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Comparison of direct surgical cost and outcomes for unstable elbow injuries: internal joint stabilizer versus external fixation

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Background: Unstable elbow injuries sometimes require External fixation (ExF) or an Internal Joint Stabilizer (IJS) to maintain joint reduction. No studies have compared the clinical outcomes and surgical costs of these 2 treatment modalities. The purpose of this study was to determine whether clinical outcome and surgical encounter total direct costs (SETDCs) differ between ExF and IJS for unstable elbow injuries

Methods: This retrospective study identified adult patients (aged ≥ 18 years) with unstable elbow injures treated by either an IJS or ExF between 2010 and 2019 at a single tertiary academic center. Patients postoperatively completed 3 patient-reported outcome measures (the Disability of the Arm, Shoulder, and Hand, the Mayo Elbow Performance score, and EQ-5D-DL). Postoperative range of motion was measured in all patients, and complications tallied. SETDCs were determined and compared between the 2 groups.

Results: A total of 23 patients were identified, with 12 in each group. Clinical and radiographic follow-up for the IJS group averaged 24 months and 6 months, respectively, and for the ExF group, 78 months and 5 months, respectively. The 2 groups had similar final range of motion, the Mayo Elbow Performance score, and 5Q-5D-5L scores; ExF patients had better the Disability of the Arm, Shoulder, and Hand scores. IJS patients had fewer complications and were less likely to require additional surgery. The SETDCs were similar between the 2 groups, but the relative contributors to cost differed significantly between the groups.

Conclusions: Patients treated with an ExF or IJS had similar clinical outcomes, but complications and second surgeries were more likely in ExF patients. The overall SETDC was also similar for ExF and IJS, but relative contributions of the cost subcategories differed.

Elbow instability may persist after dislocation or fracture dislocation despite bony stabilization and ligament repair. Traditionally, surgeons use external fixation (ExF) that spans the elbow to maintain joint reduction, but this is associated with complications including incongruent joint reduction, nerve injury, and pin tract infections.[1,5,8,10,17-19] Moreover, surgeons may not be able to restore normal joint kinematics accurately and consistently with dynamic ExF due to the technical difficulty in identifying joint axis of rotation.[4,21,23]

In 2014, Orbay and Mijares introduced an alternative to ExF for elbow instability, a device later named the Internal Joint Stabilizer (IJS).[14] The IJS is a completely implantable device consisting of a hinge pin inserted into the distal humerus which is then connected to a base plate attached to the olecranon.[15,20] A guide placed over the distal articular surface of the humerus facilitates identification and cannulation of the axis of rotation. While not entirely interchangeable, the clinical indications for the IJS and elbow external fixators largely overlap.

No studies have compared the clinical outcomes of ExF vs. IJS. Also, the surgical encounter total direct costs (SETDCs) have not been studied for these devices, which are warranted given their similar clinical indications. The purpose of this retrospective study is two-fold: to compare the clinical outcomes and SETDCs of ExF and IJS for the treatment of complex elbow instability at a single institution. Our null hypotheses are that there is no difference in the SETDCs between these devices, and there will be similar clinical outcomes between fixation types.

Methods

Patient demographic collection

Our institutional review board approved this retrospective study. Patients treated between January 2010 and December 2019 at our tertiary academic institution were identified via the

The University of Iowa Hospital and Clinic Institutional Review Board approved this study (#: 202107052).

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electronic medical record. Patients aged ≥ 18 years treated with an IJS or ExF for elbow instability following an elbow dislocation or fracture dislocation were included. We reviewed preoperative injury radiographs to ensure the injury involved a dislocation of the ulna from the humerus. Chronic simple dislocations and complex fracture dislocations with associated coronoid tip fracture and/or radial head fracture were included. Exclusion criteria included patients with lower extremity fractures/dislocations, open elbow injuries, ipsilateral humerus fractures, and ipsilateral fractures distal to the elbow. Preoperative elbow instability of included patients was determined by presence of a dislocation at time of initial presentation. Furthermore, the postoperative stability was determined by maintenance of radiographic congruence at subsequent follow-up visits. The need to stabilize the elbow with a spanning device (ie, use the IJS or ExF) was at the discretion of the treating surgeon. There were a total of 8 treating surgeons, 5 of which exclusively provided ExF, with 3 providing both IJS and ExF. Postoperatively, all patients were immobilized for approximately 2 weeks after device placement, with subsequent range of motion (ROM) beginning at the discretion of the treating surgeon. We also collected demographic information including age, body mass index (BMI), American Society of Anesthesiologists (ASA) score, mechanism of injury, insurance payor, total follow-up, last clinical follow-up elbow ROM, and postoperative complications.

