Original Research Article

SAGE Open Medicine

SAGE Open Medicine
Volume 10: 1–5
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DOI: 10.1177/20503121221128690
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A cost analysis of ankle fractures treated by orthopedic surgeons with or without foot and ankle fellowship training at ambulatory surgery centers and hospitals

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Abstract

Introduction: Ankle fractures are commonly treated by orthopedic surgeons. Fellowship versus non-fellowship training often adds a different perspective, use of specialty-specific implants, comfort with outpatient procedures, and may contribute to cost differences between surgeons. To assess the impact of fellowship training on the value of care provided, the difference in cost of ankle fracture open reduction internal fixation procedures between foot and ankle trained orthopedic surgeons and non-foot and ankle trained orthopedic surgeons over the past 10 years was retrospectively evaluated. We additionally evaluated the cost differences of ankle fracture open reduction internal fixations between hospitals, hospital-owned ambulatory surgery centers, and physician-owned ambulatory surgery centers. The study also assessed the costs effects of inpatient versus outpatient procedures and ankle open reduction internal fixation procedure volume of the surgeon observed within the timeframe of the study.

Methods: Patient data was collected from electronic medical records and billing documents for patients who underwent an ankle open reduction internal fixation procedure performed by an orthopedic surgeon in our hospital system and local hospital-owned ambulatory surgery centers between the years 2010 and 2020. Data were also collected from a physician-owned ambulatory surgery center for patients who underwent an ankle open reduction internal fixation procedure performed by an orthopedic surgeon between the years 2015 and 2020. Statistical analyses were performed to observe potential cost differences among all variables.

Results: Procedures performed by fellowship-trained orthopedic surgeons were significantly less costly than those performed by non-foot and ankle trained orthopedic surgeons when performed at ambulatory surgery centers but not at hospitals. Procedures performed at ambulatory surgery centers were found to be significantly less costly than those performed at hospitals. In addition, it was noted that procedures performed at hospital-owned ambulatory surgery centers were less costly than physician-owned ambulatory surgery centers. It was also found that procedure cost decreased with an increase in surgeon volume.

Conclusion: An ankle fracture open reduction internal fixation performed by a foot and ankle trained orthopedic surgeon in a hospital-owned ambulatory surgery center is the lowest cost option available, and an increase in volume of open reduction internal fixations is associated with a further decrease in cost when within our hospital system between the years 2010 and 2020.

Keywords

Ankle fracture, open reduction internal fixation, cost analysis, fellowship training, ambulatory surgery center

Date received: 10 November 2021; accepted: 08 September 2022

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Introduction

Ankle fractures are one of the most common injuries in the United States, comprising nearly 10% of all fractures annually.[1] Furthermore, the overall incidence of ankle fracture injuries has increased steadily over the past four decades and is projected to nearly triple by 2030.[2] Because of these increasing rates of incidence, in tandem with increasing operative cost, ankle fracture repairs comprise a nearly US$11 billion economic burden. Of this burden, approximately US$1.2 billion is attributed to direct healthcare costs, such as physician fees, surgical supplies, and operating time.[3] With greater emphasis on value-based care and the implementation of bundled payment plans, it is of increasing importance to understand the components of these costs to improve the ratio of quality to cost of care for ankle fracture repairs.

Although there is a significant amount of evidence on operational cost variations within surgical practice, little research has been done to determine the effects of fellowship training on surgical cost, specifically the effects of a foot and ankle orthopedic fellowship training on the cost of ankle fracture open reduction internal fixations (ORIFs). We hypothesize that foot and ankle fellowship-trained orthopedic surgeons (FAFTOS) will have reduced operational cost of ankle fracture ORIFs in comparison to non-foot and ankle fellowship-trained surgeons (NFAFTOS). We additionally hypothesize that the operational cost of an ankle fracture ORIF performed by FAFTOS will be lower when performed at ambulatory surgery centers (ASCs) than at hospitals.

Methods

After Institutional Review Board (IRB) approval, patient data was collected from electronic medical records and billing documents for patients who underwent an ankle ORIF procedure in our hospital and hospital-owned ASCs between the years 2010 and 2020. Electronic medical records and billing documents were additionally collected from a local physician-owned ASC for patients who underwent an ankle ORIF procedure between the years 2015 and 2020. Data from physician-owned ASCs were unavailable prior to 2015, likely due to transfers of ownership. Patients were excluded from the study if they underwent any type of surgery other than an ankle ORIF, or if multiple procedures were performed in a single setting that were not directly related to the ankle injury. Patients were also excluded if the ORIF procedure was performed by a non-orthopedic trained surgeon. Additional exclusions included any procedure with a charge equal to US$0, and any duplicate data points. All analyses were performed using Stata software version 17 (Stata, College Station, TX). Statistical significance was set a p-value of less than 0.05 level.

