Comparative Study of Early Health Care Use after Forearm Corrective Osteotomy

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Abstract

Background Bone reconstruction is frequently required for corrective osteotomy of the forearm long bones. Studies have evaluated long term outcomes but not the impact of these procedures on early postoperative complications and health care utilization.

Questions/Purposes This study evaluated the early postoperative health care utilization following corrective osteotomy of the radius and/or ulna.

Patients and Methods The American College of Surgeons' National Surgical Quality Improvement Program (NSQIP) was the primary data source to perform a comparative statistical analysis of the bone autograft and nonautograft (allograft, graft substitute, or no graft) procedures. We performed a review of the NSQIP database (2005–2013) to evaluate patients who underwent a corrective osteotomy of the radius and/or ulna.

Results There were 362 cases; autograft ($n = 117$) and nonautograft ($n = 245$). There were no significant differences with demographics or comorbidities. The majority of cases were outpatient surgeries and there were no significant differences in anesthesia time, operative time, or hospital length of stay. Overall, the average length of stay was 0.6 days, readmission rate was 2%, and the total complication rate was 1% and there was no statistically significant difference between reconstruction groups. Harvesting of autograft was not associated with the overall 30-day complications and specific markers of health care utilization.

Conclusions Our results are derived from the heterogeneous hospital setting of NSQIP contributing centers. The health care utilization and 30-day complications are low following corrective osteotomy of forearm long bones and autograft harvest did not influence the health care utilization.

Level of Evidence Therapeutic Level II.

Keywords
- osteotomy
- bone graft
- outcome
- health care utilization metrics
- radius
- ulna

Bone reconstruction using autograft, allograft, or bone substitute is frequently required for corrective osteotomy of the radius and ulna. There are aspects of autograft, such as donor site morbidity that make it a less favored choice of bone graft.[1] Retrospective studies comparing autograft, allograft, and no graft techniques for corrective osteotomies of the radius have demonstrated no significant differences in time to union, outcome scores, and complications.[2] Although many studies have evaluated patient outcomes, there is a dearth of information regarding the impact of these outcomes on health care utilization. Given the renewed focus on quality and cost management within health care, this information may influence the surgical treatment for corrective osteotomy of the forearm long bones.

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Autograft is considered as the gold standard for bone grafting procedures and provides osteoinductive growth factors and has osteoconductive potential.[3] Small bone defects can be successfully treated with nonvascularized iliac crest bone graft, although autograft presents the possibility for donor site morbidity.[2] Bone allograft is available in many forms ranging from demineralized bone matrix, cancellous chips, corticocancellous and cortical grafts, and osteochondral and whole-bone segments. Allograft bone is osteoconductive and osteoinductive and available in various shapes and sizes with no donor site morbidity. However, bone allograft only partially retains the structural strength compared with an autograft.[4] Allograft techniques have lower indirect costs compared with an autograft (postoperative rehabilitation, pain management, and missed time from work).[5] In a randomized controlled trial (RCT), comparing allograft bone chips and iliac crest bone graft for treatment of distal radius fractures ($n = 90$ patients), a higher treatment cost was associated with iliac crest bone grafting.[6]

Bone graft substitutes that are osteoinductive or osteoconductive are an alternative to autograft performing corrective osteotomies. Hydroxyapatite, an osteoconductive bone graft substitute, has been used effectively for corrective osteotomy of malunited distal radius fractures.[7] Similar to allograft, bone graft substitutes may lead to increased direct health care costs but may reduce the indirect costs.[5]

Union rate has substantial implications regarding future utilization of the health care resources and patient morbidity and is an important outcome to evaluate techniques using nongraft, autograft, allograft, and bone graft substitute. In an RCT ($n = 30$ patients), comparing bone graft substitute (rhBMP7) to iliac crest bone graft for corrective osteotomy of the distal radius, the duration of time to union was longer following bone graft substitute compared with iliac crest bone graft.[8] Similarly, other retrospective studies have compared allograft to nongrafting methods for corrective osteotomy and reported no difference in the time to union.[9] In a comprehensive literature review comparing autograft, bone graft substitute, and no graft, the rate of union was comparable among techniques.[2] The early postoperative complications, length of stay, and hospital readmission are important considerations to assess patient morbidity associated with corrective osteotomies of the radius and/or ulna. These markers provide valuable insight into quality improvement initiatives and in health care utilization.

The purpose of this study was to evaluate the health care utilization metrics (readmission rate, reoperation rate, length of stay, complications) in the early postoperative period (within 30 days) following corrective osteotomy of the forearm long bones, including the ulna, radius, or both. We hypothesized that bone autograft compared with nonautograft for corrective osteotomy of the forearm long bones would lead to an increase in health care utilization.