Patient-reported outcome collection

Authors collected 3 patient-reported outcomes (PROs) postoperatively to assess functionality of affected extremity with activities of daily living, quality of life, and overall health. These included the Disability of the Arm, Shoulder, and Hand (DASH), the Mayo Elbow Performance score (MEPS), and the European Quality of Life 5 Dimensions 5 Level. The DASH questionnaire measures self-rated upper extremity disability and symptoms and is scored from 0 (no disability) to 100 (completely disabled).[2] The MEPS questionnaire measures limitations caused by pathology of the elbow during activities of daily living and includes 4 subscales of pain, ROM, stability, and daily function. This results in a point score on a scale of 0 to 100 where < 60 is considered poor, 60-74 is considered fair, 75-89 is considered good, and 90-100 is considered excellent.[3,6] The European Quality of Life 5 Dimensions 5 Level is a questionnaire that measures patients' quality of life, irrespective of disease, yielding an index score anchored at 0 (dead) and 1 (full health).[9,12]

Cost data collection

Our institution collects cost data for individual patient encounters which can be broken down into subcategories. Following methodology used in similar studies,[13,22] we identified subcategories that could be specifically linked to an individual surgical encounter rather than overall hospital stay. This allowed focused analysis of the direct surgical costs of the patient's treatment. We analyzed 5 subcategories including implant cost, nonimplant supply costs, operating room (OR) utilization cost, postanesthesia care unit utilization cost, and anesthesia cost. We excluded imaging costs because of the wide variation in imaging utilization. Subcategories were then combined to produce a SETDC for each patient. Analysis excluded the cost of additional implants used (eg, radial head prostheses, suture anchors). Supply included any common supplies used between both procedures. It is also worth noting that components of an ExF at our institution including bar clamps, carbon fiber rods, and caps are considered supply and not implant as these items are not physically implanted into a patient.

Our hospital administration does not permit disclosure of raw cost data (ie, cost in dollars) due to contractual agreements and institutional policies. Therefore, we reported costs relative to the mean SETDC (ie, divided by the mean total direct cost of the entire cohort). The mean was scaled to a value of 1.0. The relative contribution of each subcategory was then represented as relative contributors to the overall SETDC. For example, implant cost in dollars is divided by the mean total direct cost in dollars. An example derivation of SETDC is demonstrated in Supplementary Appendix S1.

We also collected cost data for any subsequent procedures, in addition to SETDC for each index procedure. We included any return to the OR related to patient's elbow injury such as for hardware removal, manipulation under anesthesia for stiffness, deep infection requiring irrigation and débridement, or persistent instability requiring revision of implant. IJS removal requires a return to the OR and was performed when the patient felt it was prominent or there was radiographic evidence of loosening or other implant failure. Regarding ExF removal, patients are given the option of having this done in the OR or clinic. Given the original manufacturer description of the IJS included a secondary hardware removal procedure, we also performed a hypothetical cost analysis if all IJS patients returned to the OR for hardware removal, and no ExF patients returned to the OR for hardware removal (ie, removed in clinic).

Statistical analyses

Descriptive statistics of patient, injury, and surgical characteristics were performed and reported. The median (interquartile range [IQR]) was used to describe continuous variables while categorical variables were presented as frequencies (percentages). Due to the small number of subjects in each group, we reported the median (IQR) and used nonparametric methods. Between-group comparisons were made using the Wilcoxon rank-sum test for continuous variables and chi-square or exact tests, as appropriate, for categorical variables.

Outcomes of surgery including complications, PRO scores, and ROM were compared between the 2 groups using the same analytic methods. Hospital-related direct costs were adjusted for inflation to 2021 dollars using the Gross Domestic Product price index from the US Department Commerce. The direct overall and component costs were scaled to the overall, cohort mean direct cost[22] and compared between surgery groups using Wilcoxon rank-sum tests. In addition, the median (IQR) was reported by sex, age group (18 to < 35, 35-< 65, ≥ 65 years), overweight status (BMI < 30, ≥ 30), insurance, fixation type, ASA class (< 3, ≥ 3), and operative and anesthetic total time categorized as per the 75th percentile (140 minutes for operative time, 203 minutes for anesthesia time) and compared between categories using the Wilcoxon rank-sum test to evaluate factors associated with total direct costs. Analyses used SAS statistical software version 9.4 (SAS Institute, Inc., Cary, NC, USA). We considered a P value < .05 to indicate statistical significance with all tests two-tailed.

