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Plastic Surgery-Assisted Closure of Complex Posterior Spine Surgery Wounds Are Associated with Rate of Readmission and Reimbursement

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Abstract

Objective: The objective of this study is to compare clinical outcomes and reimbursements between plastic surgeon (PS) and spine surgeon (SS) closure of wounds following complex posterior spine reconstruction surgery.

Methods: Data was sourced from the PearlDiver Mariner Administrative claims database. The patient cohorts included those who underwent posterior spinal fusion with at least 7 levels fused. Several 30-day postoperative outcomes were examined, including readmission rates, sepsis, myocardial infarction, pneumonia, cerebrovascular accident, deep vein thrombosis, pulmonary embolism, venous thromboembolism, surgical site infections (SSI), and emergency department visits. Mean 30-day reimbursement costs were also analyzed. Statistical analysis involved Chi-square testing for categorical variables and T-tests for continuous variables. Multivariate logistic regression was employed to calculate odds ratios and 95% confidence intervals. Statistical significance was defined as a p-value of less than 0.05.

Results: The demographics of the matched cohorts indicated no significant differences in age, gender and Elixhauser Comorbidity Index. The readmission rate for the PS group was 19.6%, compared to 12.1% for the SS group (OR = 1.74, CI 1.35-2.22, $p < 0.001$). Mean 30-day reimbursement was lower for the PS group at $24,072.94 compared to $31,204.64 in the SS group ($p < 0.0001$). No significant differences were observed in other 30-day outcomes.

Conclusion: No significant difference in the rate of SSI was demonstrated between the two closure teams. However, we found that PS closure correlates with an increased rate of 30-day readmission and decreased reimbursement.

Keywords: Spine surgery; Plastic surgery; Spine; wound closure; Plastics assisted closure; Orthopedics

Introduction

Plastic surgery (PS)-assisted wound closure and care following complex spinal reconstruction surgery has popularized in recent years to address the higher rate of wound complications in complex spine surgery. The wound complication rate is reported in the literature to exist between 2.2% and 13.3% [1,2], though other studies have reported rates as high as 19% in low-risk patients and 40% in high-risk patients. Risk factors in patient profile include, but are not limited to advanced age, smoking, alcohol abuse, malnutrition,

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previous radiation therapy and history of previous spine infection [3]. These factors have been found to contribute to poor 30-day outcomes, specifically surgical site infections (SSIs) [4,5]. Operative factors that affect postoperative wound complications include staged procedures, intervention via the posterior approach, instrumentation, cerebral spinal fluid (CSF) leak, operating room (OR) in time greater than 5 hours and procedures involving 7-13 vertebral levels [4-6]. Preservation of the paraspinal tissue is important as new research has shown that degenerating paraspinal muscles are associated with lower bone mineral density, higher risk of fractures, and the development of osteoporosis [7]. The prophylactic use of PS to assist in wound closure is hypothesized to prevent wound complications by improving the quality of the closure by reducing paraspinal tissue tension and dead space while improving blood flow and oxygen exchange [8,9]. The question remains, however, whether PS produces better outcomes, and the published literature has been both broad and mixed.

A small number of studies have investigated outcomes of PS versus spine surgeon (SS) closure, though none have shown significant differences when compared directly. A 2024 systematic review included 4 studies that compared PS versus SS closure and reported no significant differences in postoperative complication rates [10]. Other studies without direct comparison have shown promising results in terms of reducing wound complications with PS closure [6, 11-13]. A recent retrospective review looked at closures specifically in fusion of 1-4 levels and found no significant differences in surgical outcomes, perioperative complications, SSIs, or seroma requiring return to OR (RTOR), though overall there was a higher incidence of postoperative seromas with PS-assisted closure (PS 36.5% vs. SS 3.8%, p<0.001) [8]. A cost analysis of PS versus SS closures has yet to be explored in the literature per our group's knowledge.

The objective of this study is to compare clinical outcomes and reimbursements between PS and SS closure in complex posterior spine reconstruction using a large-volume national database of both private and government insurance claims. We hypothesize PS closure for posterolateral spinal fusion (PSF) of 7+ levels minimizes 30-day wound complications and improves patient outcomes, particularly in SSIs, compared to SS closure.

