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Cost minimization analysis of the treatment of olecranon fracture in elderly patients: a retrospective analysis

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Abstract

Background: Operative treatment of olecranon fractures in the elderly can lead to greater complications with similar outcomes to nonoperative treatment. The purpose of this study was to analyze cost differences between operative and nonoperative management of isolated closed olecranon fractures in elderly patients.

Methods: Using a United States Medicare claims database, the authors identified 570 operative and 1,863 nonoperative olecranon fractures between 2005 and 2014. The authors retrospectively determined cost of treatment from the payer perspective for a 1-year period after initial injury, including any surgical procedure, emergency room care, follow-up care, physical therapy, and management of complications.

Results: One year after diagnosis, mean costs per patient were higher for operative treatment (United States dollars [US$]10,694 vs US$2,544). 31.05% of operative cases were associated with a significant complication compared with 4.35% of nonoperative cases. When excluding complications, mean costs per patient were still higher for operative treatment ($7,068 vs $2,320).

Conclusions: These findings show that nonoperative management for olecranon fractures in the elderly population leads to fewer complications and is less costly. Nonoperative management may be a higher-value management option for this patient population. These results will help inform management of olecranon fractures as payers shift toward value-based reimbursement models in which quality of care and cost influence surgical decision making.

Level of Evidence: Level IV

Keywords

cost; elderly; olecranon; quality; value

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SUPPLEMENTAL DIGITAL CONTENT

Supplemental Digital Content 1.doc

Supplemental Digital Content 2.doc

INTRODUCTION

Olecranon fractures comprise approximately 20% of proximal forearm fractures and 1% of all skeletal fractures in adults.[1,2] These fractures are increasing in incidence, with low-energy falls from standing height accounting for the majority of olecranon fractures among the elderly population.[1] Operative management, such as tension-band wire fixation, plate fixation, and fragment excision with triceps advancement, has historically been the primary choice for displaced olecranon fractures.[2,3] The aim of these procedures is to allow early motion and maintain extensor power of the elbow, which is of particular importance to individuals with active lifestyles or those requiring a gait aid to ambulate.[2–4] However, patients with comorbidities and elderly patients are at an increased risk of postoperative complications.[4,5] Recent evidence has demonstrated increased utilization and considerable efficacy of nonoperative treatment, such as casting and splinting, of olecranon fractures in the elderly population.[6] Although nonoperative treatment may lead to minor extension deficits, it is associated with significantly fewer complications and equivalent patient satisfaction compared with surgical treatment in elderly patients.[5–8]

A 2017 randomized controlled trial (RCT) investigating operative versus nonoperative management of displaced olecranon fractures in elderly patients found no significant benefit of operative treatment.[9] Nine of 11 (82%) patients randomized to the operative management group experienced postoperative complications including infection, loss of reduction, and hardware removal, compared with one of seven (14%) in the nonoperative group, leading to the premature discontinuation of the study. The authors found no difference between treatment groups with regard to patient-reported outcome measures such as Disabilities of the Arm, Shoulder and Hand (DASH) scores, Broberg and Morrey Score, or the Mayo Elbow Score. Additionally, a recent systematic review of adverse events and clinical outcomes among operative and nonoperative treatment of closed olecranon fractures in patients over the age of 65 found comparable clinical outcomes among geriatric patients and found that surgical intervention carried a high risk of reoperation regardless of whether plate or tension band wire fixation was used.[10]

As payers and health systems shift towards value-based care models, the cost-minimization framework has become an essential tool for reducing costs without sacrificing quality of care.[11] This framework compares the costs of different treatments resulting in similar outcomes for identical diagnoses. If one treatment is more costly, physicians and health systems may provide higher value of care by opting to perform the lower cost option when appropriately indicated and aligned with the patient's values and preferences.[9,11,13] Although research exists suggesting similar outcomes for olecranon fractures in elderly patients, no research comparing operative and nonoperative costs in this population has been completed.[14] This study aimed to determine if there is a difference in cost from the payer's perspective between operative and nonoperative treatment of closed isolated olecranon fractures in elderly patients. A secondary aim was to examine differences in costs associated with complications between the two treatment approaches. The authors hypothesized that patients undergoing nonoperative treatment would have lower costs both overall and related to complications.

