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A Bundled Payment Model for Pediatric Distal Radius Fractures: Defining an Episode of Care

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Abstract

Background: Distal radius fractures are the most common fracture of childhood, occurring in approximately 1 per 100 children annually. Given the high incidence of these fractures, we explored feasibility of a bundled payment model. We determined the total treatment costs for each child and identified components of fracture management that contributed to variations in cost.

Methods: We retrospectively reviewed all hospital and physician costs related to the treatment of closed distal radius fractures at a large academic children's hospital. We included all children age 2–15 years treated by an orthopaedic surgeon for an isolated closed distal radius fracture between 2013 and 2015. We compared total treatment costs by fracture management approach. We then estimated the contribution of each component of fracture management to total treatment costs using linear regression.

Results: We identified 5,640 children meeting the inclusion criteria, of which 4,602 (81.6%) received closed treatment without manipulation, 922 (16.3%) underwent closed reduction in the clinic, emergency department, or radiology procedure suite, and 116 (2.1%) underwent treatment in the operating room. The median cost for closed treatment without manipulation was \$1,390 (IQR 1,029–1,801), compared to \$4,263 (IQR 3,740–4,832) for closed reduction and \$9,389 (IQR 8,272–11,119) for closed reduction and percutaneous pinning ($p < 0.001$). In multivariable regression analysis, fracture management approach and use of the operating room environment were the largest cost drivers ($p < 0.001$, $R^2 = 0.88$). Closed reduction in the clinic or emergency department added \$894 (95% confidence interval 819–969) to treatment costs, while closed reduction in the operating room added \$5,568 (95% CI 5,224–6,297). Location of the initial clinical evaluation, number of radiographic imaging series obtained, and number of orthopaedic clinic visits also contributed to total costs.

Conclusions: Closed pediatric distal radius fractures treated without manipulation show small variations in treatment costs, making them well suited for bundled payment. Bundled payments for these fractures could reduce costs by encouraging adoption of existing evidence-based practices.

INTRODUCTION

Healthcare spending in the United States has reached an unprecedented high, accounting for 17.5% of the gross domestic product in 2014¹. In the same year, the United States ranked last among eleven industrialized nations in “quality, efficiency, access to care, equity and healthy lives”². To lower the costs and improve the quality of health care delivery many payers, and in particular the Centers for Medicare & Medicaid Services (CMS), are exploring alternative payment systems^{3, 4}.

One proposed method for linking cost containment with quality involves a global reimbursement, or bundled payment model^{5–8}. The current fee-for-service model incentivizes productivity through the reimbursement of each individual service provided to a patient, potentially resulting in fragmented care, higher costs, and unnecessary procedures^{5, 6}. A bundled payment model groups both hospital and provider services related to a single diagnosis or treatment over a defined period, or episode of care. Bundled payments incentivize care coordination and reduced spending by allowing providers and hospitals to share in the cost savings^{6, 7}.

Orthopaedic surgeons have developed⁹, tested¹⁰, and deployed¹¹ bundled payment programs for adult conditions, yet no bundled payment programs have been described for pediatric orthopaedic conditions. Orthopaedic surgeons have also consistently increased surgeon revenue and decreased overall healthcare costs through their participation in bundled payment programs^{5, 12}. Pediatric distal radius fractures are an attractive candidate for bundled payment because they account for 25% of fractures in the pediatric population¹³. Pediatric distal radius fractures also meet all twelve criteria for bundled payment developed by the American College of Surgeons (Table 1)^{7, 13–17}. Based on these attributes, bundled payment may be feasible for pediatric distal radius fractures.

To develop a bundled payment program, it is important to understand the total treatment costs and the cost drivers. The purpose of this study is to describe the total treatments costs for pediatric closed distal radius fractures and to identify the components of fracture management that contribute to variations in cost at a single large, academic children’s hospital.

MATERIALS AND METHODS

This study was approved by the authors’ institutional review board.

