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Research article

Rates of readmission and reoperation following pelvic osteotomy in adolescent patients: a database study evaluating the pediatric health information system

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ABSTRACT

Rates and reasons for readmission and reoperation following adolescent pelvic osteotomy are not well-defined. This study aimed to (1) determine 30-day and 90-day readmission rates and the 2-year reoperation rate after pelvic osteotomy in adolescents and (2) identify reasons for readmission and reoperation. The Pediatric Health Information System database was queried between 10 January 2015 and 1 January 2020 for patients meeting selected International Classification of Diseases (ICD-10) procedure and diagnosis codes relating to pelvic osteotomies. Readmission rates were calculated within 30 and 90 days from index osteotomy. The ipsilateral reoperation rate was calculated within 2 years from index osteotomy. Reasons for these outcomes were identified. Univariate and multivariate analyses were utilized to identify readmission risks. Of 1475 patients, 5.4% and 9.2% were readmitted within 30 and 90 days, respectively. Reasons for readmission were consistent across both time points and included infection, hip-related orthopedic conditions and neurologic conditions. Younger age (OR 0.83, 95% CI: 0.76, 0.89; $P < 0.0001$) and male sex (OR 1.77, 95% CI: 1.23–2.54; $P = 0.002$) were predictive of readmission within 90 days. The 2-year reoperation rate was 32.1%, of which 79.8% underwent reoperation for hardware removal, 17.7% for revision and 1.3% for hip replacement. 30-day readmission, 90-day readmission and 2-year reoperation rates after adolescent pelvic osteotomy were 5.4%, 9.2% and 32.1%, respectively. Younger age and male sex were predictive of 90-day readmission. Most ipsilateral reoperations were for hardware removal. Understanding readmission and reoperation risks following pelvic osteotomy can benefit patient counseling and improve expectations of post-surgical outcomes.

Level of Evidence: IV, case series.

INTRODUCTION

Elective lower extremity procedures are common in pediatric and adolescent patients, with an expanding focus on hip preservation in this population. Pediatric and adolescent hip preservation procedures include pelvic osteotomies such as periacetabular osteotomy (PAO), hip arthroscopy, surgical hip dislocation and others.

With increasing attention to hip preservation procedures, complications after pelvic osteotomies have been recently evaluated. Known complications after pelvic osteotomy in this patient population include infection, venous thromboembolism, malunion and nonunion, nerve palsies, symptomatic hardware and joint degeneration among others [1–5]. Such complications may result in hospital readmission as well as reoperation after the index pelvic osteotomy. Thus far, there is limited data on the overall risks for adolescent patients undergoing pelvic osteotomies in terms of readmission or reoperation. Understanding the reasons, frequency and risks of readmission and reoperation helps guide patient counseling and expectations in addition to providing a benchmark to allow surgeons and healthcare systems to improve the quality of care provided to patients. Moreover, if the reasons for readmission and reoperation are defined, it may be possible to mitigate contributing avoidable and modifiable factors.

The purposes of this study were to (i) determine the 30-day and 90-day readmission rates and the 2-year reoperation rate after pelvic osteotomy in adolescents and (ii) identify the reasons for readmission and reoperation after pelvic osteotomy in this population. We hypothesized that the most common reasons for readmission would be for hip-related orthopedic conditions and infection and that the most common type of reoperation would be for hardware removal.

MATERIALS AND METHODS

This retrospective database study utilized the Pediatric Health Information System (PHIS) database for admissions and procedures between 1 October 2015 and 1 January 2020. The PHIS is a comparative pediatric database that collects clinical and

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Table I. Baseline characteristics of the cohort and characteristics of those readmitted within 90 days versus those who were not. Length of stay describes the postoperative length of stay after index surgical procedure. P-values compare patients that were readmitted within 90 days (n = 136) versus those who were not (n = 1343). Continuous variables are reported as mean ± standard deviation. Categorical variables are reported as n (% within the column)

