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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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Abstract

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 two treatment modalities. The purpose of this study was to determine whether clinical outcome and surgical encounter total direct costs (SETDC) differ between ExF and IJS for unstable elbow injuries

Methods: This retrospective study identified adult patients (≥18 years) with unstable elbow injures treated by either an IJS or ExF between 2010-2019 at a single tertiary academic center. Patients postoperatively completed three patient reported outcome measures (DASH, MEPS, EQ-5D-DL). Postoperative range of motion (ROM) was measured in all patients, and complications tallied. SETDCs were determined and compared between the two 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 two groups had similar final ROM, MEPS, and 5Q-5D-5L scores; ExF patients had better DASH scores. IJS patients had fewer complications and were less likely to require additional surgery. The SETDCs were similar between the two 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.

Level of Evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: internal joint stabilizer, unable elbow injuries, external fixation, surgical encounter total direct costs

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 external fixation 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 versus IJS. Also, the surgical encounter total direct costs (SETDCs) have not been studied for these devices, which is warranted given their similar clinical indications. The purpose of this retrospective study is twofold: 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 electronic medical record. Patients ≥18 years old 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. Further, 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 (i.e., use the IJS or ExF) was at the discretion of the treating surgeon. There was a total of 8 treating surgeons, 5 of which exclusively provided external fixation, with 3 providing both IJS and external fixation. Postoperatively, all patients were immobilized for approximately 2 weeks after device placement, with subsequent range of motion 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 (MOI), insurance payor, total follow-up, last clinical follow-up elbow range of motion (ROM), and postoperative complications.

Patient-Reported Outcome Collection

Authors collected three patient reported outcomes (PRO) 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 (EQ-5D-5L). 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, range of motion, 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 EQ-5D-5L 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 five subcategories including implant cost, nonimplant supply costs, operating room (OR) utilization cost, post anesthesia care unit (PACU) utilization cost, and anesthesia cost. We excluded imaging costs because of the wide variation in imaging utilization. Subcategories were then combined to produce a surgical encounter total direct cost (SETDC) for each patient. Analysis excluded the cost of additional implants used (e.g., 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 (i.e., cost in dollars) due to contractual agreements and institutional policies. Therefore, we reported costs relative to the mean SETDC (i.e., 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 Appendix 1.

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 (i.e. removed in clinic).

Statistical Analyses

Descriptive statistics of patient, injury, and surgical characteristics were performed and reported. The median (interquartile range) 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 (interquartile range) and used non-parametric 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 two groups using the same analytic methods. Hospital-related direct costs were adjusted for inflation to 2021 dollars using the Gross Domestic Product (GDP) price index from the U.S. 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 (interquartile range) 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) as well as operative and anesthetic total time categorized according to the 75th percentile (140 minutes for operative time, 203 minutes for anesthesia time) and compared between categories using the Wilcoxon Rank Sum Test in order 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 five 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 (ORIF) of the coronoid (Table 1). 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 patient demonstrated a posterior elbow dislocation without additional fracture. The only additional procedure at the time of ExF application was LCL 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 that underwent ExF, 5 patients had static fixators, and 7 patients had dynamic fixators. There was a total of 8 treating surgeons, 5 of which exclusively provided external fixation, with 3 providing both IJS and external fixation (Table 8).

The two fixation methods did not demonstrate statistically significant difference for age, sex, BMI, MOI, or insurance payor. Further, 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 ($p=0.04$) (Table 2). 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 3). 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 was available for each patient at required time points for data collection. Due to the small number of subjects in each group, we only utilized 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% CI=2.8-27.4) representing not only statistical, but clinical significance.

The ExF group had more complications compared to IJS (p=0.03). 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 4).

ExF demonstrated significantly greater OR utilization, anesthesia, and supply costs compared to IJS with a median inter-quartile range (IQR) of 0.15 (0.13-0.17) versus 0.09 (0.08-0.12) (p=0.003), 0.06 (0.04-0.06) versus 0.04 (0.03-0.04) (p=.007), and 0.2 (0.09-0.4) versus 0.05 (0.05-0.06) (p=0.01), respectively. IJS demonstrated significantly greater implant cost compared to ExF with a median IQR of 0.7 (0.6-0.8) versus 0.2 (0.1 – 0.4) (p=0.0003) (Figure 1). The two fixation types did not affect PACU costs (Table 5, Figures 2, 3). When considering additional return to OR costs, ExF showed greater costs for OR utilization, anesthesia, and supply costs (Table 6). Further, when performing a hypothetical cost analysis comparing

SETDCs assuming all IJS patient 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=0.5) (Table7).