We retrospectively reviewed treatment costs for all children treated for a closed distal radius fracture at a large academic children’s hospital medical center between 2013 and 2015. Inclusion criteria were age 2–15 years at time of injury and closed distal radius fracture with or without fracture of the distal ulna. Exclusion criteria were presence of additional injuries, open fractures, osteomyelitis or myositis diagnosed prior to presentation, fevers at

presentation, osteogenesis imperfecta, cancer, benign bone cysts, reflexive sympathetic dystrophy of the upper limb, and nerve injury.

Eligible children were identified from orthopaedic surgery medical records by presence of either (1) a diagnosis of closed distal radius fracture indicated by International Classification of Diseases, Ninth Revision (ICD-9) codes 813.40, 813.41, 813.42, 813.44, 813.45, or (2) treatment of a distal radius fracture indicated by Current Procedural Terminology (CPT) codes 25600, 25605, 25606, 25607, 25608, or 25609.

For children meeting the inclusion and exclusion criteria, physician and hospital records were used to identify all medical services delivered at the medical center over the course of each subject's treatment. Records were available for all providers employed by the medical center, including all orthopaedic, emergency medicine, pediatric, and urgent care providers. Information for visits outside the medical center was not available. Information extracted from medical records included ICD-9 diagnosis codes and CPT codes assigned, date of service delivery, gender, provider specialty and place of service. No attempt was made to determine which patients had medical trainees and/or physician assistants involved in their treatment, although as an academic children's hospital both trainees and physician assistants are frequently involved in care delivery.

An episode of care was defined for each child, beginning 30 days prior to the child's first orthopaedic surgery evaluation and ending 90 days after this evaluation. We chose this definition to include all fracture-related care delivered prior to orthopaedic evaluation, such as evaluation, radiographs, and splinting in the emergency department. Only medical services delivered during the child's episode of care were included.

To limit the analysis to fracture related services, only medical services from orthopaedic surgery, emergency medicine, urgent care, radiology, physical or occupational therapy, general pediatrics, and infectious disease were included. ICD-9 diagnosis codes for all encounters were reviewed and encounters unrelated to the fracture were excluded. Hospital services unrelated to the management of a distal radius fracture (such as infusion medicine, recurrent unrelated lab draws, hospitalizations unrelated to the injury, etc.) were also excluded.

Fracture management approach for each subject was assigned using CPT codes and medical records (see Appendix 1 for details). Each subject's medical record was reviewed to determine the age at presentation, location of the initial evaluation, the method of initial fracture immobilization, occurrence of hospital admission, presence of a postoperative infection requiring administration of oral or intravenous antibiotics, unplanned return to the emergency department, and hospital readmission. Occurrence of fracture reduction under sedation in the emergency department was determined by administration of propofol, ketamine, midazolam, and/or delivery of sedation services by the emergency department provider. Occurrence of fracture reduction in the radiology procedure suite was determined by the presence of CPT code 26505 (closed treatment distal radius fracture with manipulation) and delivery of monitored sedation in the radiographic procedure suite. The radiology procedure suite is a room in our radiology department, outside of the operating

room environment, where minimally invasive procedures may be performed with conscious sedation and fluoroscopy. Finally, the number of radiographic series obtained, fluoroscopic series obtained, and orthopaedic clinic visits attended during the episode of care were calculated.

For each medical service delivered during the episode of care, costs to the medical center for delivering that service were obtained from the corporate financial database of the medical center. Costs were calculated in US Dollars (USD) at time of service delivery (2013–2015). Costs included both direct costs (i.e. medical supplies, provider salary and benefits, division-specific administrative expenses) and indirect costs (i.e. facilities, equipment, and hospital administration).