Materials and Methods

The study utilized a retrospective cohort design to assess the outcomes of PSF for spinal deformity with PS or SS closures. Data was sourced from the PearlDiver Mariner Administrative claims database, identifying patients through specific Current Procedural Terminology (CPT), International Classification of Diseases (ICD)-9, and ICD-10 codes. The patient cohorts included those who underwent PSF in cervical, thoracic, and lumbar regions with at least 7 levels fused. The analysis further stratified these patients based on the presence or absence of PS closure.

Patients were substratified by the inclusion of additional three-column osteotomies (3CO) or posterior column osteotomies (PCO). The cohorts were matched for age, gender, obesity, and Elixhauser Comorbidity Index (ECI) to minimize confounding variables. Patient demographics are displayed in Table 1. Several 30-day postoperative outcomes were examined, including readmission rates, sepsis, myocardial infarction (MI), pneumonia (PNA), cerebrovascular accident (CVA), deep vein thrombosis (DVT), pulmonary embolism (PE), venous thromboembolism (VTE), SSIs, and emergency department (ED) visits. Economic outcomes, particularly the mean 30-day reimbursement costs, were also analyzed.

Statistical analysis involved Chi-square testing for categorical variables and T-tests for continuous variables such as mean reimbursement. Multivariate logistic regression was employed to calculate odds ratios (OR) and 95% confidence intervals (CI) for the risk of 30-day readmissions and other outcomes, comparing groups based on the presence of PS closure. Statistical significance was defined as a p-value of less than 0.05.

Table 1: Post-Matched Patient Demographics: With or Without Plastic Surgery Closure

Post Matching–Age, Gender, Obesity, and ECI (-1 = <11 patients)					
Demographics					
	With Plastics Closure (n = 536)	%	Without Plastics Closure (n = 2672)	%	p-value
Age					0.99
05 to 09	<11		44	1.65	1.6
10 to 14	243	45.3	1217	45.55	45.5
15 to 19	192	35.8	958	35.85	35.9
20 to 24	21	3.9	102	3.82	3.8
25 to 29	<11		20	0.75	0.7
30 to 34	<11		<11		

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35 to 39	<11		<11		
40 to 44	<11		<11		
45 to 49	<11		30	1.12	1.1
50 to 54	<11		20	0.75	0.7
55 to 59	<11		39	1.46	1.5
60 to 64	11	2.1	54	2.02	2
65 to 69	15	2.8	75	2.81	2.8
70 to 74	11	2.1	55	2.06	2.1
75 to 79	<11		34	1.27	1.3
Gender					0.99
Female	322	60.1	1604	60.03	60
Male	214	39.9	1068	39.97	40
ECI					0.9
0	63	11.8	315	11.79	11.8
1	91	17	455	17.03	17
2	99	18.5	494	18.49	18.5
3	76	14.2	380	14.22	14.2
4	62	11.6	310	11.6	11.6
5	62	11.6	309	11.56	11.6
6	38	7.1	190	7.11	7.1
7	18	3.4	86	3.22	3.2
8	<11		50	1.87	1.9
9	<11		37	1.38	1.4
10	<11		22	0.82	0.8
11	<11		15	0.56	0.6
12	<11		<11		
13	<11		<11		

Abbreviations: MI= Myocardial Infarction, PNA= Pneumonia, CVA= Cerebrovascular Accident, DVT= Deep Vein Thrombosis, PE= Pulmonary Embolism, VTE= Venous Thromboembolism, SSI= superficial surgical infection, ED= Emergency Department

Table 1 Legend: Demographics differences based on the presence or absence of plastic surgery (PS) closure. Patients were substratified by the inclusion of additional three-column osteotomies (3CO) or posterior column osteotomies (PCO). The cohorts were matched for age, gender, obesity, and Elixhauser Comorbidity Index (ECI) to minimize confounding variables. Statistical testing for these categorical variables were performed by Chi-square testing. Statistical significance was defined as a p-value of less than 0.05.

Results

Demographics

The demographics of the matched cohorts indicated no significant differences in age distribution between those with PS (n = 536) and those without (n = 2672), with p-value = 0.99. Gender distribution was also comparable, with 60.1% female in the PS group and 60.03% in the SS group (p-value = 0.99). Similarly, the Elixhauser Comorbidity Index (ECI) showed no significant variation, confirming successful matching (p-value = 0.9).