Material and Methods

The American College of Surgeons' National Surgical Quality Improvement Program (NSQIP) was used as the primary data source to perform a comparative statistical analysis of the autograft and nonautograft procedures. NSQIP is a validated, prospective database of patients undergoing surgical procedures at over 570 institutions. The NSQIP database includes perioperative data regarding patient demographics and outcomes. This database has been used extensively in other surgical fields to study 30-day complication profiles and associated risk factors.[10] To compile the NSQIP database, trained surgical clinical reviewers record 240 preoperative and intraoperative variables for each case enrolled and any complications occurring in the first 30 days after the surgery. The perioperative surgical data are prospectively collected primarily from hospitals located in the United States and Canada. Complete follow-up is ensured through chart review, patient telephone calls, and scheduled visits.[10]

Following our institutional ethics board notification of exemption, we performed a review of the NSQIP database (2005–2013) to identify all patients who underwent a corrective osteotomy of the radius and/or ulna. The current procedural terminology (CPT) codes (CPT 25400, 25405, 25415, 25420) were used to identify these cases.

We included two primary study groups: cases where autograft was used to perform the corrective osteotomy and the remainder were nonautograft cases. For the nonautograft cases, the NSQIP data do not identify if allograft or bone substitute was used for the reconstruction. There were a total of 362 cases identified; autograft group ($n = 117$) and nonautograft group ($n = 245$). The demographic variables, medical comorbidities, and operative details were compared between groups. The 30-day complications were compared between groups for specific complications and for overall complication rate, major complication rate, readmission rate, and reoperation rate. Mean anesthesia time, mean operating time, and mean length of stay were compared.

Statistical Analyses

Patient demographics and outcomes were compared between autograft and nonautograft groups using Chi-square, or Fisher's exact tests (categorical variables), or unpaired *t*-tests, or Mann–Whitney test (continuous variables), as appropriate. A *p*-value of < 0.05 was considered to be statistically significant.

Results

Comparing patients who underwent a corrective osteotomy with autograft and nonautograft, there was no significant difference ($p > 0.05$) with demographics or comorbidities (►**Table 1**). The majority of cases were completed as outpatient surgery with a higher percentage of inpatients present in the autograft group (22%) relative to the nonautograft group (15%). There were no significant differences in anesthesia time ($p = 0.52$), operative time ($p = 0.12$), or hospital length of stay ($p = 0.69$; ►**Table 2**).

Overall, the average length of stay was 0.6 days, readmission rate was 2%, and the total complication rate was 1%. There were five complications, including superficial ($n = 2$) and deep ($n = 2$) surgical site infection, and pneumonia

Table 1 Demographic data of autograft and nonautograft samples

Variable	Total *n* (%)	Graft *n* (%)	No Graft *n* (%)	*p*-Value
Total sample	362	117	245	
Female	188 (52)	56 (48)	132 (54)	0.28
Male	174 (48)	61 (52)	113 (46)	
Outpatient	297 (82)	96 (82)	201 (82)	0.08
Inpatient	65 (18)	21 (18)	44 (18)	
Diabetic	33 (9)	11 (9)	22 (9)	0.79
Smoker	119 (33)	38 (32)	81 (33)	0.29
Alcohol	12 (3)	0 (0)	12 (5)	0.001
Independent	347 (96)	112 (96)	235 (96)	0.93
COPD	20 (6)	5 (4)	15 (6)	0.47
CHF	0 (0)	0 (0)	0 (0)	–
TIA	3 (0.8)	1 (0.8)	2 (0.8)	0.45
PVD	3 (0.8)	2 (2)	1 (0.4)	0.45
Previous wound infection	5 (1)	1 (0.8)	4 (2)	0.55
Wound class				
1	347 (96)	113 (97)	234 (96)	0.26
2	4 (1)	0 (0)	4 (2)	
3	8 (2)	4 (3)	4 (2)	
4	2 (0.6)	0 (0)	2 (0.8)	
ASA class				
1	49 (14)	19 (16)	30 (12)	0.71
2	208 (57)	66 (56)	142 (58)	
3	97 (27)	29 (25)	68 (28)	
4	5 (1)	2 (2)	3 (1)	

Abbreviations: ASA, American Society of Anesthesiologists; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease; TIA, transient ischemic attack.