Data Analysis

Data was analyzed using STATA 15.1 (StataCorp, College Station, TX). Mean and standard deviation (SD) were reported, with median and inter-quartile range (IQR) for measures that were not normally distributed. We compared demographics and components of fracture management between subjects treated outside the operating room and subjects treated in the operating room using Pearson's chi squared test for categorical variables and Wilcoxon Rank Sum test for continuous variables. We compared total treatment costs by fracture management approach using the Kruskal-Wallis test. Linear regression was performed to estimate the contribution of each demographic feature and component of fracture management to overall treatment cost. Variable selection for the regression model was performed using backward elimination with a threshold of $p > 0.05$ for item elimination. All p-values reported are two-sided.

RESULTS

During the study period, 5,710 children were treated for a closed distal radius fracture at our institution. Seventy children were excluded due to the presence of additional injuries or other diagnoses that would substantially influence fracture management.

Of the 5,640 children who met the inclusion and exclusion criteria for the study, 4,602 (81.6%) received closed treatment without manipulation, 922 (16.3%) underwent closed reduction in the clinic, emergency department, or radiology procedure suite, and 116 (2.1%) underwent treatment in the operating room. Among children treated in the operating room, 13 (11.2%) underwent closed reduction, 86 (74.1%) underwent closed reduction and percutaneous pinning, and 17 (14.7%) underwent open reduction and internal fixation. Patient demographics and components of treatment delivery are shown in Table 2.

In comparing patients treated outside the operating room ($n=5,524$), with patients treated in the operating room ($n=116$), patients treated in the operating room were older (median age 11, IQR: 8–13 v median age 9, IQR: 6–11, $p < 0.001$), had more radiographic series (median 6, IQR: 5–8, v median 2, IQR: 1–3, $p < 0.001$), and more clinic visits (median 5, IQR: 4–5, v 2, IQR: 2–3, $p < 0.001$). More patients in the operating room group were initially treated in the emergency department (63.8% v 43.8%, $p < 0.001$), and underwent reduction with conscious sedation in the emergency department (45.7% v 14.9%, $p < 0.001$).

Treatment costs were primarily influenced by the fracture management approach, as shown in Table 3. Management in the operating room increased costs, even in patients undergoing closed reduction. The cost of treatment with closed reduction outside the operating room was \$4,263 (IQR 3,740–4,832), compared to \$7,820 (IQR 6,559–9,196) for the same procedure performed in the operating room environment ($p<0.001$). Fractures managed by closed treatment without manipulation made up 81.6% of all fractures in the children examined and accounted for 56.9% of all costs. By comparison, fractures managed in the operating room made up 2.1% of all fractures and 9.7% of all costs.

We investigated the impact of individual treatment interventions on costs using multivariable linear regression (Table 4). We initially included patient age and gender in the regression model as potential predictors of cost; neither was associated with treatment costs ($p>0.05$) and we removed both from the final model. Fracture management approach and use of the operating room environment were the largest cost drivers. Closed reduction in the clinic or emergency department added \$894 (95% confidence interval 819–969) to treatment costs, while closed reduction in the radiology procedure suite added \$3,554 (95% CI 3,358–3,750) and closed reduction in the operating room added \$5,568 (95% CI 5,224–6,297). Location of the initial clinical evaluation, hospital admission, number of diagnostic radiographic imaging series obtained, number of fluoroscopic series obtained, and number of orthopaedic clinic visits also contributed to total costs; incremental cost added by each intervention is shown in Table 4.

DISCUSSION

Creation of a bundled payment model is predicated on identifying an average episodic cost and cost drivers in order to determine inclusion criteria for the bundle. Our analysis of 5,640 children treated at a single center for closed distal radius fractures indicates that the major cost drivers were fracture management approach and use of the operating room environment. Children treated in the operating room accounted for 2.1% of fractures reviewed, but 9.7% of the costs incurred. Even for the same procedure (closed reduction and immobilization), costs varied substantially depending on the setting; closed reduction with sedation in the radiology procedure suite costs \$2,014 less than the same procedure in the operating room. While costs varied substantially among different treatment approaches, variation in costs within individual approaches was relatively small. These results suggest that a bundled care model for closed distal radius fracture would need to be defined by fracture management approach.