Data collected included the service date, the operating physician and that physician's fellowship status, location of service, ownership of the location of service, whether the encounter was inpatient or outpatient, the length of patient stay in the facility after the procedure, and the net revenue of the procedure. For this study, net revenue was used as a surrogate for procedure cost. Net revenue was defined as gross revenue minus operating costs. Net revenue is not a perfect surrogate for procedure cost. However, as total procedure cost increases, billing charges typically increase as well. Assuming that all unaccounted-for variables remain equal with variation in cost, an increase in billing charge will result in an increase in gross revenue. Therefore, all other cost variables held equal, it may be extrapolated that net revenue will reflect trends of change in total procedural cost due to its mirroring of changes in gross revenue and billing charges. Encounters were pulled using International Classification of Diseases (ICD)-9, ICD-10, and Healthcare Common Procedure Coding System (HCPCS) codes and Current Procedural Terminology (CPT) codes were used to make any exclusions. Any procedure not performed as inpatient in a hospital was considered outpatient. Procedures performed outpatient were further subdivided into hospital outpatient and ASC outpatient groups. Procedures performed at an ASC were again subdivided into groups based on whether the ASC was owned by a hospital or by physicians.

Surgeon ORIF volume was determined by sorting the data by physician and then sorting within the physician data by service date. For each surgeon, volume was set to 1 for their first service date, 2 for their second service date, and so on. Surgeon volume was prospective and only accounted for the number of procedures performed by a surgeon during the 10-year timeframe of the study. Interpretation of the volume variable was that an increase of one volume point was represented by an increase of one surgery in the data collection.

A market analysis was also performed to compare charges for ankle ORIF procedures statewide among varying hospital and surgery center locations. Data collected included service year, location of operation, whether the encounter was inpatient or outpatient, and the charge of the service. Physician information was found to be inconsistent in the statewide market analysis and was therefore excluded. Encounters were pulled using ICD-9, ICD-10, and HCPCS codes. Data for inpatient procedures were available and gathered from 2016 to 2020. Data for outpatient procedures were available and gathered from 2015 to 2020. In the market analysis, billing charge of the procedure was used as a surrogate.

Tabulations of specific Medicare Severity Diagnosis Related Group (MSDRG) codes were calculated across inpatient and outpatient records. Tabulations for outpatient records were further distinguished between ASC versus Acute/HOPD records.

Statistical analysis

Linear regression models were fit to estimate the association between charges and net revenue and various collections of

whether the record was inpatient, whether the procedure was performed at an ASC hospital, whether the procedure was performed at Prisma, the length of stay, and various interactions. These models identify associations of covariates with the average responses.

In addition to linear regression models, we also estimated simultaneous quantile regression models for which we included associations for the 5th, 25th, 50th, 75th, and 95th percentiles. In this way, we could look at the association of covariates with the outcome at various points in the distribution so that we could examine whether an association was universally present across the distribution or if it exhibited influence only at the lower or upper ends (the less or more expensive) cases. Such a focus on the extremes of the distribution is common in healthcare where outcomes tend to be highly skewed. In addition, it is usually the case that the extreme values of the distribution are of greater interest since that is the part of the distribution of outcomes where costs are highest and/or outcomes are most severe.

Effects of covariates were tested using Wald tests of regression coefficients. For models without interactions, we used the standard regression table output of Wald tests, but for models with interactions, we estimated specific linear combinations of the estimated coefficients to accurately estimate specific effects.

All tests were run at a 5% level of significance where test statistics were constructed from model-based standard errors. Significance was inferred if the associated *p*-value of the test was less than 0.05.

Results

When surgery was performed at an ASC and surgeon experience was not accounted for, net revenue of ankle ORIF procedures performed by FAFTOS was significantly less than those performed by NFAFTOS, with an estimated difference of US$4054.42 ($p < .001$). However, when only procedure location was accounted for and the procedure was performed as inpatient or outpatient in a hospital, it was found that there is no significant difference in net revenue of ankle ORIF procedures performed by FAFTOS versus NFAFTOS ($p = .058$).

When surgeon volume was accounted for and procedure location was not considered, there was no significant difference in net revenue of ankle ORIF procedures performed by FAFTOS and NFAFTOS ($p = .540$). But as surgeon volume increased, a significant difference was observed as the net revenue decreased incrementally by US$34.83 more per procedure for FAFTOS compared to NFAFTOS ($p = .014$).