MATERIALS AND METHODS

Ethical Review and Study Design

because all data used were deidentified, this study was exempt from formal review by the Institutional Review Board. The authors completed a retrospective analysis of insurance claims data from an administrative claims database (PearlDiver, Colorado Springs, CO, USA) from 2005 through 2014. This database consists of records from approximately 51 million patients with Medicare, the national federal insurance program in the United States (US) for persons 65 years and older as well as younger individuals with certain disabilities. Diagnosis (International Classification of Disease, 9th Edition, Procedure Coding System ICD-9-PCS and Clinical Modification ICD-9-CM) and procedural (Current Procedural Terminology, CPT) codes were utilized to identify patients for inclusion.

Data Collection

All patients with a closed fracture of the olecranon process of the ulna, with or without intra-articular extension were identified based on ICD-9 codes. Using the cutoff age for “elderly” most commonly used in orthopaedic research, patients under the age of 65 were excluded.[15] In order to limit the analysis to isolated olecranon fractures, patients were excluded if they had an ICD-9 code for one of the following conditions (See Appendix Table 1, Supplemental Digital Content 1, http://links.lww.com/COP/A64 which lists excluded ICD-9 codes): other fractures of the ulna including coronoid, radial head fractures, distal humerus fractures;, ulnar collateral ligament tear or sprain, dislocated elbow, and pathologic fracture of the radius or ulna.

Patients with isolated olecranon fractures were grouped into two separate cohorts based on whether they received nonoperative (closed reduction of proximal ulna, with or without manipulation; CPT-24670, CPT-24675) or operative treatment (open reduction of proximal ulna; CPT-24685). To ensure that cases in which this was the primary mode of intervention and not a conversion or revision surgery were studied, patients were limited to those that received treatment within 14 days of their initial olecranon fracture diagnosis.

Each cohort was assessed for complications within 1 year of the initial fracture (Figure 1). These complications were chosen based on prior studies and the existence of corresponding ICD-9 or CPT codes.[3,5,8,16–18] In the nonoperative group, possible complications included malunion, ulnar neuropathy, and need for a revision operation. For the operative cohort, possible complications included malunion, infection, and ulnar neuropathy, as well as need for debridement, revision fixation, and hardware removal. Complications assessed in both cohorts included elbow contracture, arthritis, stiffness, and pain. The authors assumed that all complications that occurred within 1 year were related to the olecranon fracture as all other complex elbow fractures were excluded, as detailed above and in Appendix I (See Supplemental Digital Content 1, http://links.lww.com/COP/A64 which lists excluded ICD-9 codes).

Lastly, the authors captured records for patients who received physical therapy or an elbow cast, brace, or orthosis within 1 year of initial fracture (Figure 1). Physical therapy was

captured using 10 of the most common CPT codes listed by the American Physical Therapy Association.[19]

Data Analysis

The explanatory variable in this cost-minimization analysis was treatment approach for the patient's olecranon fracture (operative versus nonoperative). The primary response variable was mean cost per patient in United States dollars (US$), including physician and facility fees, new and return office visit fees, physical therapy fees, and supply fees within 1 year of the initial diagnosis, for billings in which the inclusion diagnoses were listed as the primary diagnosis. Secondary response variables included the additional cost of complications within each treatment group. Cost was defined as the total reimbursement from the payer's perspective—the amount paid to the physician and health system by Medicare. This method has been used to extrapolate cost to society in previous studies.[19–21]

Statistical Analysis

Shapiro Wilk tests were used to determine whether costs were normally distributed. Costs between operative and nonoperative groups were compared using nonparametric, Mann-Whitney U tests. The authors also completed a subanalysis to assess the change in cost over the study period across cohorts. A two proportion Z test was used to compare proportions of new, return, consultation, or emergency department visits, physical therapy visits, supply charges, and complications between groups. The authors ran sub-analyses that excluded extreme outliers, defined as three times the interquartile range below the first quartile or above the third quartile. Statistical analyses were calculated using R (R Core Team, 2017). Significance was set at $p < 0.05$. Based on prior cost minimization analyses, a sample size estimate of at least 20 patients per group was needed to detect a cost difference of approximately US$1,800 per patient, which was felt to be meaningful to health systems and payers.[22]