Our results are consistent with and extend those of similar studies looking at cost drivers across healthcare settings. Treatment setting is a major driver of costs in adult medicine. In a 2013 study of community-acquired pneumonia treatment costs for patients over age 50, costs were tenfold-higher for inpatient care compared to outpatient care¹⁸. These results are similar to the current study's findings that incremental cost for closed reduction of distal radius fractures is four-fold higher when performed in the radiology procedure suite compared to the emergency department or clinic, and almost six-fold higher when performed in the operation room.

Orthopaedic surgeons have a strong history of achieving improved patient outcomes and increased surgeon revenue through their participation in bundled payment programs. In 2009, CMS tested a bundled payment model for Medicare patients undergoing total knee and hip arthroplasty⁵. The program achieved decreased length of stay, improved rates in the administration of prophylactic antibiotics, and decreased hospital readmission rates^{5, 7}. Total treatment costs were reduced approximately 10% at each site⁵. As a result of the cost savings, participating physicians received a 25% bonus in nearly all cases⁵. Similar reduction in length of stay and costs of treatment have been reported for hospitals participating in the more recent CMS Bundled Payment for Care Improvement (BPCI) initiative^{12, 19, 20}. While actual cost savings and incentive payment structures will depend upon the specific condition being treated, bundled payment models do appear to be an opportunity for orthopaedic surgeons to increase payments for their services and improve patient outcomes while simultaneously reducing total healthcare costs.

The purpose of the current study was to identify cost drivers for pediatric distal radius fractures with the goal of creating a bundled payment model. We identified fracture management approach and care in the operating room as the major cost drivers in pediatric patients with closed distal radius fractures. Enabling providers to perform closed reductions outside the operating room appears to be the single greatest opportunity to reduce individual treatment costs. After adjusting for treatment approach, we found that additional cost savings could be achieved by facilitating initial evaluation by an orthopaedic surgeon, reducing the number of radiographic series obtained during treatment, and reducing the number of orthopaedic appointments for each patient.

Examples in the orthopaedic literature demonstrate where these approaches may be employed safely. Evaluation by an orthopaedic surgeon may be facilitated by use of orthopaedic-specific urgent care clinics; these clinics have been initiated at several medical centers, with evidence that they expedite definitive orthopaedic management and reduce treatment cost²¹. The number of radiographs obtained during treatment may be safely reduced by avoiding post-immobilization radiographs immediately following splint application for non-displaced or minimally displaced fractures^{22, 23}, avoiding post-reduction radiographs immediately follow reduction with mini C-arm fluoroscopy^{24, 25}, and reducing frequency of follow-up radiographs to monitor fracture alignment after reduction²⁶. Finally, the number of orthopaedic appointments may be reduced for children with Greenstick²⁷ and buckle fractures²³. For buckle fractures in particular, multiple randomized trials have shown treatment with removable splints and fewer orthopaedic clinic visits is safe, effective, and leads to improved patient satisfaction^{28, 29}. Despite this strong evidence in support treating buckle fracture with removable splints, there remains a large implementation gap at present with only 29% of pediatric orthopedic surgeons adopting this management approach³⁰. Taken together, these evidence-based approaches demonstrate safe, effective opportunities exist to reduce treatment costs for pediatric distal radius fractures; while they may not be applicable to all patients or all fractures, they do suggest starting points for surgeons and hospitals interested in reducing treatment costs.