		Total Cohort (n = 1475)	*90-day readmission (n = 136)*	*Not readmitted within 90 days (n = 1339)*	*P-value*
Age (years)		14.4 ± 2.4 (range, 10.0–19.0)	13.3 ± 2.3 (range, 10.0–18.7)	14.5 ± 2.4 (range, 10.0–19.0)	<0.0001[a]
Sex	*Female*	938 (63.6)	65 (47.8)	873 (65.2)	<0.0001[a]
	Male	537 (36.4)	71 (52.2)	466 (34.8)	
Ethnicity	*Hispanic or Latino*	242 (16.4)	28 (20.6)	214 (16.0)	0.08
	Not Hispanic or Latino	1101 (74.6)	102 (75.0)	999 (74.6)	
	Unknown	132 (8.9)	6 (4.4)	126 (9.4)	
Race	*American Indian*	10 (0.7)	0 (0)	10 (0.7)	0.72
	Asian	39 (2.6)	4 (2.9)	35 (2.6)	
	Black	150 (10.2)	18 (13.2)	132 (9.9)	
	Pacific Islander	4 (0.3)	0 (0)	4 (0.3)	
	White	1027 (69.6)	89 (65.4)	938 (70.1)	
	Other	169 (11.5)	18 (13.2)	151 (11.3)	
	Unspecified	76 (5.2)	7 (5.1)	69 (5.2)	
Census Region	*Midwest*	338 (22.9)	35 (25.7)	303 (22.6)	0.71
	Northeast	356 (24.1)	29 (21.3)	327 (24.4)	
	South	385 (26.1)	33 (24.3)	352 (26.3)	
	West	396 (26.8)	39 (28.7)	357 (26.7)	
Length of stay (days)		4.1 ± 7.4 (range, 0–250)	4.9 ± 3.8 (range, 0–22)	4.0 ± 7.6 (range, 0–250)	0.17

Source: [a]Denotes statistical significance.

resource utilization data from multiple hospital settings including inpatient, ambulatory surgery, emergency department and observation unit patient encounters affiliated with the Children's Hospital Association (Lenexa, KS) [6]. The PHIS database currently contains de-identified data from over 49 children's hospitals in the USA [6].

Patients with selected International Classification of Diseases (ICD-10) procedure codes relating to pelvic osteotomies were queried in the PHIS database and only patients with relevant ICD-10 diagnosis codes to pelvic osteotomies were included [5]. A readmission was defined as a distinct hospital admission from that of the index surgery with any ICD-10 diagnosis code within the specified date range. All reoperations were included within 2 years, including those within the index admission time frame. Reasons for readmission and reoperation were determined through an analysis of ICD-10 diagnosis codes. The most common causes of readmission and reoperation were then categorized and stratified by population demographics including age, sex, race, ethnicity, length of stay and census region. Contralateral hip operations (osteotomies) were also recorded, but not calculated as a component of the 2-year reoperation rate.

Data analysis

Descriptive statistics were utilized to characterize the data. Readmission rates were calculated within 30 and 90 days of the index procedure. Ipsilateral reoperation rates were calculated within 2 years of the index procedure. Reasons for readmission and reoperation were aggregated and described. Comparisons were made between the cohort readmitted within 90 days versus the cohort without. Continuous variables were compared on univariate analyses utilizing two-tailed independent sample *t*-tests. Categorical variables were compared with Fisher's Exact test. Logistic regression was performed on the outcome of 90-day readmission on variables that were significant on univariate comparisons between the readmitted and non-readmitted groups. All statistical analyses were performed on STATA v16.1 (StataCorp; College Station, TX). The level of significance was set at alpha < 0.05.

RESULTS

In total, 1475 patients were included in this analysis. Our previous study [5] included an analysis of 1480 patients from the PHIS database; however, five patients were no longer in the database after hospital data resubmissions and were excluded from this study (Table I). The final cohort included 938 females (63.6%) and 537 males (36.4%). The average age at the time of index pelvic osteotomy was 14.4 ± 2.4 years (range, 10–18 years, inclusive). The average age of females was 14.7 ± 2.4 years (range, 10–18 years, inclusive) and the average age of males was 13.9 ± 2.3 years (range, 10–18 years, inclusive) ($P < 0.0001$).