Results

A total of 23 patients met inclusion criteria, with 5 treating surgeons. In addition to IJS or ExF placement, 11 patients had radial head fractures requiring arthroplasty, 18 underwent collateral ligament repair, and 4 required open reduction internal fixation of the coronoid (Table I). Initial injuries included 15 terrible triad fracture/dislocations and 8 simple dislocations that did not stay reduced after closed reduction. One patient's elbow subluxated while in an ExF and was subsequently revised to IJS. The initial injury in this

Table I
Surgical encounter demographics.

Variable	Categories	IJS	ExF	P value
Time from injury to OR (d)		17 (11-32)	14 (2-30)	.6
Additional procedures during surgical encounter	Radial head replacement	6	5	.9
	LCL repair	8	7	
	MCL repair	1	2	
	Coronoid repair	1	3	
	None	2	3	
Required secondary trips to OR	Total	2	10[†]	.04*
Operating time (min)	Median (IQR)	85 (68-136)	128 (93-163)	.08*
Anesthesia time (min)	Median (IQR)	150 (107-186)	197 (177-248)	.01*
ASA class	1	0	2 (17%)	.5
	2	6 (50%)	4 (33%)	
	3	6 (50%)	5 (42%)	
	4	0	1 (8%)	
	5	0	0	

OR, operating room; *IJS*, internal joint stabilizer; *ExF*, external fixation; *ASA*, American Society of Anesthesiologists; *LCL*, lateral collateral ligament; *MCL*, medial collateral ligament; *IQR*, interquartile range.
*Indicates significance.
†Total includes 5 patients who went to OR, for ExF removal.

Table II
Number of treating surgeons and fixation type performed.

Surgeon	# Of IJS	# Of ExF	Years in practice
Surgeon 1	0	1	>30 y
Surgeon 2	0	1	>20 y
Surgeon 3	0	3	>20 y
Surgeon 4	10	1	17 y
Surgeon 5	0	1	12 y
Surgeon 6	0	3	8 y
Surgeon 7	1	1	5 y
Surgeon 8	1	1	5 y

IJS, internal joint stabilizer; *ExF*, external fixation.

patient demonstrated a posterior elbow dislocation without additional fracture. The only additional procedure at the time of ExF application was lateral collateral ligament repair. Since this patient underwent both ExF and subsequently IJS, the patient was included in both the ExF group and IJS group analyses, with cost data for each fixation type used independently for analysis without crossover. This resulted in 12 patients in each group. Among those who underwent ExF, 5 patients had static fixators and 7 patients had dynamic fixators. There were a total of 8 treating surgeons, 5 of whom exclusively provided ExF, with 3 providing both IJS and ExF (Table II).

The 2 fixation methods did not demonstrate statistically significant difference for age, sex, BMI, mechanism of injury, or insurance payor. Furthermore, there were no differences in time from injury to OR, additional procedures during initial surgical encounter, or ASA class. The ExF group had a statistically significantly higher return to OR rate compared to IJS. Five of the patients with ExF requested device removal in the OR; therefore, more patients with ExF required a return trip to the OR: 10 returns in ExF cohort compared to 2 returns to OR for device removal in IJS cohort ($P = .04$) (Table III). Average postoperative radiographic and clinical follow-up for IJS was 6 months (±4 months) and 24 months (±7 months) and ExF was 5 months (±2 months) and 78 months (±42 months), respectively.

Average arc of extension-flexion was better in the IJS group (25-130°) than in the ExF group (22.5-115°) but this trend did not reach statistical significance (Table IV). Similarly, the IJS pronation-supination arc (160°) exceeded that of the ExF (145°) but was not statistically significant. Regarding PRO collection, 2 IJS patients and 4 ExF patients were unable to be contacted at time of study for final PRO data, otherwise all data were available for each patient at required time points for data collection. Due to the small number of subjects in each group, we only used available data for analyses. The ExF group had better DASH scores than the IJS group (2.5 and 12.1, respectively), a trend that reached statistical significance. The minimal clinically important difference (MCID) for DASH is 10.8.[7] The mean MCID between fixation types was 15.1 (95% confidence interval = 2.8-27.4) representing not only statistical but clinical significance.

