Plastic Surgery Involvement in Pediatric Upper and Lower Extremity Oncologic Reconstruction: Patterns and Outcomes from the National Surgical Quality Improvement Program (2012–2023)

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INTRODUCTION

Sarcomas account for 7% of pediatric malignancies, with a significant proportion arising in the extremities.[1] Bone tumors are substantially more common, typically benign, but frequently require surgical excision. Over four decades, management has evolved **from routine amputation toward limb-sparing oncologic resection** with immediate or staged reconstruction.[2-6]

Multidisciplinary orthoplastic collaboration is necessary to achieve adequate margins, durable soft-tissue coverage, preserved growth potential, and optimized function in the developing child.[7-9]

National-level data on reconstruction frequency, case selection, and short-term outcomes across the full spectrum of pediatric limb-salvage surgery remain limited. Prior work by Kim et al. (2025) focused on higher-acuity cases requiring amputation or microsurgery — leaving **population-level benchmarks undefined**.[10]

OBJECTIVES

1) Quantify the **national frequency of immediate soft-tissue reconstruction** following pediatric extremity oncologic excision in limb-salvage cases.
2) Evaluate how **anatomic location and excision complexity** are associated with reconstruction utilization
3) Identify **independent predictors of 30-day postoperative complications**

METHODS

Data Source

- **ACS NSQIP-Pediatric, 2012–2023** — nationally validated, risk-adjusted outcomes registry; 30-day postoperative outcomes from **150+ participating hospitals**.[11] De-identified data; IRB approval not required.

Patient Selection

- Pediatric patients undergoing **oncologic excision of UE or LE tumors** identified by CPT code. **Amputations excluded** to isolate limb-salvage cases. CPT codes captured soft-tissue excisions by size and depth, and bone tumor excisions **across all anatomic levels** (shoulder girdle through tarsal/metatarsal), including benign bone lesions underrepresented in prior analyses.

Reconstruction & Outcomes

- Cases with **concurrent reconstructive CPT codes** = immediate soft-tissue reconstruction. Techniques categorized as: muscle flaps, free flaps, local flaps, regional flaps, STSG, FTSG, complex closure. **Primary outcome:** 30-day wound complications and overall morbidity.

Statistical Analysis

- Chi-square / Fisher's exact tests; **multivariable logistic regression** for predictors of reconstruction and complications. Results as **OR (95% CI)**. R v4.3.2; α = 0.05.

RESULTS

Patient Demographics and Tumor Characteristics

- Between 2012–2023, **4,500 pediatric patients** were identified (LE: 4,295; UE: 205). Mean age 12.4 ± 3.7 years; 57.6% male. **Bone tumors comprised 94.8%** of cases; **87.7% underwent simple excisions**, reflecting the predominance of benign bone lesions in pediatric practice.

Reconstruction Patterns

- Overall, **159/4,500 cases (3.5%) underwent immediate reconstruction**, with UE rates nearly 4× higher than LE (12.2% vs. 3.1%; p<0.001). Reconstruction rates rose sharply with excision complexity — from **0.3% for simple excisions to 36.7% for deep excisions**. Rates also varied substantially by anatomic site, with distal and periarticular locations carrying the highest burden.

Table 1. Reconstruction Rates by Anatomic Site and Excision Type

Characteristic	Total N	Recon n	Rate (%)
Overall	**4,500**	**159**	**3.5**
By Extremity			
Lower Extremity	4,295	134	3.1
Upper Extremity	205	25	12.2
Lower Extremity Sites			
Foot	87	20	23.0
Pelvis/Hip	318	50	15.7
Leg/Ankle	2,104	47	2.2
Thigh/Knee	1,786	17	1.0
Upper Extremity Sites			
Shoulder	68	12	17.6
Upper Arm/Elbow	44	5	11.4
Forearm/Wrist	93	8	8.6
By Excision Type (LE)			
Deep	60	22	36.7
Radical	377	95	25.2
Small	31	7	22.6
Medium	36	7	19.4
Simple	3,791	12	0.3

Technique Patterns

- Among 159 reconstructed cases, **muscle flaps were dominant (52.8%)**. **Proximal sites** favored muscle flaps (pelvis/hip 78.0%; shoulder 58.3%); **distal sites** relied on skin grafts and local flaps (foot: 60.0% FTSG; forearm/wrist: 37.5% local flaps).[12,13] Reconstructed cases had significantly longer **operative time (351.8 ± 209.9 vs. 100.1 ± 118.2 min; p<0.001)** and **LOS (8.3 ± 6.5 vs. 2.9 ± 4.4 days; p<0.001)**.