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 versus 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 two 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 difference but not the MEPS difference statistically significant. 5Q-5L-5D scores were identical between the two 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 out 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 that have been published, with clinical results similar to ours. In a multicenter prospective study involving six 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 ten patients ultimately underwent device removal and arthroscopic release, respectively. Our clinical outcomes and complication rates were also like previous reports of elbow external fixation.[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) versus 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. Further, 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 versus ExF. We found that the total cost of the procedures was similar between the two 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 is 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. This data maybe useful if surgical services administrators challenge a surgeon's request to procure and utilize 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 (i.e. removed in clinic). In this hypothetical analysis, the SETDCs were not significantly different between the two treatment groups (p=0.5) (Table7). 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 two 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 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 institutions evidently do not have these restrictions[16], which in our opinion yields data more meaningful to the surgeon interested in cost effective care. Nevertheless, we believe surgeons should have some understanding 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. Further, 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. Given that the differences in ROM and MEPS did not reach statistical significance, it may be underpowered. Clinical decision making and ultimate implant choice was at the discretion of the eight treating surgeons, and postoperative rehabilitation protocols were not standardized. Given that the IJS is a relatively new device, "learning curve" variability in operating room 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, e.g., the IJS is a more expensive implant, but its application required less OR utilization. Further, 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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Figure Legends

Figure 1. Scaled Average Cost Breakdown – Initial Procedure.

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

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

Table Legends

Table 1. Surgical Encounter Demographics.

Table 2. Patient Demographics.

Table 3. Patient Reported Outcomes and Postoperative Range of Motion.

Table 4. Postoperative complication comparison.

Table 5. Scaled Average Cost Breakdown - Initial Procedure.

Table 6. Scaled Average Cost Breakdown - Initial Procedure and Additional Procedures.

Table 7. 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.

Table 8. Number of treating surgeons and fixation type performed.

Appendix Legends

Appendix 1: Sample calculation of Surgical Encounter Total Direct Cost.

Table 1. Surgical Encounter Demographics.

Variable	Categories	IJS[£]	ExF[€]	P-value
Time from injury to OR[¥] (days)		17 (11-32)	14 (2-30)	0.6
Additional procedures during surgical encounter	Radial head replacement	6	5	0.9
	LCL[∞] repair	8	7	
	MCL[˚] repair	1	2	
	Coronoid repair	1	3	
	None	2	3	
Required secondary trips to OR[¥]	Total	2	10[ᵞ]	0.04*
Operating time (minutes)	Median (IQR[φ])	85 (68-136)	128 (93-163)	0.08*
Anesthesia time (minutes)	Median (IQR[φ])	150 (107-186)	197 (177-248)	0.01*
ASA[℧] class	1	0	2 (17%)	0.5
	2	6 (50%)	4 (33%)	
	3	6 (50%)	5 (42%)	
	4	0	1 (8%)	
	5	0	0	

*indicates significance; [¥]OR=operating room; [£]IJS=internal joint stabilizer; [€]ExF=external fixation; [℧]ASA=American Society of Anesthesiologists; [∞]LCL=lateral collateral ligament; [˚]MCL=medial collateral ligament; [ᵞ]total includes 5 patients who went to OR for ExF removal; [φ]IQR=inter-quartile range

Table 2. Patient Demographics.

Variable	Categories	IJS[€]	ExF[¥]	P-value
Age	Median (IQR[Ʊ])	52 (34-65)	58 (50-72)	0.5
Sex	Male	6 (50%)	5 (42%)	0.7
BMI[£] (kg/m^2)	Median (IQR[ᵠ])	32 (30-35)	30.7 (26-49)	0.8
Mechanism of Injury	MVA[δ]/MCC[ᵞ]	2 (17%)	4 (33%)	0.4
	Ground level fall	7 (58%)	7 (58%)	
	Fall from height	3 (25%)	1 (0.1%)	
Insurance	Commercial	5 (42%)	1	0.1
	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; [Ʊ]IQR=interquartile range; [ᵠ]SD=standard deviation; [δ]MVA=motor vehicle accident; [ᵞ]MCC=motorcycle crash

Table 3. Patient Reported Outcomes and Post-operative Range of Motion.

