effectively reprocess conventional systems may ultimately make them more appealing from both a cost and environmental perspective. However,

Table 2. Cohort Outcomes

Factor or Variable	FastFrame Cohort	Conventional Cohort	Ratio	*P*
Surgical times	29.2 min	38.9 min	0.75,064,267	**0.002**
Loss of distraction ratio	0.726	0.628	0.86,501,377	**0.02**
Supply/implant cost	1.0	1.58	0.63,411,607	<**0.001**
OR facility cost	1.0	1.39	0.7,201,684	0.41
Sum cost	1.0	1.28	0.78,236,493	0.07

Bold values are statistically significant.
OR = operating room

these data span a number of years and are pragmatic, and they should be interpreted as such. In addition, we were unable to report exact dollar amounts due to possible breaches with vendor contracts. Value improvements may be dependent on the treating institution.

Conclusion

To the authors knowledge, this is the first study to report on a series using the FastFrame system. The Zimmer FastFrame demonstrates a lower supply and implant cost, faster surgical times, and clinical equivalence in loss of distraction when compared with conventional, modular, external fixation systems.

References

1. *AO/OTA Fracture and Dislocation Classification Compendium—2018*. Available at: https://www.aofoundation.org/trauma/clinical-library-and-tools/journals-and-publications/classification.

2. Powers JS: *Value Driven Healthcare and Geriatric Medicine*. Cham, Switzerland, Springer International Publishing, 2018.

3. Greenberg S, Mir HR, Jahangir AA, Mehta S, Sethi MK: Impacting policy change for orthopaedic trauma. *J Orthop Trauma* 2014;28(suppl 10):S14-S16.

4. Andrawis JP, Chenok KE, Bozic KJ: Health policy implications of outcomes measurement in orthopaedics. *Clin Orthop Relat Res* 2013;471:3475-3481.

5. Okike K, O'Toole RV, Pollak AN, et al: Survey finds few orthopedic surgeons know the costs of the devices they implant. *Health Aff (Millwood)* 2014;33:103-109.

6. Lansky D, Nwachukwu BU, Bozic KJ: Using financial incentives to improve value in orthopaedics. *Clin Orthop Relat Res* 2012;470: 1027-1037.

7. Nwachukwu BU, Hamid KS, Bozic KJ: Measuring value in orthopaedic surgery. *JBJS Rev* 2013;1:e2.

8. Horwitz DS, Schabel KLS, Higgins TF: The economic impact of reprocessing external fixation components. *J Bone Joint Surg Am* 2007; 89:2132-2136.

9. Egol KA, Tejwani NC, Capla EL, Wolinsky PL, Koval KJ: Staged management of high-energy proximal tibia fractures (OTA types 41): The results of a prospective, standardized protocol. *J Orthop Trauma* 2005;19: 448-456, discussion 456.

10. Hayek KR, Parikh HR, McCreary DL, et al: Cost variation in temporizing external fixation of tibial plateau fractures. *J Orthop Trauma* 2019;33(suppl 7):S5-S10.

11. Albright P, Only A, Parikh HR, et al: External fixation characteristics drive cost of care for high-energy tibial plateau fractures. *J Orthop Trauma* 2022;36:189-194.

12. Logan C, Hess A, Kwon JY: Damage control orthopaedics: Variability of construct design for external fixation of the lower extremity and implications on cost. *Injury* 2015;46:1533-1538.

13. Chaus GW, Dukes C, Hak DJ, Mauffrey C, Mark Hammerberg E: Analysis of usage and associated cost of external fixators at an urban Level 1 trauma centre. *Injury* 2014;45:1611-1613.

14. Wetzel RJ, Kempton LB, Lee ES, Zlowodzki M, McKinley TO, Virkus WW: Wide variation of surgical cost in the treatment of periarticular lower extremity injuries between 6 fellowship-trained trauma surgeons. *J Orthop Trauma* 2016;30:e377-e383.

15. *FastFrame® External Fixation System*, Zimmer Biomet. Available at: https://www.zimmerbiomet.com/en/products-and-solutions/specialties/trauma/fastframe-external-fixation-system.html.

16. Kawamoto K, Martin CJ, Williams K, et al: Value Driven Outcomes (VDO): A pragmatic, modular, and extensible software framework for understanding and improving health care costs and outcomes. *J Am Med Inform Assoc* 2015;22:223-235.

17. Lee VS, Kawamoto K, Hess R, et al: Implementation of a value-driven outcomes program to identify high variability in clinical costs and outcomes and association with reduced cost and improved quality. *JAMA* 2016;316: 1061-1072.

18. Federer AE, Yoo M, Stephens AS, et al: Minimizing costs for dorsal wrist ganglion treatment: A cost-minimization analysis. *J Hand Surg Am* 2023;48:9-18.

19. Randall DJ, Peacock K, Nickel KB, Olsen MA, Kazmers NH: Moving minor hand surgeries out of the operating room and into the office-based procedure room: A population-based trend analysis. *J Hand Surg Am* 2022;47:1137-1145.

20. Okelana B, McMillan L, Huyke-Hernandez FA, Only AJ, Parikh HR, Cunningham BP: Cost variation in temporizing external fixation of tibial plateau and pilon fractures: Is there room to improve? *Injury* 2022;53: 2872-2879.