Approximately 80 patients were readmitted within 30 days of index surgery (overall 30-day readmission rate of 5.4%). Of the 80 readmissions within 30 days of index surgery, 76 were readmitted via an elective pathway (95%), three were readmitted via an urgent pathway (3.75%), and one did not have available information (1.25%). Thus, the vast majority of 30-day readmissions were categorized as elective. Reasons for 30-day readmission are detailed and categorized in Table II. The most common diagnosis codes for 30-day readmission included codes relating

Table II. Five most common reasons for 30-day readmission following pelvic osteotomy. Individual ICD-10 codes are detailed below the broader categories in which they have been sorted. The remaining 37 patients had miscellaneous, less frequent diagnoses and are not listed in this table

Reasons for readmission	*Readmitted patients (N = 80)*
Infection	15 (18.75%)
Infection following a procedure, initial encounter (T81.4XXA)	5 (6.25%)
Infection following a procedure, deep incisional surgical site, initial encounter (T81.42XA)	2 (2.5%)
Sepsis, unspecified organism (A41.9)	2 (2.5%)
Bacteremia (R78.81)	1 (1.25%)
Infection following a procedure, other surgical sites, initial encounter (T81.49XA)	1 (1.25%)
Infection following a procedure, superficial incisional surgical site, initial encounter (T81.41XA)	1 (1.25%)
Methicillin-resistant Staphylococcus aureus infection as the cause of diseases classified elsewhere (B95.62)	1 (1.25%)
Sepsis due to enterococcus (A41.81)	1 (1.25%)
Viral infection, unspecified (B34.9)	1 (1.25%)
Hip-related Orthopedic Conditions	12 (15%)
Other specified congenital deformities of the hip (Q65.89)	6 (7.5%)
Other articular cartilage disorders, right hip (M24.151)	2 (2.5%)
Congenital dislocation of right hip, unilateral (Q65.01)	1 (1.25%)
Displaced fracture of posterior wall of right acetabulum, initial encounter for closed fracture (S32.421A)	1 (1.25%)
Unspecified dislocation of left hip, sequela (S73.005S)	1 (1.25%)
Unspecified slipped upper femoral epiphysis (nontraumatic), right hip (M93.001)	1 (1.25%)
Neurologic Conditions	6 (7.5%)
Other encephalitis and encephalomyelitis (G04.81)	1 (1.25%)
Dystonia, unspecified (G24.9)	1 (1.25%)
Epilepsy, unspecified, intractable, with status epilepticus (G40.911)	1 (1.25%)
Epilepsy, unspecified, intractable, without status epilepticus (G40.919)	1 (1.25%)
Epilepsy, unspecified, not intractable, without status epilepticus (G40.909)	1 (1.25%)
Lennox-Gastaut syndrome, intractable, without status epilepticus (G40.814)	1 (1.25%)
Fever	5 (6.25%)
Fever, unspecified (R50.9)	5 (6.25%)
Bleeding Event	5 (6.25%)
Acute posthemorrhagic anemia (D62)	1 (1.25%)
Gastrointestinal hemorrhage, unspecified (K92.2)	1 (1.25%)
Postprocedural hematoma of a musculoskeletal structure following other procedures (M96.841)	1 (1.25%)
Postprocedural hematoma of a musculoskeletal structure following a musculoskeletal system procedure (M96.840)	1 (1.25%)
Postprocedural hemorrhage of a musculoskeletal structure following a musculoskeletal system procedure (M96.830)	1 (1.25%)

to infection (15 patients, 18.8% of 30-day readmissions), hip-related orthopedic conditions (12 patients, 15% of 30-day readmissions), neurologic conditions (six patients, 7.5% of 30-day readmissions), fever (five patients, 6.3% of 30-day readmissions) and bleeding events (five patients, 6.3% of 30-day readmissions). Sub-categories and proportions with included diagnoses codes for each of the causes of 30-day readmission are included in Table II.