Complications

- Overall complication rate: **27.7% reconstructed vs. 2.4% non-reconstructed (p<0.001)**. Rates varied markedly by technique — muscle flaps carrying the highest burden; local flaps and FTSG comparable to no reconstruction.[14,15]

Table 2. 30-Day Complications by Reconstruction Type

Reconstruction Type	n	Overall (%)	SSI (%)	Deep Infxn (%)	Dehiscence (%)	Reop (%)
No Reconstruction	4,341	2.4	0.5	0.3	0.4	1.2
Any Reconstruction	**159**	**27.7***	**5.0***	**2.5***	**1.9***	**6.3***
Muscle Flaps	**83**	**51.8***	**5.2***	**2.6***	**2.6***	**8.5***
STSG	**14**	**42.9***	**14.3***	0.0	0.0	7.1
Free Flaps	**16**	**18.8***	3.1	1.6	0.0	5.3
Local Flaps	14	7.1	0.0	0.0	0.0	2.4
FTSG	14	7.1	0.0	0.0	0.0	2.4
Regional Flaps	1	0.0	0.0	0.0	0.0	0.0

* p<0.05 vs. No Reconstruction (Fisher's exact). Highlighted rows indicate statistically significant overall complication rates. Subtype-specific denominators reflect patients with complete 30-day outcome data. SSI = surgical site infection; FTSG = full-thickness skin graft; STSG = split-thickness skin graft.

Multivariable Analysis

- In LE multivariable analysis, **excision complexity was the dominant predictor of reconstruction** (radical/deep excision OR 93.05, 95% CI 48.80–177.39; p<0.001).[12,13] **Immediate reconstruction** (OR 3.48, 95% CI 1.56–7.75; p=0.002) and **ASA III–IV** (OR 2.17, 95% CI 1.18–3.98; p=0.013) were the only independent predictors of 30-day complications. Age, sex, tissue type, and proximal location were not significant after adjustment.

Table 3. Multivariable Predictors of Reconstruction and 30-Day Complications (LE Cohort, n = 4,295)

Predictor	OR (95% CI)	p-value
Panel A: Predictors of Immediate Reconstruction		
Radical/Deep Excision vs. Other	**93.05 (48.80–177.39)**	**<0.001**
Proximal vs. Distal Location	**0.15 (0.09–0.25)**	**<0.001**
ASA Class III–IV	**2.22 (1.37–3.61)**	**0.001**
Soft-Tissue vs. Bone Tumor	1.47 (0.85–2.54)	0.164
Panel B: Predictors of 30-Day Complications		
Immediate Reconstruction	**3.48 (1.56–7.75)**	**0.002**
ASA Class III–IV	**2.17 (1.18–3.98)**	**0.013**
Excision Type (Radical vs. Deep)	0.85 (0.40–1.79)	0.661
Proximal Location	1.12 (0.74–1.70)	0.585
Soft-Tissue vs. Bone Tumor	1.17 (0.51–2.68)	0.716

CONCLUSIONS

- Immediate reconstruction is utilized in **only 3.5% of pediatric limb-salvage extremity tumor cases** — markedly lower than prior reports[10], reflecting both the inclusion of benign bone lesions and the registry's inability to capture delayed/staged reconstructions.
- **Excision complexity — not tumor histology — is the dominant driver** of reconstructive need; deep or radical excision was the dominant predictor of reconstruction (OR 93.05).[12,13]
- Tumor histology was not independently associated with reconstruction after adjustment.
- **These findings support early preoperative orthoplastic consultation** when deep or radical excision is anticipated.[8,9]
- **Anatomy shapes technique**: proximal sites favor muscle flaps; the **foot carries the highest reconstruction rate (23.0%)** despite its distal location, driven by limited soft-tissue envelope.[16,17]
- Expandable endoprostheses and vascularized fibula transfers address the **unique growth and physeal considerations** of pediatric limb-salvage — reconstruction planning must account for longitudinal growth, not just immediate defect coverage.[18]
- Reconstructed cases show **significantly higher 30-day morbidity** (27.7% vs. 2.4%); immediate reconstruction remains an independent complication predictor (OR 3.48), likely reflecting unmeasured underlying case/defect complexity rather than the reconstruction itself.[14,15]
- These findings provide **national benchmark data** for case selection, perioperative counseling, and institutional resource planning in pediatric limb-salvage surgery.[19]

LIMITATIONS

30-day outcomes only; no radiation/chemotherapy history; CPT codes are proxies for defect size; staged reconstruction not captured; multidisciplinary composition not tracked in NSQIP-Pediatric.[15]

REFERENCES

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