The ExF group had more complications compared to IJS ($P = .03$). One elbow subluxated while in an ExF, while no elbows in the IJS group subluxated or dislocated. We defined deep infection as patient return to OR to undergo irrigation and débridement. Two deep infections within the ExF group began as superficial infections treated initially with oral antibiotics but did not resolve and required operative irrigation and débridement. No patients with an IJS had an infection. Cohorts did not demonstrate significant differences in postoperative neuritis/neuropraxa (Table V).

ExF demonstrated significantly greater OR utilization, anesthesia, and supply costs compared to IJS with a median IQR of 0.15 (0.13-0.17) vs. 0.09 (0.08-0.12) ($P = .003$), 0.06 (0.04-0.06) vs. 0.04 (0.03-0.04) ($P = .007$), and 0.2 (0.09-0.4) vs. 0.05 (0.05-0.06) ($P = .01$), respectively. IJS demonstrated significantly greater implant cost compared to ExF with a median IQR of 0.7 (0.6-0.8) vs. 0.2 (0.1-0.4) ($P = .0003$) (Fig. 1). The 2 fixation types did not affect postanesthesia care unit costs (Table VI, Figs. 2 and 3). When considering additional return to OR costs, ExF showed greater costs for OR utilization, anesthesia, and supply costs (Table VII). Furthermore, when performing a hypothetical cost analysis comparing SETDCs assuming all IJS patients underwent hardware removal and no ExF patients underwent hardware removal, the IJS group had a higher SETDC than the ExF group (1.1 vs. 0.9), but this difference was not statistically significant ($P = .5$) (Table VIII).

Discussion

Our retrospective study from a single institution compares the clinical outcomes of patients with complex elbow instability treated with a relatively novel internal stabilizing device vs. an external fixator. The IJS group had superior final ROM compared to the ExF group, but this trend did not reach statistical significance nor did it reach MCID. The true significance in ROM between the 2 fixation groups is difficult to ascertain with such a small cohort of included patients. Patients treated with an ExF scored better on DASH and MEPS than IJS patients, with the DASH

Table III
Patient demographics.

Variable	Categories	IJS	ExF	*P* value
Age	Median (IQR)	52 (34-65)	58 (50-72)	.5
Sex	Male	6 (50%)	5 (42%)	.7
BMI (kg/m^2)	Median (IQR)	32 (30-35)	30.7 (26-49)	.8
Mechanism of Injury	MVA/MCC	2 (17%)	4 (33%)	.4
	Ground level fall	7 (58%)	7 (58%)	
	Fall from height	3 (25%)	1 (0.1%)	
Insurance	Commercial	5 (42%)	1	.1
	Medicaid	3 (25%)	3 (25%)	
	Medicare	3 (25%)	3 (25%)	
	Government other	0	0	
	Workers' compensation	1 (0.1%)	1 (0.1%)	
	Unknown	0	4 (33%)	

BMI, body mass index; *IJS*, internal joint stabilizer; *ExF*, external fixation; *IQR*, interquartile range; *SD*, standard deviation; *MVA*, motor vehicle accident; *MCC*, motorcycle crash.

Table IV
Patient-reported outcomes and postoperative range of motion.

Patient-reported outcomes	IJS	ExF	*P* value
DASH	12 (8-34)	2.5 (1-8)	.04*
EQ-5L-5D	0.8 (0.7-0.9)	0.8 (0.7-0.9)	.9
MEPS	78 (65-95)	95 (88-98)	.06
Active ROM (degrees ± SD)			
Flexion	130° (120-140)	115° (90-140)	.3
Extension	25° (15-35)	23° (10-30)	.8
Supination	80° (60-90)	60° (20-90)	.3
Pronation	80° (70-90)	85° (30-90)	.9

IJS, internal joint stabilizer; *ExF*, external fixation; *DASH*, disability of the arm, shoulder, and hand; *EQ-5L-5D*, European quality of life in 5 dimensions; *MEPS*, mayo elbow performance score; *ROM*, range of motion; *SD*, standard deviation.
*Indicates significance.

difference but not the MEPS difference statistically significant. 5Q-5L-5D scores were identical between the 2 groups. Patients treated with an IJS had fewer complications than the ExF patients, including one who lost reduction and had to be converted to an IJS. This patient's elbow remained reduced and to date has not required additional surgery. Two ExF patients had pin tract infections and did not improve with oral antibiotics and required operative débridement. The IJS manufacturer guidelines recommend device removal at 6-8 weeks because the implant may eventually fail. Like Sochol et al we do not regularly remove the device unless the patient requests it, or if we observe signs of loosening or subsidence over time.[20] In this cohort, 2 of 12 had their IJS implant removed. Given that external fixators must be removed and that IJS removal was discretionary, we did not count these returns to the OR as a complication.