A total of 136 patients were readmitted within 90 days of index surgery (overall 90-day readmission rate of 9.2%). Of the 136 patients, 109 were readmitted once within 90 days and 27 were readmitted multiple times for a total of 172 readmissions for the full group. Of 172 total readmissions, 167 were readmitted via an elective pathway (97.1%), four were readmitted via an urgent pathway (2.3%), and one did not have available information (0.6%). Thus, the vast majority of 90-day readmissions also were categorized as elective. Reasons for 90-day readmission are categorized in Table III. The most common diagnosis codes for 90-day readmission included codes relating to infection (26 patients, 19.1% of 90-day readmissions), hip-related orthopedic conditions (24 patients, 17.7% of 90-day readmissions), neurologic conditions (17 patients, 12.5% of 90-day readmissions), pain (10 patients, 7.4% of 90-day readmissions), disruption of surgical wound or repair (nine patients, 6.6% of 90-day readmissions). Sub-categories and proportions with included diagnoses codes for each of the causes of 90-day readmission are included in Table III.

On univariate analyses, age was significantly younger in the group readmitted within 90 days versus those not readmitted (13.3 ± 2.3 years versus 14.5 ± 2.4 years, $P < 0.0001$). There was a higher proportion of males in the group readmitted within 90 days (52.2% versus 34.8%, $P < 0.0001$). In the logistic regression model incorporating age and sex as covariates, age had an OR of 0.83 (95% CI: 0.76, 0.89; $P < 0.0001$) on the outcome of 90-day readmission. The male sex had an OR of 1.77 (95% CI: 1.23–2.54; $P = 0.002$).

A total of 474 reoperations took place within 2 years of index surgery (overall 2-year reoperation rate of 32.1%). Reasons for

Table III. Most common categorized reasons for 90-day readmission following pelvic osteotomy. Individual ICD-10 codes are detailed below the broader categories in which they have been sorted. The remaining 50 patients had miscellaneous, less frequent diagnoses and are not listed in this table

Reasons for readmission	*Readmitted patients (N = 136)*
Infection	26 (19.11%)
Infection following a procedure, initial encounter (T81.4XXA)	10 (7.35%)
Infection following a procedure, deep incisional surgical site, initial encounter (T81.42XA)	3 (2.21%)
Infection following a procedure, superficial incisional surgical site, initial encounter (T81.41XA)	2 (1.47%)
Sepsis, unspecified organism (A41.9)	2 (1.47%)
Acute appendicitis with generalized peritonitis (K35.2)	1 (0.74%)
Bacteremia (R78.81)	1 (0.74%)
Infection following a procedure, other surgical sites, initial encounter (T81.49XA)	1 (0.74%)
Infection and inflammatory reaction due to internal fixation device of right femur, initial encounter (T84.620A)	1 (0.74%)
Methicillin-resistant Staphylococcus aureus infection as the cause of diseases classified elsewhere (B95.62)	1 (0.74%)
Pneumonia, unspecified organism (J18.9)	1 (0.74%)
Sepsis due to Enterococcus (A41.81)	1 (0.74%)
Unspecified viral infection characterized by skin and mucous membrane lesions (B09)	1 (0.74%)
Viral infection, unspecified (B34.9)	1 (0.74%)
Hip-related Orthopedic Conditions	24 (17.65%)
Other specified congenital deformities of the hip (Q65.89)	15 (11.03%)
Congenital dislocation of right hip, unilateral (Q65.01)	2 (1.47%)
Other articular cartilage disorders, right hip (M24.151)	2 (1.47%)
Displaced fracture of posterior wall of right acetabulum, initial encounter for closed fracture (S32.421A)	1 (0.74%)
Other specified joint disorders, right hip (M25.851)	1 (0.74%)
Recurrent dislocation, right hip (M24.451)	1 (0.74%)
Unspecified dislocation of left hip, sequela (S73.005S)	1 (0.74%)
Unspecified slipped upper femoral epiphysis (nontraumatic), right hip (M93.001)	1 (0.74%)
Neurologic Conditions	17 (12.5%)
Dysphagia, unspecified (R13.10)	2 (1.47%)
Muscle weakness (generalized) (M62.81)	2 (1.47%)
Dysphagia, oral phase (R13.11)	1 (0.74%)
Dystonia, unspecified (G24.9)	1 (0.74%)
Epilepsy, unspecified, intractable, with status epilepticus (G40.911)	1 (0.74%)
Epilepsy, unspecified, intractable, without status epilepticus (G40.919)	1 (0.74%)
Epilepsy, unspecified, not intractable, without status epilepticus (G40.909)	1 (0.74%)
Hereditary spastic paraplegia (G11.4)	1 (0.74%)
Lennox-Gastaut syndrome, intractable, with status epilepticus (G40.813)	1 (0.74%)
Lennox-Gastaut syndrome, intractable, without status epilepticus (G40.814)	1 (0.74%)
Neuromuscular scoliosis, thoracolumbar region (M41.45)	1 (0.74%)
Other encephalitis and encephalomyelitis (G04.81)	1 (0.74%)
Other incomplete lesions at C7 level of cervical spinal cord, sequela (S14.157S)	1 (0.74%)
Other sequelae of cerebral infarction (I69.398)	1 (0.74%)
Spastic diplegic cerebral palsy (G8.01)	1 (0.74%)
Pain	10 (7.35%)
Other acute postprocedural pain (G89.18)	2 (1.47%)
Pain in right leg (M79.604)	2 (1.47%)
Pain in left lower leg (M79.662)	1 (0.74%)
Pain in right hip (M25.551)	1 (0.74%)
Pain in throat (R07.0)	1 (0.74%)
Pain in unspecified joint (M25.50)	1 (0.74%)
Pelvic and perineal pain (R10.2)	1 (0.74%)
Other chest pain (R07.89)	1 (0.74%)
Disruption of Surgical Wound or Repair	9 (6.62%)
Disruption of external operation (surgical) wound, not elsewhere classified, initial encounter (T81.31XA)	5 (3.68%)
Disruption of internal operation (surgical) wound, not elsewhere classified, initial encounter (T81.32XA)	3 (2.21%)
Breakdown (mechanical) of the internal fixation device of other bones, initial encounter (T84.218A)	1 (0.74%)