($n = 1$; ►**Table 3**). Only one complication occurred following allograft (deep wound infection). The autograft group complications included wound infection ($n = 1$). The nonautograft group included superficial wound problems ($n = 2$),

Table 2 Comparison of operative and hospital times between autograft and nonautograft

Variable	Autograft ($n = 117$)	Nonautograft ($n = 245$)	*p*-Value
Anesthesia time (min)	164	171	0.52
Operative time (min)	122	111	0.12
Hospital length of stay (d)	0.58	0.63	0.69

Table 3 The 30-day complication data between autograft and nonautograft populations

Variable	Total *n* (%)	Graft *n* (%)	No Graft *n* (%)
Total sample	362	117	245
Superficial wound	2 (0.6)	0 (0)	2 (0.8)
Wound infection	2 (0.6)	1 (0.8)	1 (0.4)
Pneumonia	1 (0.3)	0 (0)	1 (0.4)
Major complications	3 (0.8)	1 (0.8)	2 (0.8)
Overall complications	5 (1.4)	1 (0.8)	4 (1.6)
Reoperation	2 (0.6)	0 (0)	2 (0.8)

Note: No reported mortality, pulmonary embolism, urinary tract infection, central nervous system/cerebral vascular accident, deep vein thrombosis or readmission.

wound infection ($n = 1$) and pneumonia ($n = 1$). Harvesting of autograft was not associated with the overall 30-day complications and specific markers of health care utilization, including readmission, length of stay, and complication rate. For the autograft group, the average length of stay was 0.6 days, readmission rate was 4%, complication rate of 0.9%. For the nonautograft group, the average length of stay was 0.6 days, readmission rate was 0%, and the complication rate was 1.6%.

Discussion

Health care utilization and 30-day complications are low (1%) following corrective osteotomy of forearm long bones including the radius and/or ulna. In our study, autograft harvest did not influence the health care utilization, in several important areas including readmission, length of stay, and complication rate. The most common complication overall was superficial surgical site infection and deep surgical site infection which were each noted twice within the data analyses. With respect to readmission rate and length of stay we hypothesized that there would be an increase in the autograft vs nonautograft group given the donor site morbidity associated with autografting but found no significant difference in our study. We hypothesized that harvest of autograft would lead to longer operating and anesthesia times but similar operating room resources were found in both groups. One argument that would balance the cost of bone graft substitute or allograft is decreased operating time, which is an expensive resource, yet this was not apparent.

A literature review study by Mugnai et al[2] found low complication rates comparing autograft and nonautograft reconstructions, which is consistent with our study results from a large population database. However, the study by Mugnai et al[2] did identify several complications, including hardware failure, delayed union, complex regional pain syndrome, and posttraumatic fracture, which were not found in our study. These long-term complications were not captured in a thorough 30-day review of complications

and health care utilization. In many cases, the studies included in the literature review were limited by low statistical power due to small sample sizes, ranging from 3 to 28 patients (mean of 16). This is consistent with the study numbers noted in most of the available literature due to the relative rarity of long bone fracture corrective osteotomy procedures. The results of our study benefit from the large sample size obtained through the NSQIP database and are generalizable as they are obtained from many centers across the United States which will include a more heterogeneous practice pattern from different surgeons.

A limitation of this study is that within the NSQIP database the nonautograft group includes various types of allograft, bone graft substitutes, and no bone graft. Therefore, it was not possible to conduct a more detailed review of those data or perform subgroup analyses of the complication rates and possible impact on health care utilization. Selection bias may have been introduced through our method of identifying patients using CPT codes; the autograft group may represent a specific subset of corrective osteotomy patients that are not present in the nonautograft group, which could influence early health care utilization with differences in postoperative course. The complications within our data were focused within the postoperative 30-day time period and thus late stage complications (such as symptomatic hardware removal, late stage infection) were not reported. Studies evaluating late stage autograft and nonautograft complication rates have shown similarly low complication rates.[11] However, future large population studies of the complications over a long-term time period may demonstrate differences in the type and rate of complications between the autograft and nonautograft group. Finally, due to the low rate of 30-day morbidity, this study may not have a sufficient sample size to adequately address the question.

The data presented within this study provide the rates of complications, length of stay, and hospital readmission, and these short-term complications are important markers in quality improvement initiatives and in health care utilization. Our study results are derived from the heterogeneous hospital setting of NSQIP contributing centers and can be cited when counseling patients on the types of complications and informing surgeons on average complication rates associated with both autograft and nonautograft procedures.

Conclusion

Although the autograft procedure may have greater morbidity and no apparent difference in health care utilization, further studies should focus on comparative cost-effectiveness of the use of autograft and nonautograft techniques in corrective osteotomy to assess the direct and indirect economic burden to the health care system and potentially to patients, to direct our management. In the current health care landscape, there is a renewed focus on improving efficiency while maintaining quality, and this type of study provides critical insight into the most relevant cost and quality metrics for the long bone corrective osteotomy procedures.

Conflict of Interest
None declared.

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