RESULTS

The selection criteria identified 2,433 elderly patients who sustained an isolated closed olecranon fracture between 2005 and 2014, 76.6% of whom received nonoperative treatment. Both groups were comprised of mostly female patients (Table 1). Patients receiving nonoperative treatment had higher Charlson Comorbidity Index (CCI) scores (CCI 3.33 vs 2.62; $P < 0.001$). Trends of operative and nonoperative treatment between 2005 and 2014 are shown in Figure 2.

The mean total cost 1 year after diagnosis for patients receiving operative treatment was significantly higher than those receiving nonoperative treatment when including complications (US$10,694 vs US$2,544 ; $P < 0.01$) (Fig. 3) and when excluding complications (US$7,068 vs US$2,320; $P < 0.01$). Physical and occupational therapy costs did not vary between groups. Excluding outliers, all mean costs both with and without complications remained significantly different between the two groups ($P < 0.01$ in both comparisons). Of note, mean costs varied significantly over time for nonoperative treatment ($P = 0.03$) but not for operative treatment ($P = 0.21$). From 2005 to 2014, costs related

to operative management increased by an estimated 2.3% compared with an increase of 31.3% for nonoperative management (See Appendix Figure 1, Supplemental Digital Content 2, http://links.lww.com/COP/A65 which illustrates total cost per patient of operative versus nonoperative treatment).

The most common surgical complication was infection, which occurred in approximately 5% of patients and resulted in a mean additional cost of US$6,781 per patient, or US$203,416 in total for all patients with infections (n = 30). Infections accounted for approximately 3% of overall cost and 24% of costs attributed to surgical complications (Figure 4A). For nonoperative treatment, the most common complication was malunion or nonunion, which occurred in 2% of patients and accounted for 49% of the cost of complications and 3% of the overall cost of treatment (Figure 4B). The mean costs of total complications, malunion, revision, and ulnar neuropathy per patient were not significantly different between groups, but the mean cost of total complications, including elbow contracture, arthritis, stiffness, and pain, did vary significantly (operative: US$636; nonoperative: US$477, $P = 0.004$). The most expensive surgical complication was revision, which cost on average US$7,129 per patient.

When including all complication types, 31.05% of operative cases were associated with a significant complication compared with 4.35% of nonoperative cases. This difference was largely caused by rates of additional surgery (11.75% and 1.34%) and complications exclusive to surgical treatment, such as infection, debridement, and removal of hardware. Since some hardware removals may be the result of patient preference as opposed to complication, a separate analysis was performed excluding removals. Excluding removals, 23.51% of surgical cases had one or more complications, which was significantly different than the aforementioned rate in nonsurgical cases ($P < 0.01$). The mean total cost per operative patient decreased to US$10,523, which remained significantly greater than the nonoperative cost ($P < 0.01$).

DISCUSSION

The current investigation demonstrated that operative intervention for treating isolated closed olecranon fractures in the elderly resulted in significantly higher costs than nonoperative treatment, regardless of whether complications or extreme outliers were included in the analysis, these results support the initial hypothesis. Cost minimization is a focal point for improving value in all healthcare systems, given that reduction in cost affects all stakeholders. Recent publications show satisfactory results for nonoperative treatment of displaced olecranon fractures in the elderly and suggest that patient-reported outcomes associated with operative versus nonoperative management may be comparable in this population with nonoperative treatment also resulting in fewer complications.[6,9–11,23] Therefore, cost-minimization analysis is an appropriate framework to determine if one treatment is favored to improve value of care. Previous cost minimization studies in orthopaedic surgery have also demonstrated significantly higher costs with operative treatment for other conditions where operative and nonoperative treatment have similar outcomes - proximal humeral fractures in the elderly,[24] distal radial fractures in the elderly,[22] and Achilles tendon ruptures.[19]