There was no significant difference in net revenue between inpatient procedures and outpatient procedures when surgeon volume was not accounted for. When surgeon volume was accounted for, a significant difference was observed with net revenue for an inpatient procedure US$8717.26 more on average than outpatient procedures ($p < .001$).

When only location was considered and fellowship training was not accounted for, a significant difference was found between procedures performed at ASCs compared to inpatient procedures and outpatient procedures performed in hospitals, with net revenue of ASCs estimated to be US$2027.21 less than procedures performed elsewhere ($p < .001$). When surgeon volume was accounted for in addition to procedure location, a significant difference was observed as the net revenue of a procedure performed at an ASC was US$2972.01 less on average than procedures performed at hospitals ($p < .001$).

Net revenue of procedures performed at hospital-owned ASCs were significantly lower than net revenue of physician-owned ASCs by an estimated US$3992.78, indicating lower costs of procedures in hospital-owned ASCs when compared to physician-owned ASCs ($p < .001$).

In the market analysis of ankle ORIFs performed in South Carolina, a total of 8932 procedure data points were collected. Of those, 6090 were inpatient and 2842 were outpatient. All inpatient procedures and 2626 outpatient procedures occurred in hospitals, while 216 of the outpatient procedures occurred in ASCs. On average, the inpatient charge was US$96,697. The outpatient procedures performed in hospitals averaged US$35,944, while the outpatient procedures performed in ASCs averaged US$12,315. The average for all procedures performed was US$76,795. It was found that differences in charges between all three procedure locations were statistically significant ($p < .001$). A quantile regression was performed and it was found that the 50th percentile cost of inpatient procedures was US$68,300, while the 50th percentile of outpatient procedures performed in hospitals and ASCs was US$31,826 and US$8,523, respectively.

In the market analysis, an ankle ORIF procedure performed in our hospital system was discounted by US$7842.25 compared to other procedure sites ($p < .001$). When surgeon experience was accounted for, that discount margin increased by US$53.03 for each extra procedure that the surgeon performed ($p < .001$).

Discussion

Previous studies have found that the number of annual outpatient procedures has more than tripled in the past three decades,[4] and that the costs of outpatient procedures performed in ASCs remain low compared to the increasing costs of procedures performed in hospitals.[5]We further evaluated this relationship between reduced costs and specialization within healthcare by analyzing total costs of procedures performed by specialized and nonspecialized orthopedic surgeons in both hospital and ASC settings. We found that within our hospital system between the years 2010 and 2020, when procedures were performed at ASCs, net revenue of procedures performed by FAFTOS were significantly lower than those performed by NFAFTOS. We speculate that this is due to the fact that hospital-owned ASCs have less revenue

than physician-owned ASCs, which is where most of the FAFTOS operated. In addition, we were unable to control for fracture pattern or difficulty of the case. Most surgeons would agree that certain fracture patterns are more difficult and/or require more hardware which could lead to increased implant costs and operative time. When these locations were separated, we did not observe this association. In general, ASCs were found to be significantly less costly than outpatient procedures performed in hospitals for both FAFTOS and NFAFTOS. This held true for both groups of orthopedic surgeons and represents the direct healthcare overhead costs often accrued during procedures performed at hospitals.[6]

A significant direct healthcare cost is operative time, with the mean cost of operating room time in acute care hospitals calculated to be approximately US$36 per min.[7] Operative times have been shown to decrease significantly when procedures are performed at ASCs as opposed to hospitals. Cost of care for outpatient hindfoot and ankle surgery at ASCs has been shown to be as much as 54% lower than the same inpatient surgeries.[8] While some patients are admitted necessarily, the decision to admit ankle fracture patients often precedes treatment decisions, annually resulting in more than US$280 million in unnecessary excess expenditures as compared to outpatient care.[9] Of operational cost savings observed in ASCs, nearly 80% has been attributed to time, with 73% of operational time saving being attributed to surgical factors.[10]

The correlation of specialization and training with decreased costs did not hold when procedures were performed at hospitals. This is possibly because hospitals are less specialized than ASCs, which decreases the effect of FAFTOS due to the small amount of impact surgeon time and implant choice may have relative to the significantly higher costs. This is supported by evidence that hospital surgical wards specialized in orthopedics exhibit decreased costs of procedures performed in those wards with observed improvements of up to 19 min per procedure.[11]