Table IV. Most common categorized reasons for 2-year reoperation following pelvic osteotomy

Reasons for reoperation	*Reoperated patients (N = 474)*
Hardware Removal	378 (79.75%)
Removal of Internal Fixation from Right Pelvic Bone, Open Approach (0QP.204Z)	115 (24.26%)
Removal of Internal Fixation from Left Pelvic Bone, Open Approach (0QP.304Z)	87 (18.35%)
Removal of Internal Fixation from Right Hip Joint, Open Approach (0SP.904Z)	37 (7.81%)
Removal of Internal Fixation from Left Hip Joint Device, Open Approach (0SP.B04Z)	35 (7.38%)
Removal of Internal Fixation Device from Right Upper Femur, Open Approach (0QP.604Z)	32 (6.75%)
Removal of Internal Fixation Device from Left Upper Femur, Open Approach (0QP.704Z)	27 (5.70%)
Removal of Internal Fixation Device from Right Acetabulum, Open Approach (0QP.404Z)	10 (2.11%)
Removal of Internal Fixation from L Acetabulum, Open Approach (0QP.504Z)	5 (1.05%)
Other Miscellaneous Codes	30 (6.33%)
Revision[a]	84 (17.72%)
Reposition Right Upper Femur with Internal Fixation Device, Open Approach (0QS.604Z)	15 (3.16%)
Reposition Left Upper Femur with Internal Fixation Device, Open Approach (0QS.704Z)	9 (1.90%)
Reposition Right Acetabulum with Internal Fixation Device, Open Approach (0QS.404Z)	7 (1.48%)
Division of Left Pelvic Bone, Open Approach (0Q8.30ZZ)	3 (0.63%)
Reposition Left Acetabulum with Internal Fixation Device, Open Approach (0QS.504Z)	3 (0.63%)
Reposition Right Upper Femur with Intramedullary Internal Fixation Device, Open Approach (0QS.606Z)	3 (0.63%)
Division of Left Upper Femur, Open Approach (0Q8.70ZZ)	2 (0.42%)
Division of Right Pelvic Bone, Open Approach (0Q8.20ZZ)	2 (0.42%)
Excision of Left Upper Femur, Open Approach (0QB.70ZZ)	2 (0.42%)
Excision of Right Pelvic Bone, Open Approach (0QB.20ZZ)	2 (0.42%)
Insertion of Internal Fixation Device into Left Upper Femur, Open Approach (0QH.704Z)	2 (0.42%)
Insertion of Internal Fixation Device into Right Pelvic Bone, Open Approach (0QH.204Z)	2 (0.42%)
Reposition Left Hip Joint, External Approach (0SS.BXZZ)	2 (0.42%)
Reposition Left Hip Joint with Internal Fixation Device, Open Approach (0SS.B04Z)	2 (0.42%)
Reposition Left Pelvic Bone with Internal Fixation Device, Open Approach (0QS.304Z)	2 (0.42%)
Reposition Right Hip Joint, External Approach (0SS.9XZZ)	2 (0.42%)
Division of Right Upper Femur, Open Approach (0Q8.60ZZ)	1 (0.21%)
Excision of Right Hip Joint, Open Approach (0SB.90ZZ)	1 (0.21%)
Excision of Right Upper Femur, Open Approach (0QB.60ZZ)	1 (0.21%)
Insertion of Internal Fixation Device into Left Acetabulum, Open Approach (0QH.504Z)	1 (0.21%)
Insertion of Internal Fixation Device into Left Pelvic Bone, Open Approach (0QH.304Z)	1 (0.21%)