Reducing treatment costs is particularly important to patients, who may bear a portion of the financial burden of treatment (e.g., deductibles and coinsurance payments). Prior studies have shown that patients' personal finances are a multifaceted issue: not only do medical costs create financial burden for many patients, but financial hardship can in turn decrease quality of life and increase symptom burden, delays in seeking care, disability, and even mortality.[25,26] In orthopaedic surgery, patients have been shown to postpone visits and have higher levels of subjective disability as a result of financial distress.[27,28] One study found that a quarter of patients who experienced orthopaedic trauma had high financial distress, and nearly the same amount of patients needed to borrow money to pay for the costs, even though 97.9% of the sample had insurance.[29] Although indirect medical costs like transportation and lost time from paid work are more difficult to address, efforts to reduce costs in orthopaedic surgery could minimize a treatment's effect on financial distress.

This study provides further evidence that nonoperative management leads to fewer complications in the elderly population. Infection, debridement, and soft tissue irritation requiring hardware removal are inherent complications related to surgery, and no such complications occur in patients managed nonoperatively. Although comorbidity burden differed between the nonoperative and operative cohorts, the data show that patients with lower comorbidity burden were more likely to have received operative treatment. As the existing data shows that outcomes are similar between nonoperative and operative strategies,[10] this indicates that there is an opportunity for higher value care by considering nonoperative treatment in these patients, thereby lowering costs and potentially reducing complication rates.[9] Although fracture pattern and severity may influence the decision to proceed with operative management, a recent RCT provided evidence that nonoperative treatment is a viable option even for displaced fractures and is associated with significantly fewer risks.[9] In several case series, new surgical techniques involving nonmetallic fixation have been proposed to limit irritation and subsequent removal of hardware, but these techniques have not yet been compared with nonoperative management in RCTs.[30–32] A future clinical trial, made public in 2015 by Symes et al.,[33] will examine DASH scores for these two treatment options in patients who are 75 years and older. This RCT, in conjunction with the current cost minimization study, could help determine preferable treatment options in value-based healthcare models.

Limitations and Future Perspectives

The authors acknowledge several limitations to this study. First, only included US Medicare claims were included. There is a possibility that reimbursement rates for other insurance programs are not significantly different for operative and nonoperative treatments. Furthermore, Medicare data, like other forms of healthcare claims, are collected for reimbursement purposes and therefore may be susceptible to misclassification or inaccurate coding. Additionally, the authors did not seek to study patient-level data such as fracture morphology, patient preference, or other factors that may impact surgical decision making (i.e., hand dominance). It is possible that more severe fractures were preferentially fixed. Similarly, there was no way to differentiate between operative procedures such as locked plating or tension band constructs to examine if one procedure led to more complications than another. However, prior studies, including a randomized control trial,

have demonstrated similar outcomes between operative and nonoperative treatment (with higher complications in the operative group) highlighting the importance of studying cost between these treatment options.[9] Aside from complications, the authors did not include patient outcomes in this analysis. To evaluate cost-effectiveness of operative management, future studies should seek to calculate cost per quality-adjusted life year (QALY).