30-Day Outcomes

Analysis of the 30-day outcomes revealed significant differences in readmission rates and mean reimbursement costs. A full breakdown of these differences are included in Table 2, with additional odds ratios with confidence intervals in Table 3. The readmission rate for the PS group was 19.6%, compared to 12.1% for the SS group ($p < 0.0001$). Mean 30-day reimbursement was lower for the PS group at $24,072.94 compared to $31,204.64 for the SS group ($p < 0.0001$). However, no significant differences were observed in other 30-day outcomes, such as sepsis, MI, PNA, CVA, DVT, PE, VTE, and SSI, with p-values all greater than 0.05.

Efforts were made to stratify results based on the number of vertebral levels fused and the presence of 3CO or PCO. However, due to insufficient data, a detailed analysis of these stratifications could not be performed. It is important to note

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that all analyzed procedures involved at least 7 fusion levels, indicating that they were inherently complex deformity procedures. The study also did not differentiate between thoracolumbar and cervicothoracic fusions due to a lack of available data.

Table 2: 30-Day Postoperative Outcomes: With or Without Plastic Surgery Closure.

30-Day Postoperative Outcomes					
	With Plastics Closure (n = 536)	%	Without Plastics Closure (n = 2762)	%	p-value
Sepsis	<11	N/A	17	N/A	0.86
MI	<11	N/A	<11	N/A	1
PNA	<11	N/A	38	1.37	0.88
CVA	<11	N/A	<11	N/A	0.92
DVT	<11	N/A	<11	N/A	0.15
PE	<11	N/A	<11	N/A	0.26
VTE	<11	N/A	<11	N/A	0.11
SSI	17	3.2	61	2.2	0.1
ED Visit	18	3.4	56	2.02	0.24
Readmission	**105**	**19.6**	**333**	**12.1**	**<0.0001**
Mean Reimbursement	**$24,072.94**		**$31,204.64**		**<0.0001**

Abbreviations: MI= Myocardial Infarction, PNA= Pneumonia, CVA= Cerebrovascular Accident, DVT= Deep Vein Thrombosis, PE= Pulmonary Embolism, VTE= Venous Thromboembolism, SSI= superficial surgical infection, ED= Emergency Department

Additionally, we attempted to investigate the reasons for readmissions, focusing on whether re-admits required RTOR for subsequent irrigation and debridement (I&D) procedures. Unfortunately, there was not enough 30-day data available for this query.

Multivariate Logistic Regression

Table 2 Legend: 30-day postoperative outcomes based on the presence or absence of plastic surgery (PS) closure. Statistical analysis involved Chi-square testing for categorical variables and T-tests for continuous variables. Statistical significance was defined as a p-value of less than 0.05.

Table 3: 30-Day Postoperative Outcomes with or Without Plastic Surgery Closure: Odds Ratios

30-Day Postoperative Outcomes Odds Ratios				
	OR	CI LL	CI UL	p-value
Sepsis	0.58	0.09	2.05	0.473
MI	3.61	0.44	23.92	0.18
PNA	0.78	0.29	1.73	0.578
CVA	2.52	0.11	27.44	0.458
DVT	2.91	0.74	9.91	0.094
PE	2.05	0.28	10.24	0.406
VTE	2.57	0.78	7.48	0.093
SSI	1.4	0.78	2.37	0.227
ED Visit	1.63	0.92	2.76	0.075
Readmissions	**1.74**	**1.35**	**2.22**	**0.001**

Abbreviations: MI= Myocardial Infarction, PNA= Pneumonia, CVA= Cerebrovascular Accident, DVT= Deep Vein Thrombosis, PE= Pulmonary Embolism, VTE= Venous Thromboembolism, SSI= superficial surgical infection, ED= Emergency Department

Table 3 Legend: Multivariate logistic regression was employed to calculate odds ratios (OR) and 95% confidence intervals (CI) for the risk of 30 day outcomes comparing groups based on the presence of PS closure. Statistical significance was defined as a p-value of less than 0.05.

Multivariate logistic regression analysis demonstrated a significant increase in the odds of 30-day readmission for patients with PS closure (OR = 1.74, CI 1.35-2.22, $p < 0.001$). This suggests that PS closure is associated with a higher likelihood of readmission within 30 days post-surgery. Other outcomes did not show significant associations.