Patient-Reported Outcomes	IJS‡	ExF€	P-value
DASH§	12 (8-34)	2.5 (1-8)	0.04*
EQ-5L-5D¥	0.8 (0.7-0.9)	0.8 (0.7-0.9)	0.9
MEPS£	78 (65-95)	95 (88-98)	0.06
Active ROM± (degrees ± SDð)			
Flexion	130° (120-140)	115° (90-140)	0.3
Extension	25° (15-35)	23° (10-30)	0.8
Supination	80° (60-90)	60° (20-90)	0.3
Pronation	80° (70-90)	85° (30-90)	0.9

*indicates significance. 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; ðSD=standard deviation.

Table 4. Post-operative complication comparison.

Complication	**Categories**	**IJS[‡]**	**ExF[€]**	**P-value**
Return to OR[¥]	Total	2	5	0.3
	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.

Table 5. Scaled Average Cost Breakdown - Initial Procedure.

Cost Type	IJS[£] (IQR[δ])	ExF[¥] (IQR[δ])	P-value
OR[€] utilization	0.1(0.1-0.1)	0.2(0.1-0.2)	0.003*
Anesthesia	0.04(0.03-0.04)	0.1(0.04-0.1)	0.007*
Supply	0.05(0.05-0.06)	0.2(0.09-0.4)	0.01*
PACU[γ]	0.04(0.02-0.06)	0.03(0.02-0.05)	0.5
Implant	0.7(0.6-0.8)	0.21(0.1-0.4)	0.0003*
Surgical encounter total direct cost	0.9(0.9-1.1)	1.0(0.8-1.3)	0.9

*indicates significance. [€]OR=operating room; [£]IJS=internal joint stabilizer; [δ]IQR=inter-quartile range; [¥]ExF=external fixation; [γ]PACU=post-anesthesia care unit

Table 6. 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)	0.002*
Anesthesia	0.04 (0.03-0.04)	0.06 (0.05-0.08)	0.005*
Supply	0.05 (0.05-0.06)	0.2 (0.08-0.4)	0.01*
PACUð	0.05 (0.03-0.06)	0.04 (0.02-0.05)	0.6
Implant	0.6 (0.5-0.8)	0.2 (0.1-0.4)	0.003*
Surgical encounter total direct cost	0.9 (0.8-1.0)	1.1 (0.9-1.2)	0.2

*indicates significance. §IJS=internal joint stabilizer; ¥IQR=inter-quartile range; €ExF=external fixation; ‡OR=operating room; ðPACU=post-anesthesia care unit

Table 7. 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.