CONCLUSIONS

Cost-minimization analysis of operative and nonoperative management of olecranon fractures in the elderly favors nonoperative management. Nonoperative management may be more cost saving compared with operative management and result in fewer complications. These results will help inform management of olecranon fractures as payers shift toward value-based reimbursement models in which quality of care and cost influence surgical decision making.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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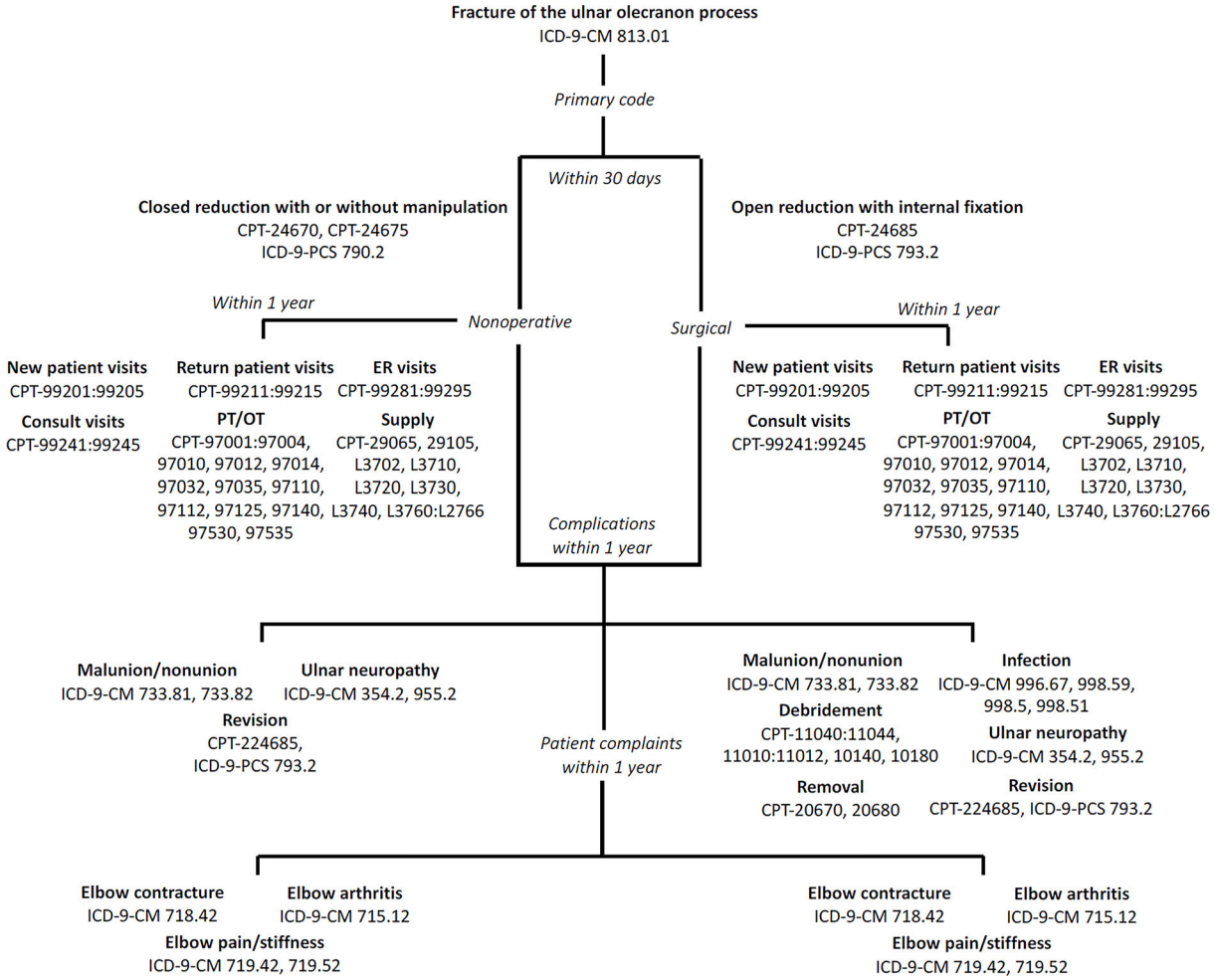

Figure 1.

Coding flow chart illustrating patient selection and identification of associated costs and complications using Current Procedural Terminology (CPT) and International Classification of Diseases, 9th Revision (ICD-9). ER=Emergency Room, PT=Physical Therapy, OT= Occupational Therapy