Two other clinical outcome studies of the IJS have been published with clinical results similar to ours. In a multicenter prospective study involving 6 surgeons, Orbay et al reported an average postoperative arc of elbow motion as 119 degrees and DASH score of 16 in 24 patients, all of whom underwent device removal.[14] In a single-center/single-surgeon study, Sochel et al reported an average arc of motion of 124.3 degrees, DASH scores of 37.3, and MEPS of 82.5 in 20 patients.[20] Six and 10 patients ultimately underwent device removal and arthroscopic release, respectively. Our clinical outcomes and complication rates were also like previous reports of elbow ExF.[1,10] However, it is worth noting that the ExF group demonstrated more patients with high-energy elbow trauma based on mechanism of action (4 patients) vs. the IJS group (2 patients). Based on the smaller cohorts, this could have contributed to the higher rate of infection that was demonstrated in the ExF group.

This is the first study to compare PROs between fixation types for unstable elbow injuries. Only DASH scores were statistically different between fixation types. This could be explained by the detailed nature of the DASH questionnaire which focuses on specific individual tasks of the shoulder and hand in addition to the elbow. This contrasts with MEPS which focuses specifically on elbow performance. Furthermore, we did not know hand dominance of patients between groups which could affect overall score of PROs of the upper extremity. Finally, this study demonstrates a small cohort and is underpowered to potentially show a true difference in outcomes.

The second aim of this study was to compare the SETDCs of patients treated with an IJS vs. ExF. We found that the total cost of the procedures was similar between the 2 groups. However, the subcategory breakdown revealed significant differences in the source of cost. The implant cost of the IJS was 70% of SETDC, significantly more than that of the ExF which was 21%. For the IJS, OR utilization cost and nonimplant supply costs were 14% of the SEDTC, and for ExF 37%. As noted previously, in our institution, the clamps and bars on an external fixator are classified as a supply, not an implant. If factoring in complications and the costs of secondary surgeries, the average cost of care is higher with ExF use than with IJS use at our institution. These data may be useful if surgical services administrators challenge a surgeon's request to procure and use the IJS because of its initial cost.

Indications for IJS removal are controversial. Because the manufacturer of the IJS recommends routine removal, we performed a hypothetical cost analysis if all IJS patients returned to the OR for hardware removal and no ExF patients returned to the OR for hardware removal (ie, removed in clinic). In this hypothetical analysis, the SETDCs were not significantly different between the 2 treatment groups ($P = .5$) (Table VIII). In our cohort, only 2 IJS patients were symptomatic enough to require removal. Limiting IJS removal to those patients who are symptomatic or demonstrate radiographic signs of loosening or subsidence would obviously reduce overall cost.

Given the similar clinical context in which ExF and IJS are used, an analysis of SETDCs between the 2 devices is useful. Value analyses in orthopedic surgery have become common and sometimes demonstrate an opportunity for healthcare cost savings.[11,16,22] Lee et al demonstrated that implementation of a value-driven outcomes tool to identify high variability in costs and outcomes was associated with reduced costs and improved quality in total joint arthroplasty.[13] They opined that there may be a benefit for individual physicians to understand actual care costs (not charges) and outcomes achieved for defined clinical conditions. Unfortunately, our institution prohibited expression of the data in dollars. Other