Insertion of Internal Fixation into Right Upper Femur, Open Approach (0QH.604Z)	1 (0.21%)
Insertion of Spacer into Left Hip Joint, Open Approach (0SH.B08Z)	1 (0.21%)
Repair Left Hip Joint, Open Approach (0SQ.B0ZZ)	1 (0.21%)
Repair Right Hip Joint, Open Approach (0SQ.90ZZ)	1 (0.21%)
Reposition Left Femur Shaft with Intramedullary Fixation Device, Open Approach (0QS.906Z)	1 (0.21%)
Reposition Left Lower Femur with Internal Fixation Device, Open Approach (0QS.C04Z)	1 (0.21%)
Reposition Left Pelvic Bone, Open Approach (0QS.30ZZ)	1 (0.21%)
Reposition Left Upper Femur with Intramedullary Internal Fixation Device, Open Approach (0QS.706Z)	1 (0.21%)
Reposition Right Femoral Shaft, External Approach (0QS.8XZZ)	1 (0.21%)
Reposition Right Femur Shaft with Intramedullary Internal Fixation Device, Open Approach (0QS.806Z)	1 (0.21%)
Reposition Right Hip Joint with Internal Fixation Device, Open Approach (0SS.904Z)	1 (0.21%)
Reposition Right Hip Joint, Open Approach (0SS.90ZZ)	1 (0.21%)
Reposition Right Lower Femur with Internal Fixation Device, Open Approach (0QS.B04Z)	1 (0.21%)
Reposition Right Sacroiliac Joint with Internal Fixation Device, Open Approach (0SS.704Z)	1 (0.21%)
Reposition Right Upper Femur with Intramedullary Internal Fixation Device, Percutaneous Approach (0QS.636Z)	1 (0.21%)
Reposition Right Upper Femur, Open Approach (0QS.60ZZ)	1 (0.21%)
Revision of Internal Fixation Device in Left Pelvic Bone, Open Approach (0QW.304Z)	1 (0.21%)
Revision of Internal Fixation in Left Upper Femur, Open Approach (0QW.704Z)	1 (0.21%)
Revision of Internal Fixation Device in Right Pelvic Bone, Open Approach (0QW.204Z)	1 (0.21%)
Incision and Drainage	6 (1.27%)
Drainage of Left Hip Joint, Percutaneous Approach, Diagnostic (0S9.B3ZX)	2 (0.42%)
Drainage of Left Upper Leg Subcutaneous Tissue and Fascia, Open Approach, Diagnostic (0J9.M0ZX)	1 (0.21%)

(continued)

Table IV. (Continued)

Reasons for reoperation	*Reoperated patients (N = 474)*
Drainage of Right Femoral Region with Drainage Device, Open Approach (0Y9.700Z)	1 (0.21%)
Drainage of Right Hip Joint with Drainage Device, Open Approach (0S9.900Z)	1 (0.21%)
Drainage of Right Upper Leg Subcutaneous Tissue and Fascia, Open Approach (0J9.L0ZZ)	1 (0.21%)
Hip Replacement	6 (1.27%)
Replace Left Hip Joint with Ceramic on Polyethylene Synthetic Substitute, Uncemented, Open Approach (0SR.B04A)	4 (0.84%)
Replacement of Left Hip Joint with Metal Synthetic Substitute, Uncemented, Open Approach (0SR.B01A)	1 (0.21%)
Replacement of Right Acetabulum with Nonautologous Tissue Substitute, Open Approach (0QR,40KZ)	1 (0.21%)

Source: [a]For revisions, codes listed exclude concomitant hardware removal codes.