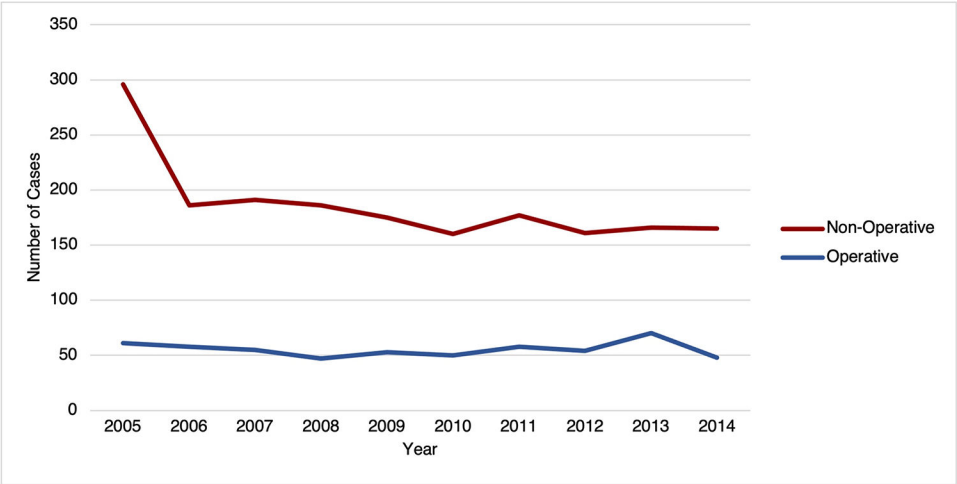

Figure 2.

Trendlines illustrating olecranon fracture cases requiring nonoperative and operative (open reduction and internal fixation [ORIF]) management from 2005 to 2014. Units are number of cases per year.

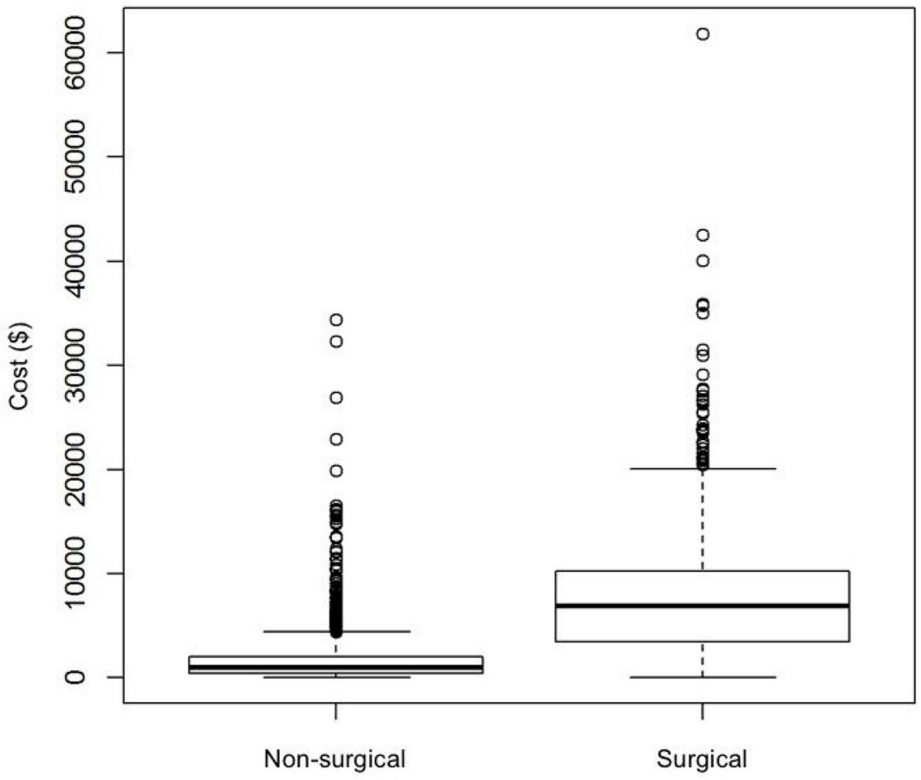

Figure 3.
Box plots of total cost per patient of surgical vs nonsurgical olecranon fracture treatment