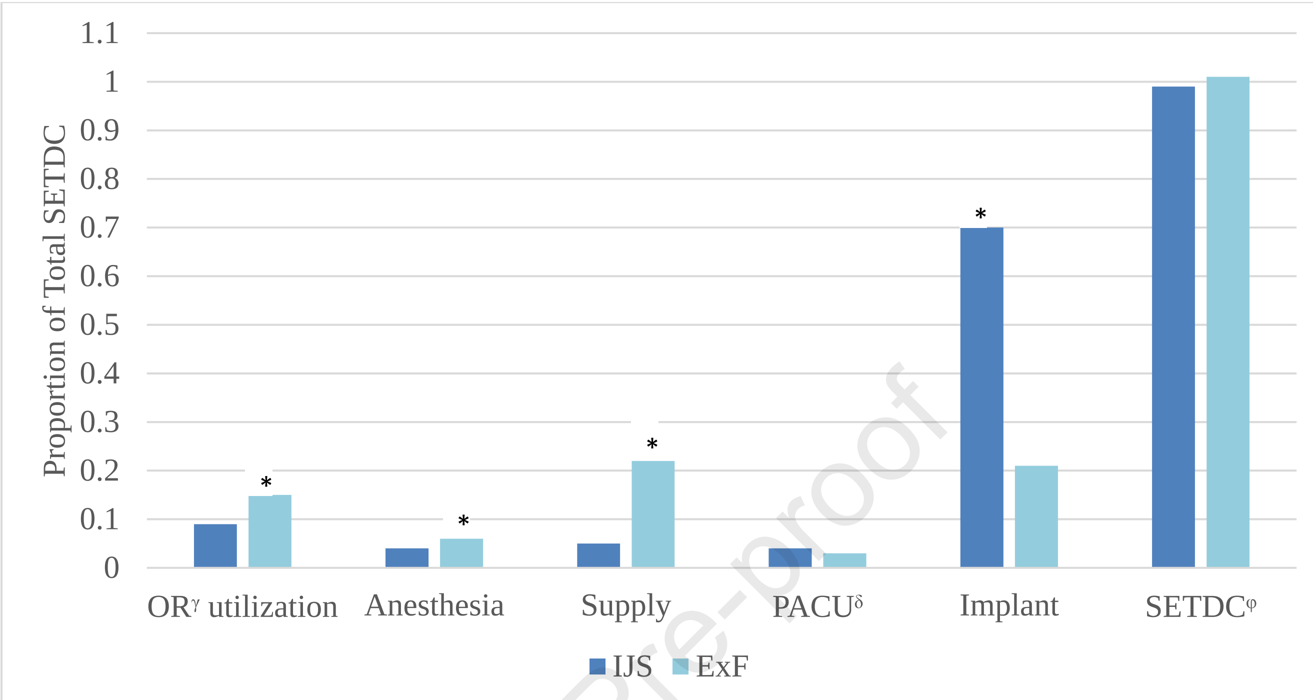
Cost Type	**IJS‡ (IQR)**	**ExH¥ (IQR)**	**ExSδ (IQR)**	**p-value**
Surgical encounter total direct cost (SETDC)	1.1 (0.9-1.1)	1.0 (0.8-1.3)	0.96 (0.6-1.0)	
		ExF€ Total (IQR)		
		1.0 (0.7-1.2)		0.5

‡IJS=internal joint stabilizer; ; ¥ExH=hinged external fixation; δExS=static external fixation; ƱIQR=inter-quartile range; €ExF=external fixation.

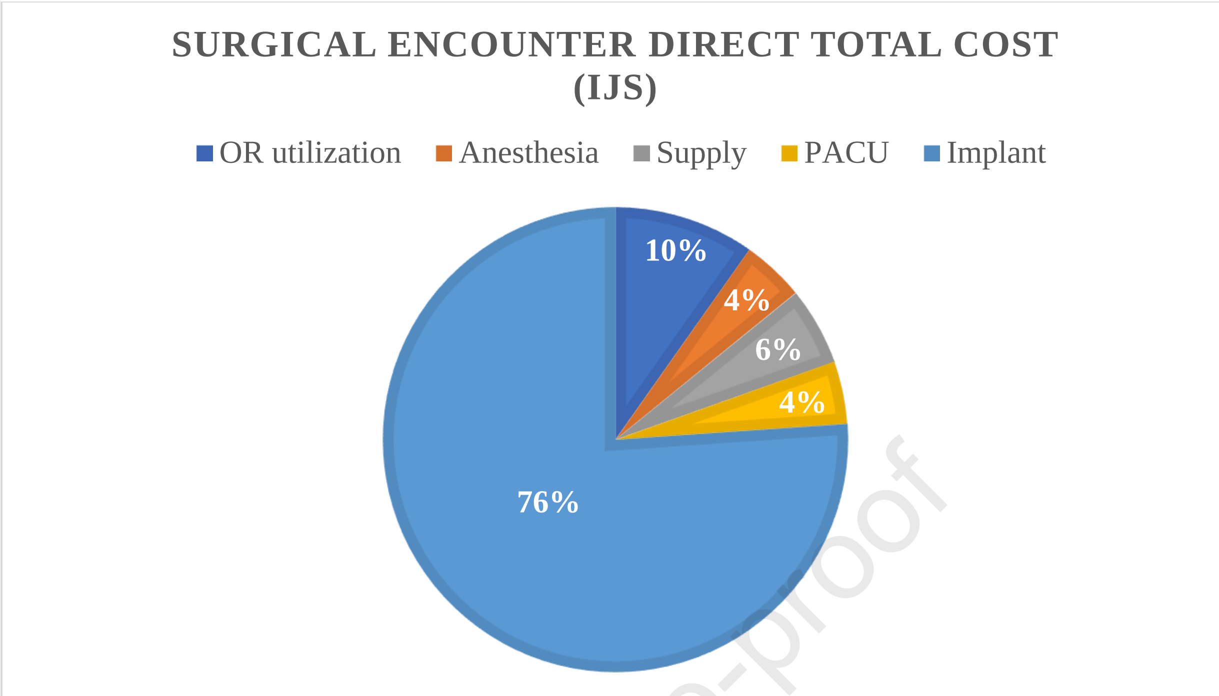
Table 8. Number of treating surgeons and fixation type performed.