Interestingly, while all procedures performed in ASCs averaged lower cost than those performed inpatient or outpatient in hospitals, physician-owned ASCs were significantly more expensive than hospital-owned ASCs. This could be due to increased cost of privatization or increased cost to drive net revenue.[12]

By accounting for surgeon volume, each surgeon was categorized independently, allowing for a more specific analysis of the impact of procedure location on procedure cost. Although no significant difference in cost was found between inpatient and outpatient procedures when surgeon volume was not accounted for, when surgeon volume was considered, inpatient procedures were more costly than outpatient procedures. A significant portion of these decreased costs are due to decreased length of stay.[8] Inpatient ankle fracture ORIFs are the most common type of ankle fracture repair and have the shortest mean length-of-stay. But even among inpatient ankle fracture ORIFs, mean length-of-stay may vary widely depending on facility and patient populations, ranging from as low as 1.5 days to as high as 10.4 days.[13–15]

Interestingly, as surgeon volume increased, the margin of cost between inpatient and outpatient procedures decreased, indicating that increased surgeon volume correlates with decreased cost. This is again exemplary of the implementation of specialization and the likely decrease in procedure duration that may be observed simultaneously with increased number of procedures performed by individual surgeons.[14]

In the market analysis, 68.18% of procedures were performed inpatient, 29.40% were performed outpatient in a hospital, and 2.42% were performed in ASCs. Because billing charge was used as a surrogate for cost rather than net revenue, the market analysis results vary from but follow the same trends as the internally collected data set of procedures from our institution. Inpatient procedures were charged 269.02% more than outpatient procedures performed in hospitals and 785.20% more than procedures performed at ASCs. Outpatient procedures performed at ASCs were 342.62% less than outpatient procedures performed at hospitals. This supports the trends previously observed among net revenue and procedure location, as well as the correlations between net revenue and fellowship training.

While an improvement in the quality of care with respect to rates of complications and revisions has not been correlated with fellowship training or ASCs,[16,17] this study and previous studies support that a patient value of care may increase with these specializations due to reduction of surgical cost observed when fellowship-trained surgeons operate in ASCs.[6,18]

Limitations

This study was largely limited by available data, as only a small percentage of procedures were performed in ASCs in both the local and statewide data. Data collected from physician-owned ASCs in our area were only available from the previous 5 years, likely due to transitions in ownership. However, the current trend is for an increase in outpatient treatments for many orthopedic conditions. A larger population would offer more representative results and further studies may be warranted as use of ASCs continues to increase annually. Second, in this observational study, a sample size calculation was not done. In addition, this study was limited by consistency of data with regard to surgeon fellowship training. In the statewide market analysis data, the identities of many of the attending physicians and their specialties were not included in the data collected. Because of this, the effect of fellowship training was not able to be analyzed on procedure cost within the statewide data. In addition, net revenue and billing charge had to be used as surrogates for the total procedure cost. Billing charges fluctuate with the cost of procedures, therefore procedures that are less costly often result in lesser charges and lesser net revenues if all other factors are held equal. While this relationship does not always hold true and net revenue does not serve as a perfect analog for cost, it is adequate to establish and understand current trends. Further analysis of more detailed cost and expenditures of ankle ORIFs may be beneficial in the future.

It is important to note that the cost of ankle fracture ORIFs does vary with respect to the type of fracture and the specific equipment used in the repair of the fracture, a variable we were unable to account for based on the data available for this study. It is of additional significance that evaluation and management of ankle fractures has evolved over the 10-year duration of this study, and continued changes in care may limit future implications of this study. The inclusions and exclusions of this study were designed to account for varied modalities of fracture, but the variance in the cost of repair of those different types of fractures was not analyzed. Finally, patient comorbidities and readmissions are known to alter procedural requirements and costs but were not accounted for in this study.

Conclusion

Between 2010 and 2020, within our hospital system, an ankle fracture ORIF performed by a foot and ankle trained orthopedic surgeon in a hospital-owned ASC was the lowest cost option available, and an increase in volume was associated with a further decrease in cost. Although surgical training had a significant effect on cost among procedures performed at ASCs, it did not have an effect on the cost of procedures performed in hospitals.

Acknowledgements

The authors thank Dr James Hardin for his assistance in the statistical analysis of the internally collected data and market data.

Author contributions

All authors contributed throughout the data analysis and preparation of this publication.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

Ethical approval for this study was obtained from Prisma Health IRB—Pro00099406.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Informed consent

Subject written informed consent was not obtained prior to study initiation as this requirement was waived by the Institutional Review Board. The study was retrospective, meaning patient outcomes were unaffected, and all patient identifying information was removed from the data.

Trial registration

Not applicable.

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