Two additional approaches to reducing treatment costs for pediatric closed distal radius fractures also deserve consideration. First, there is evidence that closed, nondisplaced

pediatric distal radius fractures can be safely managed by pediatricians rather than orthopaedic surgeons in some contexts^{31, 32}. If pediatricians could provide services at a lower cost than orthopaedic surgeons, this could reduce treatment costs and increase value for patients^{32, 33}. Second, there is evidence to suggest that many displaced distal radius fractures do not require a reduction to heal adequately, particularly in children with several additional years of forearm growth remaining^{14, 34, 35}. Choosing not to perform closed reduction in patients whose fracture will remodel adequately during growth may reduce treatment costs. Both these approaches offer potential for reducing treatment costs, although there are controversial aspects to each including consensus on exactly which fractures can be managed by pediatricians^{31, 36}, what if any additional training pediatricians would need to provide fracture care^{31, 37}, and criteria for which fractures do not require reduction.

Results of the current study must be interpreted in the context of the study design. Data were collected from a single center and may not generalize across institutions. The costs of care delivery and the relative distribution of fracture types will differ between institutions, so each institution will need to evaluate their own costs and care processes before proceeding with creation of a bundled payment model. As one example of how costs may vary between institutions, at our institution closed reductions in the emergency department are performed primarily by orthopaedic residents and fellows. If attending surgeons performed these reductions, treatment costs for closed reduction in the emergency department might increase substantially [at our hospital, the incremental cost for reduction by the attending surgeon is \$827]. Costs attributed to individual clinic visits, hospital admissions, and radiographs may similarly vary across institutions. Further, availability of fluoroscopy or dedicated procedure suites outside the operating room may vary across institutions. While this study suggests a bundled payment model is feasible for closed distal radius fractures, individual institutions will need to evaluate their own specific costs when negotiating a bundled payment with insurers. Institutions will also need to evaluate their own resources, sphere of influence, and the willingness of their providers to participate in bundle payment programs³⁸ when deciding which elements of care to include in a bundled payment program.

In conclusion, bundled payment models are being tested in numerous disciplines as one method to lower costs and improve quality of care. In order to outline a bundled payment model for pediatric closed distal radius fractures, we have analyzed the drivers for treatment cost using data from a single academic children's hospital. Our analysis suggests that fractures managed without manipulation could be included in a bundled payment model. Including fractures managed by closed reduction in the same bundle may incentivize health systems to provide this treatment in lower-cost environments, which is in alignment with the goals of a bundled payment: providing quality care in the most cost-efficient manner. Given the substantially higher costs of treatment with closed reduction and percutaneous fixation and open reduction with internal fixation, fractures managed by these approaches may be better addressed with a bundled payment model distinct from fractures not requiring operative intervention.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Criteria for selecting surgical procedures for bundled payment (source: American College of Surgeons 2013)

Criteria		Pediatric closed distal radius fractures
1.	Existence of adequate and relevant data for analyses	Yes
2.	Elective, nonemergent procedure	Yes
3.	High volume and/or high expenditure procedure	Yes
4.	Procedures performed across the country	Yes
5.	Existence of evidence-based or appropriateness criteria	Yes ^{15, 17}
6.	Established measureable processes of care or performance measures	Yes
7.	Ability of the surgical patient or outcomes to be risk adjusted	Yes
8.	Measurable variation in resource use	Yes ¹³
9.	Opportunity for cost savings	Yes ^{14, 16}
10.	Reasonable predictability of costs	Yes
11.	Low vulnerability to CPT/ICD/DRG upcoding or miscoding	Yes
12.	Include the involvement of multiple providers in the delivery of care	Yes

Table 2.

Patient Demographics and Components of Fracture Management. IQR, interquartile range.