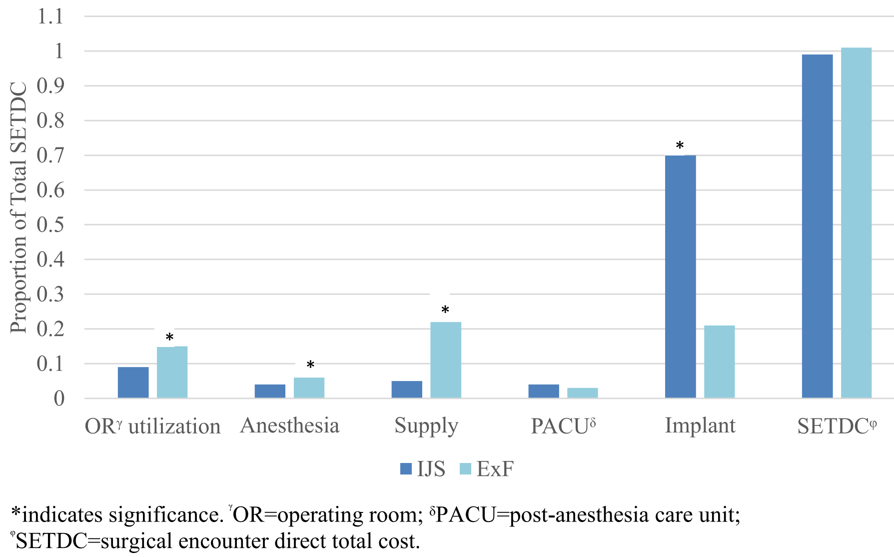


Figure 1 Scaled average cost breakdown—initial procedure. *IJR*, internal joint stabilizer; *ExF*, external fixation.

Table V
Postoperative complication comparison.

Complication	Categories	IJS	ExF	*P* value
Return to OR	Total	2	5	.3
	Hardware Removal	2	0	
	Manipulation for stiffness	0	2	
	Persistent instability	0	1	
	Deep infection	0	2	
Neuritis/Neuropraxia	Total	2	2	1.0
	Radial nerve	1	0	
	Ulnar nerve	1	2	
Superficial infection		0	0	

IJS, internal joint stabilizer; *ExF*, external fixation; *OR*, operating room.

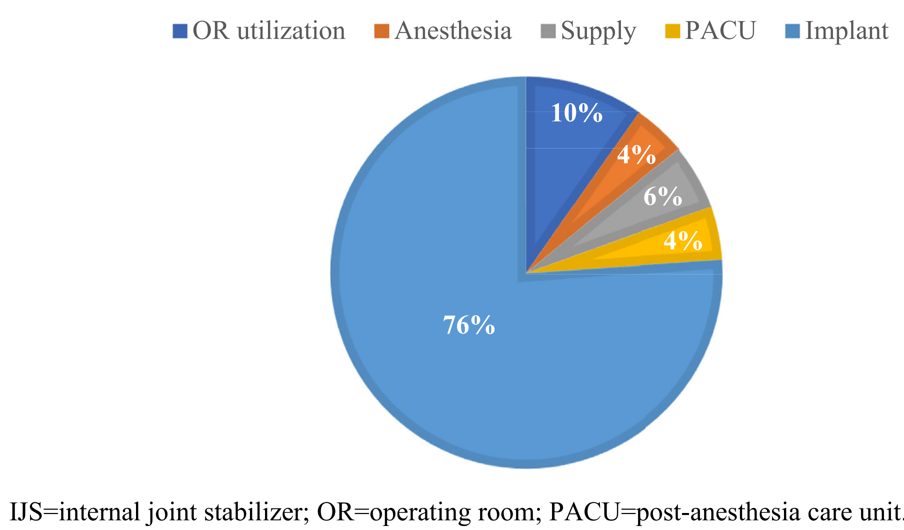
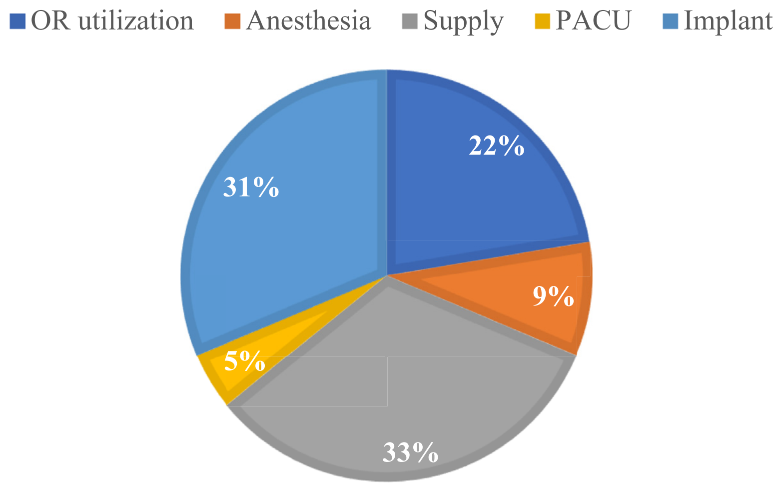


Figure 2 Category percent contribution to surgical encounter direct total cost with use of internal joint stabilizer—initial procedure.

institutions evidently do not have these restrictions,[16] which in our opinion yield data more meaningful to the surgeon interested in cost-effective care. Nevertheless, we believe surgeons should have some understanding of the relative contributors to the SETDC of their surgeries.