2-year reoperation are categorized in Table IV. Of the 474 reoperations, 378 reoperations were performed to remove hardware from previous surgeries (79.8% of reoperations), 84 reoperations were performed to revise previous surgeries (17.7% of reoperations), six reoperations were performed for incision and drainage (1.3% of reoperations), and six reoperations were performed for hip replacement surgeries (1.3% of reoperations).

211 osteotomy operations took place on the contralateral hip to the index surgery (14.3% of all patients within 2 years of the index surgery.).

DISCUSSION

This study characterizes readmission and reoperation rates following pelvic osteotomy in adolescent patients aged 10–18 years. The 30-day rate of readmission after pelvic osteotomy was 5.4% and the 90-day rate of readmission was 9.2%. The 2-year rate of ipsilateral reoperation was 32.1%. Reasons for readmission were heterogeneous, while the main reason for ipsilateral reoperation was hardware removal (>79%). Other reasons for ipsilateral reoperation included revision (17.7%) and hip replacement (1.3%). Approximately 14.3% of all patients in our cohort also had a pelvic osteotomy performed on the contralateral hip within 2 years from index surgery.

Rates of hospital readmission following adolescent pelvic osteotomy have not been well-studied and literature surrounding this topic is sparse. Additionally, the risk factors for increased perioperative morbidity following these procedures remain poorly understood, requiring a further evaluation to better understand how to minimize risks for future patients [7]. Previous studies have shown that certain individual patient characteristics, such as pediatric obesity, may increase short-term readmission and complication risks [7, 8]. In these patients, potential complications leading to readmission included pulmonary embolism, infection and wound hematoma [9]. Our study aimed to investigate the short-term and mid-term reasons for readmission following pelvic osteotomy in the adolescent population. Reasons for 30-day and 90-day readmission were varied with the most common reasons being those related to infection or hip-specific orthopedic conditions. Of the hip-related orthopedic conditions requiring readmission, the most common ICD-10 diagnosis codes included those involving congenital deformities of the hip, articular cartilage disorders and congenital dislocation of the hip. Due to the limitations of the database, it is not possible to further characterize these reasons, but they are related to the underlying diagnosis and may be related to persistent pain.

Of note, our study found that younger age and male sex were predictors of readmission within 90 days. Currently, there is minimal literature investigating the demographic predictors of readmission following pelvic osteotomies in the pediatric and adolescent population. In the adult population, demographic predictors of readmission following other types of hip surgery, such as total hip arthroplasty and hip arthroscopy, include older age, increased BMI, and medical comorbidities [10–12]. However, such results cannot be extracted to a younger and generally more healthy population, although obesity has been noted as an independent risk factor (relative risk 2.3, $P = 0.032$) for 30-day readmission after pelvic osteotomy [7]. More research needs to be done to support the demographic predictors of our study's population. We identified that nearly all readmissions were categorized as elective, which makes planned staged procedures a possibility. We are unable to formally discern which procedures were anticipated or not, but the authors presume at least non-routine diagnosis codes such as those for infection were unplanned. Prior data on staged bilateral hip reconstructions in a non-ambulatory population of patients with cerebral palsy suggests that staging surgeries are associated with a higher rate of major complications, unplanned readmissions and reoperations [13].