Surgeon	# of IJS[¥]	# of ExF[±]	Years in Practice
Surgeon 1	0	1	>30 years
Surgeon 2	0	1	>20 years
Surgeon 3	0	3	>20 years
Surgeon 4	10	1	17 years
Surgeon 5	0	1	12 years
Surgeon 6	0	3	8 years
Surgeon 7	1	1	5 years
Surgeon 8	1	1	5 years

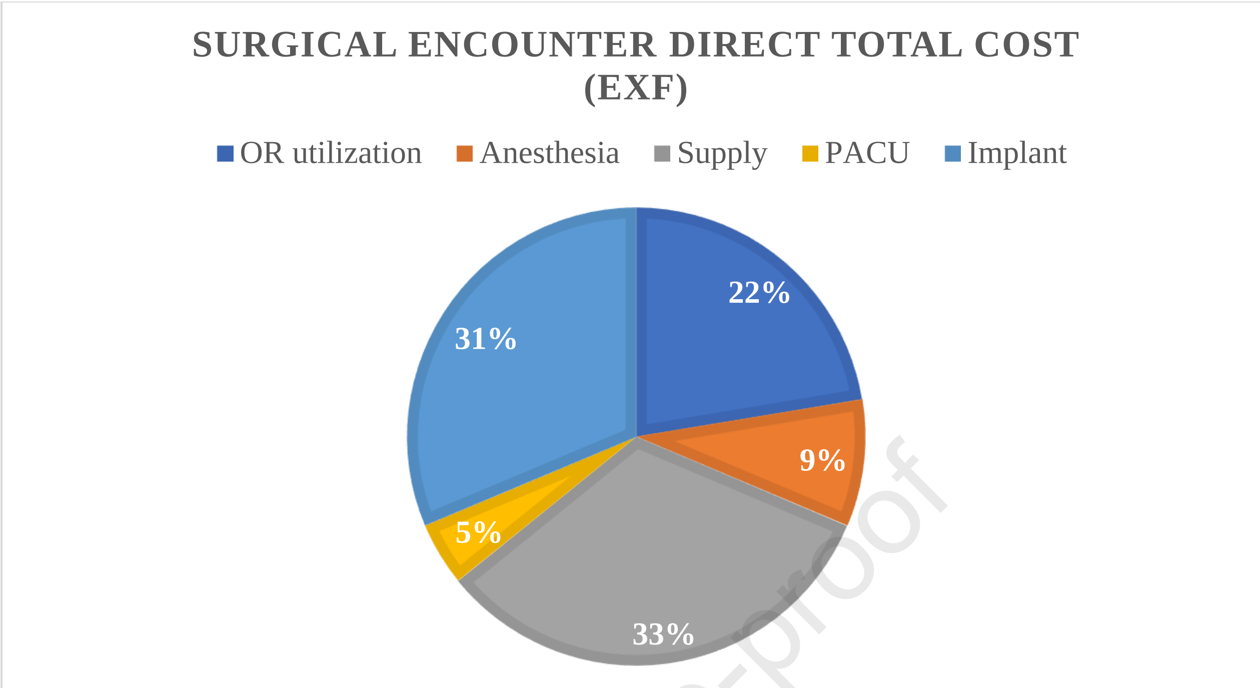
[¥]IJS=internal joint stabilizer; [±]ExF=external fixation.



*indicates significance. γOR=operating room; δPACU=post-anesthesia care unit; φSETDC=surgical encounter direct total cost.



IJS=internal joint stabilizer; OR=operating room; PACU=post-anesthesia care unit.



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