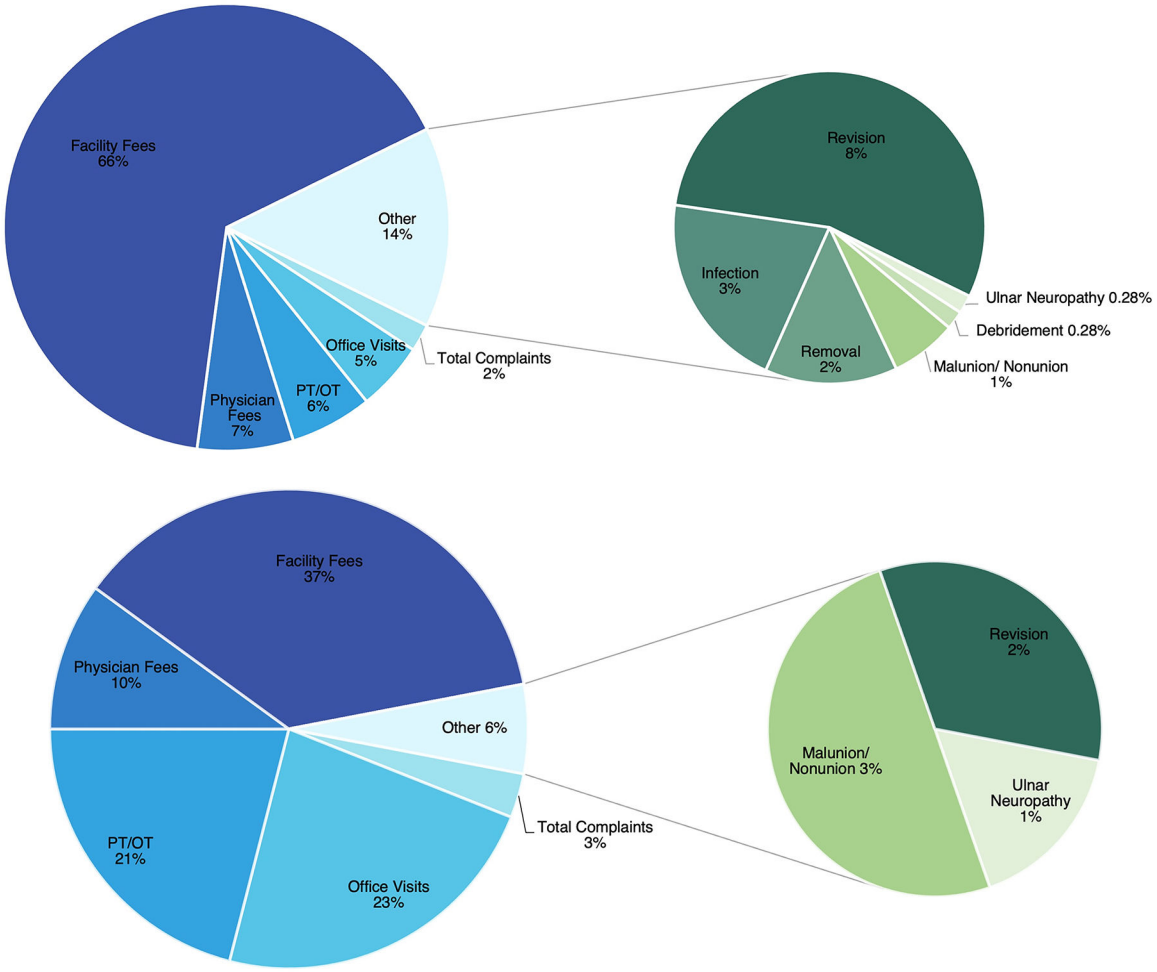

Figure 4.

(A) Pie charts depicting the breakdown of costs by category, including complications, for operative treatment within 1 year of initial treatment. PT = physical therapy, OT = occupational therapy. (B) Pie charts depicting the breakdown of costs by category, including complications, for nonoperative treatment within 1 year of initial treatment. PT = physical therapy, OT = occupational therapy.

Table 1.

Demographics of cohorts

	Nonoperative	Operative
Women/Men	1219 / 644	433 / 121
Age 65 to 69	355	82
Age 70 to 74	293	86
Age 75 to 79	342	115
Age 80 to 84	346	130
Age 85+	560	151