The presence of hip-related orthopedic conditions requiring readmission raises the question of the long-term outcomes and success of these surgeries and the potential need for reoperation. Previous studies have shown that patients with pelvic osteotomies often undergo hip surgery again, whether another pelvic osteotomy, hip arthroplasty or another procedure, later in life [14–16]. Sohatee et. al found that 9.47% of hips in their systemic review were converted to total hip arthroplasty (THA) in a mean conversion time of 24.42 months after hip arthroscopy and 70.11 months after PAO, while Lerch et. al found that 56% of hips in their cohort were converted to total hip arthroplasty after a mean follow-up of 16 years [16, 17]. Other studies showed that arthroscopy is also common after PAO, with two studies finding that 11% of patients received a hip arthroscopy after PAO [18, 19]. Reasons for these additional procedures include chondral lesions such as chondrolysis, labral lesions, secondary femoroacetabular impingement, among others [20–22]. Additionally, patients frequently undergo an additional procedure following pelvic osteotomy to remove hardware, with one study finding an incidence of 13.6% of patients within the cohort undergoing a hardware removal procedure [23]. However, a majority of the literature on reoperation rates and reasons for reoperation focuses on the adult population. A recent study by Beck et. al analyzed 47 articles, with a total of 5871 adult patients undergoing reoperation after PAO, rotational acetabular osteotomy (RAO) or eccentric rotational acetabular osteotomy (ERAO). Reoperations were defined as either revision osteotomy or conversion to total hip arthroplasty. The authors found a combined reoperation rate of 2.5%, with reoperation rates for PAO, RAO and ERAO being 1.1%, 5.1% and 4.1%, respectively in the adult population [24]. In our study of adolescent patients over 2 years, 474 reoperations took place within 2 years of index surgery, giving a reoperation rate higher than that in adult literature of 32.1%, which may be because we followed patients over a longer timeframe. The majority of these reoperations (79.8%) were performed to remove hardware. Reasons for hardware removal could not be further delineated. In our younger cohort of patients, arthroplasty or other major procedures are not as common, which potentially underscores the success of these procedures in adolescents despite a higher rate of reoperation.

While not included in our calculation of the reoperation rate, a substantial number of patients underwent pelvic osteotomy on the contralateral hip within 2 years of their index surgery. There is minimal literature investigating the incidence of contralateral pelvic osteotomy after a prior pelvic osteotomy in adolescents; however, there have been concerns about the progressive deterioration of the contralateral hip following prior unilateral pelvic osteotomy, including accelerated subluxation and dislocation [25]. This has raised the debate of whether or not to perform bilateral pelvic osteotomies instead of unilateral pelvic osteotomies to avoid future complications with the contralateral hip [26–28]. In our study, 14.3% of all patients underwent a contralateral pelvic osteotomy within 2 years of the index procedure, indicating the association of either bilateral disease or associated contralateral deterioration.

Limitations

Several limitations exist in the present study. First, this study evaluated and analyzed a large retrospective database; therefore, only correlations may be derived from the data and statements about causation cannot be confidently made. Further, as with any large database, the PHIS is inherently subject to coding errors and inaccurate reporting; however, we used a consistent research methodology with the up-to-date procedure and diagnosis codes to increase the accuracy of the cohort of patients we generated. Although we used the latest version of the ICD-10 procedure and diagnosis codes, we were unable to distinguish the different types of pelvic osteotomies performed based on the codes alone. Moreover, we were unable to consistently identify underlying diagnoses, such as cerebral palsy, which may inevitably be linked to the need for readmission or reoperation. Additionally, our readmission and reoperation rates likely underestimate the true incidence of readmission and reoperation in the study population, as patients who were seen at other institutions for such occurrences following their index procedure may not have been included. While we looked at reoperations following index surgery and characterized the proportion that was coded as 'elective', we were unable to discern whether any of these were part of planned staged surgeries (such as hip arthroscopy after PAO). Furthermore, despite the use of a large database, the sample size for this study is small. We are also unable to ascertain the reasons for revision surgeries. These limitations underscore the need for large, prospective databases or multi-center studies including radiographic analyses to guide additional research to better understand the readmission and reoperation risks following adolescent pelvic osteotomy.

CONCLUSION

The rates of 30-day readmission, 90-day readmission and 2-year reoperation after pelvic osteotomy in adolescent patients were 5.4%, 9.2% and 32.1%, respectively. Younger age and male sex were predictive of 90-day readmission. The majority of ipsilateral reoperations were for hardware removal. Understanding risks for readmission and reoperation after pelvic osteotomy can benefit patient counseling and set appropriate patient expectations.

DATA AVAILABILITY

The data underlying this article are available in the article and its online supplemental material.

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CONFLICT OF INTEREST STATEMENT

None declared.

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