Variable	Total (N=5,640)		Treatment Outside the Operating Room (N=5,524)		Treatment in the Operating Room (N=116)		P value
	No.	%	No.	%	No.	%	
Age Group							0.002
2 – 9 years old	3,070	54.4	3,023	54.7	47	40.5	
10 – 15 years old	2,570	45.6	2,501	45.3	69	59.5	
Male Gender	3,102	55.0	3,030	54.9	72	62.1	0.122
Initial Evaluation Location							<0.001
Emergency Dept (ED)	2,493	44.2	2,419	43.8	74	63.8	
Urgent Care	827	14.7	820	14.8	7	6.0	
Orthopaedic Clinic	2,291	40.6	2,256	40.8	35	30.2	
Primary Care Provider	29	0.5	29	0.5	0	0	
Initial Immobilization							<0.001
Cast	1,849	32.8	1,839	33.3	10	8.6	
Splint/Brace	2,977	52.8	2,897	52.4	80	69.0	
Other/Not Stated	814	14.4	788	14.3	26	22.4	
Reduction with Sedation							
In Emergency Dept ¹	874	15.5	821	14.9	53	45.7	<0.001
In Radiology Suite ²	46	0.8	46	0.8	0	0	0.324
Hospital Admission	4	0.1	1	0.02	3	2.6	<0.001
Post-operative Infection ³	0	0	0	0	0	0	
Unplanned Return to ED	390	6.9	378	6.8	12	10.3	0.141
Hospital Readmission	0	0	0	0	0	0	
	<i>Median</i>	<i>IQR</i>	<i>Median</i>	<i>IQR</i>	<i>Median</i>	<i>IQR</i>	<i>P value</i>
Radiographic Series ⁴	2	1–4	2	1–3	6	5–8	<0.001
Orthopedic Clinic Visits	2	2–3	2	2–3	5	4–5	<0.001

¹ Sedated reduction and anesthetic performed in the Emergency Department as indicated by administration of propofol, ketamine, midazolam and/or billing for sedation by provider

² Sedated reduction performed in radiology suite with billing for Preoperative and PACU care

³ Treated with oral or intravenous antibiotics post operatively

⁴ Total number of radiographic series during the entire episode of care; fluoroscopy included as one series

Table 3.

Costs by Management Approach. All values in US Dollars (\$). Amounts include both physician- and hospital-services. Costs include direct and indirect costs of treatment. IQR, interquartile range, SD, standard deviation.

Fracture Management	N	Cost of Treatment					P value
		Median	IQR	Mean	SD	Total	
Treatment Outside the Operating Room							
Closed Treatment Without Manipulation	4,602	1,390	1,029 – 1,801	1,499	737	6,899,302	56.9
Closed Reduction	922	4,263	3,740 – 4,832	4,398	1,108	4,054,902	33.4
Treatment in the Operating Room							
Closed Reduction	13	7,820	6,559 – 9,196	8,671	2,716	112,722	0.9
Closed Reduction and Percutaneous Pinning	86	9,389	8,272 – 11,119	9,729	2,500	836,669	6.9
Open Reduction and Internal Fixation	17	12,251	10,856 – 13,233	13,026	4,555	221,436	1.8

Table 4.

Costs of Individual Interventions in the Treatment of Closed Pediatric Distal Radius Fractures. All costs are in US dollars.

Component of Treatment	Incremental Cost (95% CI)
Base Cost	602 (569 – 635)
Fracture Management Approach	
Closed Treatment Without Manipulation	<i>Reference</i>
Closed Reduction (location)	
Clinic or Emergency Department	894 (819 – 969)
Radiology Suite	3,554 (3,358 – 3,750)
Operating Room	5,568 (5,224 – 5,911)
Closed Reduction and Percutaneous Fixation	6,145 (5,993 – 6,297)
Open Reduction and Internal Fixation	9,518 (9,212 – 9,824)
Initial Evaluation Location	
Orthopedic Clinic	<i>Reference</i>
Emergency Department	575 (533 – 616)
Urgent Care	366 (315 – 417)
Primary Care Provider	786 (557 – 1,015)
Components of Fracture Management	
Hospital Admission	1,220 (599 – 1,840)
Each Radiographic Series	142 (125 – 160)
Each Fluoroscopic Series	623 (557 – 690)
Each Subsequent Orthopedic Clinic Visit	321 (296 – 346)

$F(12, 5627) = 3527, p < 0.001, R^2 = 0.88$