Discussion

PS has been incorporated into complex spine surgery in an attempt to improve soft tissue healing and reduce postoperative morbidity. PS-assisted closure is thought to reduce dead space within the surgical bed and thus the development of seroma, hematoma and infection by way of multilayered closure and the mobilization of local muscle flaps [8,9]. Due to the paucity of high-powered, multi-center data investigating the association between PS-assisted closure and outcomes following long-segment PSFs, the authors of this study sought to explore the potential benefits and pitfalls of the approach.

Regarding wound healing, our study found a higher incidence of SSIs in PS than in SS closures, however, the relationship did not reach statistical significance (PS=3.2% vs SS=2.2%, p=0.10). It can be suggested that PS closure is utilized for more medically and surgically complex clinical scenarios. Patients who receive PS closure might already be at higher risk for developing postoperative complications by means of selection bias. The present study matched cohorts by age, gender, obesity, BMI, and ECI. While these demographic factors account for some preoperative comorbidities, they fail to account for many of the previously mentioned determinants known to increase a patient's risk for SSIs. The ECI, for example, does not account for tobacco use, nutritional status, previous radiation or corticosteroid use [11]. The risk of SSI is also affected by surgical length, surgical approach, use of intraoperative antibiotics and history of previous spine surgery [12,13]. While our study was able to

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successfully match cohort demographics, subtleties in patient complexity may have confounded results. Additionally, the database query was not able to specify which procedures were index versus revision, complicating the interpretation of outcomes like SSI known to be affected by previous surgical intervention.

The results of the present study, which utilized the PearlDiver Database, echo the findings from previous investigations into the American College of Surgeons' National Surgical Quality Improvement Program (ACS-NSQIP) database. A study conducted by Gong et al. queried the ACS-NSQIP database to analyze differences in wound complication rates between prophylactic muscle flap closure and standard closure in posterior thoracolumbar fusions. The group reported there was no statistically significant difference in wound complication rates between the two cohorts (adjusted OR 0.74; 95% CI 0.33 to 1.51; p= 0.42) despite the higher comorbidity burden of the muscle flap group [13]. A study published in 2022 queried the ACS-NSQIP for all spine surgeries performed between 2005 and 2017 with and without concomitant paraspinal muscle flaps and found there to be higher rates of deep and organ space SSIs in the muscle flap group, whereby deep infection involved the deep soft tissue layers, and the organ space infection concerned the deeper muscles and fascia. Patients in this group were noted to have higher rates of preoperative ascites, steroid use, recent rapid weight loss, transfer from acute care facilities, elevated white blood cell counts and lower hematocrit levels. When these baseline characteristics were controlled for in propensity matching, however, the difference in wound complication rates were not statistically significant [11].

The risk of 30-day readmission after spine surgery is about 5.5% with wound complications being the most common cause, accounting for 39.3% of readmissions in the literature. Of the potential wound complications, SSIs are the most reported problem (88.5%), followed by dehiscence and seroma [16]. Though we did not find statistically significant rates of SSI in one particular closure group, our study found there to be a significantly higher rate of readmissions in cases closed by PS (OR = 1.74, CI LL = 1.35, CI UL = 2.22, p < 0.001). In a recent study evaluating the risk factors associated with 30-day readmissions following spine surgery, an American Society of Anesthesiologists (ASA) physical status of 4 or more, surgical duration, and Medicare/Medicaid insurance status were found to have a positive correlation with readmission [17]. When controlled for independent variables, longer hospitalization time (LOS) and discharge to home were found to be significant predictors of wound-related complications requiring readmission (p = 0.007; R = 0.49; OR 1.63, 95 % CI 1.14–2.33) [16].