The biggest limitation of this study is that it is retrospective and nonrandomized. The sample size was small, with 12 patients in each group, and the follow-up duration short-term. Furthermore, there were a total of 6 patients unable to be contacted at the time of study for final PRO data which further limited the number of data points.



ExF=external fixation; OR=operating room; PACU=post-anesthesia care unit.

Figure 3 Category percent contribution to surgical encounter direct total cost with use of external fixation–initial procedure.

Table VI
Scaled average cost breakdown–initial procedure.

Cost type	IJS (IQR)	ExF (IQR)	*P* value
OR utilization	0.1 (0.1-0.1)	0.2 (0.1-0.2)	.003*
Anesthesia	0.04 (0.03-0.04)	0.1 (0.04-0.1)	.007*
Supply	0.05 (0.05-0.06)	0.2 (0.09-0.4)	.01*
PACU	0.04 (0.02-0.06)	0.03 (0.02-0.05)	.5
Implant	0.7 (0.6-0.8)	0.21 (0.1-0.4)	.0003*
Surgical encounter total direct cost	0.9 (0.9-1.1)	1.0 (0.8-1.3)	.9

OR, operating room; *IJS*, internal joint stabilizer; *IQR*, inter-quartile range; *ExF*, external fixation; *PACU*, postanesthesia care unit.
*Indicates significance.

Table VII
Scaled average cost breakdown–initial procedure and additional procedures.

Cost type	IJS (IQR)	ExF (IQR)	*P* value
OR utilization	0.1 (0.08-0.1)	0.2 (0.1-0.2)	.002*
Anesthesia	0.04 (0.03-0.04)	0.06 (0.05-0.08)	.005*
Supply	0.05 (0.05-0.06)	0.2 (0.08-0.4)	.01*
PACU	0.05 (0.03-0.06)	0.04 (0.02-0.05)	.6
Implant	0.6 (0.5-0.8)	0.2 (0.1-0.4)	.003*
Surgical encounter total direct cost	0.9 (0.8-1.0)	1.1 (0.9-1.2)	.2

IJS, internal joint stabilizer; *IQR*, inter-quartile range; *ExF*, external fixation; *OR*, operating room; *PACU*, postanesthesia care unit.
*Indicates significance.

Table VIII
Hypothetical cost analysis with surgical encounter total direct cost comparison. Hypothetical assumes all IJS patients underwent hardware removal and no ExF patients underwent hardware removal.

Cost type	IJS (IQR)	ExH (IQR)	ExS (IQR)	*P* value
Surgical encounter total direct cost (SETDC)	1.1 (0.9-1.1)	1.0 (0.8-1.3)	0.96 (0.6-1.0)	
		ExF Total (IQR)		
		1.0 (0.7-1.2)		.5

IJS, internal joint stabilizer; *ExH*, hinged external fixation; *ExS*, static external fixation; *IQR*, inter-quartile range; *ExF*, external fixation.

Given that the differences in ROM and MEPS did not reach statistical significance, it may be underpowered. Clinical decision-making and ultimate implant choice were at the discretion of the 8 treating surgeons, and postoperative rehabilitation protocols were not standardized. Given that the IJS is a relatively new device, "learning curve" variability in OR efficiency may have influenced the data and subsequent conclusions. While we excluded additional implant costs of radial head replacements, coronoid fixation, and ligamentous repair, we are unable to account for and control for time these interventions required which could influence overall cost.

Conclusion

Patients with complex elbow instability treated with an ExF or IJS had similar clinical outcomes, but ExF patients were more likely to have a complication and second surgical procedure. The total surgical encounter direct cost was also similar for ExF and IJS, but relative contributions of the cost subcategories differed, for example, the IJS is a more expensive implant, but its application required less OR utilization. Furthermore, future work of a multicenter study could improve power and therefore stronger conclusions could be made regarding clinical differences between fixation types.

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Supplementary Data

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