Gong et al. also showed that spine procedures closed with paraspinal flap are associated with prolonged length of stay (LOS) when compared to traditional closure (18.7% vs. 8.4%, p < 0.001). Additionally, spine procedures utilizing PS were found to have overall longer surgical duration (3.9 ± 1.8 hours vs. 5.1 ± 2.5 hours; P <0.001). Even when adjusted for surgical time, a statistically longer LOS remained for the muscle flap group [13]. The authors explained these findings by referencing the medical comorbidity and complexity of the muscle flap group, which was not controlled for during matching and included factors such as chronic steroid use and ASA class. Although the present study did not investigate LOS, it is plausible that those with PS closure in our study had an extended LOS when considering the current literature. While this may be due to medical complexity, we also postulate that differences in pain control requirements and postoperative wound care may exist between the groups, thus prolonging LOS. Patients who undergo more extensive soft tissue manipulation with muscle flap may have more postoperative pain, thus requiring intravenous pain medication for a longer period of time.

Another factor contributing to LOS is the use of surgical drain. These drains are oftentimes used for an extended period of time when managed by PS [21]. From the authors' anecdotal experience, the threshold for surgical drain removal at our institution is much higher for PS compared to the spine team, and drain dwelling often delays patient discharge. Although this observation has not been explicitly studied, drain dwelling may have an impact on LOS and thus the sequelae of which may lead to future need for admission. Tan et al performed a meta-analysis comprising 12 studies and 2,443 patients evaluating the effect of drain usage on SSI rate and found no significant difference when wound drainage systems were used (RD=0.001, 95% CI 0.006 to 0.007, p=0.844) [23]. Wright et al also explored drain usage in their study comprising 301 patients over a 12-year period. Their patients received a drain for a median of 19 days, and overall found a 4.9% incidence of SSI. Their analysis revealed no increased risk with longer drain dwell times in the development of SSI (OR 1.03; p= 0.282), wound complication requiring reoperation (OR, 1.02; P = 0.559) or subsequent removal of instrumentation due to infection (OR, 1.03; P = 0.528) [22]. Although these studies did not show a correlation between drain dwelling times and postoperative SSIs, they did not consider the other complications that may be related to increased LOS. For example, prolonged insertion of surgical drains and increased pain may limit patient mobilization. Though the odds ratio in our study did not reach statistical significance due to small sample size, DVT, PE and VTE trended higher in the PS group (OR 2.91, 2.05, 2.57, respectively). This discrepancy may provide some medical explanation as to why readmission rates were higher in the PS group. Future research should investigate the driving factors for readmission after PS versus SS closure. Specifically, postoperative pain and surgical drain practices associated with the different closure types may impact

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mobilization following complex spinal reconstruction surgery and therefore put patients at risk for developing short-term complications.

Our study also found a statistically significant difference in 30-day reimbursements in favor of SS (PS $24,072.94 vs SS $31,204.64, $p < 0.0001$). This finding may be intimately related to the cost of readmission. Following the Affordable Care Act in 2010, the Center for Medicare and Medicaid Services (CMS) utilized the Value Based Purchasing (VBP) Program to reduce payments to hospitals for 30-day hospital readmissions. Typically, reimbursements are calculated based on the services provided, the type of specialist involved in care, the complexity of the treatment provided, the geographical location of where the services were rendered, as well as inflation rates. With the VBP program, adjustments are made based on mortality, infections, complications, and patient safety and experience. In particular, risk-adjusted Medicare Part-A payments for procedures with complications or morbidities declined by 8.9% for spine fusion cases between the years 2012 and 2017 [25-26]. Given that our study demonstrated PS closure to be associated with higher rates of readmission, we speculate that the same postoperative complications that result in readmission, in effect, decrease procedural reimbursement. Again, we theorize that these results reflect the selection bias involved in indicating higher risk patients for postoperative complications for PS-assisted closure (i.e. those with more medical comorbidities or risk factors for poor wound healing). Unfortunately, our study was limited in the fact that we were unable to identify distinct reasons for readmission in the PS group. We were also limited by our inability to identify trends in readmission for RTOR, as RTOR carries a heavy burden on reimbursement.

This study compared clinical outcomes and reimbursement following PS versus SS closure for large PSF surgeries using a large-volume national database of insurance claims. We demonstrated no significant difference in the rate of SSI between the two closure teams, however found that PS-assisted closure correlates with an increased rate of 30-day readmission and decreased reimbursement. Future research should aim to identify the particular causes for readmission and where tolls are taken on reimbursement for PS-assisted closure. Additionally, future directions should determine if specialty-specific trends exist in wound care management and if these practices affect outcomes and patient recovery following complex spine reconstruction.

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