Custom 3D-Printed Pelvic Reconstruction Versus No Implant Reconstruction Following Oncologic Periacetabular Resection: A Multi-Institutional Comparative Outcomes Study

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Significance & Hypothesis/Techniques

Periacetabular tumor resection remains among the most morbid procedures in musculoskeletal oncology, and reconstruction after internal hemipelvectomy remains controversial. Early pelvic implants were associated with high complication rates, leading many surgeons to favor no implant reconstruction. However, patient-specific 3D-printed implants have renewed interest in reconstruction, while modern comparative multi-institutional data remain limited. The goal of this study was to determine whether custom 3D-printed pelvic reconstruction improves perioperative recovery and function without increasing complications or compromising oncologic outcomes compared with no implant reconstruction.

Innovation

This study evaluates pelvic reconstruction in the modern era of patient-specific 3D-printed implants using a multi-institutional comparative design. It directly compares no implant reconstruction with custom 3D reconstruction and incorporates clinically relevant recovery outcomes including discharge disposition, weightbearing status, implant retention, and early oncologic outcomes.

Approach (Materials & Methods)

We performed a retrospective multi-institutional review of patients undergoing oncologic periacetabular (Type II) pelvic resection at 6 high-volume musculoskeletal oncology centers from 2010–2024. Patients were stratified by reconstruction strategy: no implant reconstruction (n=62) or custom 3D-printed pelvic implant reconstruction (n=58). Demographics, tumor characteristics, perioperative variables, discharge disposition, complications, ambulatory status, and oncologic outcomes were compared between groups. Continuous variables were analyzed with parametric or nonparametric testing as appropriate, and categorical variables were compared using chi-square or Fisher's exact testing.

Results
Baseline demographics were similar between cohorts. Median follow-up was 59 months (IQR 27.6–123.3 months) for no implant reconstruction and 25.2 months (IQR 17.6–55.2 months) for custom implant reconstruction ($p<0.001$). Primary sarcoma accounted for a greater proportion of no implant cases compared with custom reconstruction (95% vs 83%, $p = 0.011$). Primary tumor size was larger in the no implant cohort (10.7 vs 8.8 cm, $p = 0.023$), while other tumor-related characteristics were comparable.

Patients undergoing custom implant reconstruction were more frequently discharged directly home compared with those undergoing no implant reconstruction (38% vs 16%, $p = 0.003$). Estimated blood loss was higher in the no implant group (3200 vs 2000 mL, $p = 0.019$). Mean hospital length of stay did not differ significantly between no implant and custom implant reconstruction (19.3 vs 23.3 days, $p = 0.54$).

All-cause reoperation (74% for custom implant and 61% for no implant cases, $p=0.17$) and 90-day complication rates (58% for custom implant and 50% for no implant cases, $p=0.57$) did not differ between groups. Rate of deep infection did not differ between no implant and custom implant groups (26% vs 29%, $p=0.69$).

There was a trend toward improved ability to weight bear as tolerated among patients undergoing custom reconstruction at final follow-up ($p = 0.07$), although ambulatory status and need for gait aids were otherwise similar between cohorts. At final follow-up, 84% of patients retained their custom implant prosthesis. Oncologic status at final follow-up did not differ between groups.

Discussion & Impact
In this large multi-institutional cohort, custom 3D-printed pelvic reconstruction following oncologic periacetabular resection was associated with improved discharge disposition without increased hospital stay, complications, or adverse oncologic outcomes compared with no implant reconstruction. These findings suggest that modern patient-specific pelvic implants may support earlier postoperative recovery in selected patients, while highlighting the need to interpret results in the setting of reconstruction-specific failure modes and inherent selection bias.

Table 1. Patient demographics and surgical characteristics comparing no implant reconstruction and 3D custom endoprosthetic reconstruction for pelvic tumors.

Variable	No Implant (n = 62)	3D Custom (n = 58)	*p*-value
	n (%) or Mean ± SD	*n (%) or Mean ± SD*	
Sex[a]			0.86
Male	37 (59.7)	31 (53.4)	
Female	25 (40.3)	26 (44.8)	
Age, years[b]	49.2 ± 18.0	51.0 ± 17.2	0.55
BMI, kg/m^2[b]	27.6 ± 6.6	29.5 ± 6.9	0.13
Tobacco use[c]			**0.01**
Current	12 (19.4)	7 (12.1)	
Former	20 (32.3)	12 (20.7)	
Never	30 (48.4)	39 (67.2)	
Diagnosis[c]			**0.01**
Primary bone sarcoma	54 (87.1)	47 (81.0)	
Primary soft tissue sarcoma with bony involvement	5 (8.1)	1 (1.7)	
Metastatic disease	1 (1.6)	9 (15.5)	
Other	2 (3.2)	1 (1.7)	
Primary tumor size (largest dimension), cm[b]	10.7 ± 5.5	8.8 ± 3.1	**0.02**
Primary tumor volume, cm^3[b]	937.9 ± 1093.0	470.4 ± 683.0	**0.01**
Metastatic disease at time of surgery[a]			1.00
Yes	13 (21.0)	12 (20.7)	
No	49 (79.0)	46 (79.3)	
Neoadjuvant systemic chemotherapy[a]			0.71
Yes	26 (41.9)	22 (37.9)	
No	36 (58.1)	36 (62.1)	
Adjuvant systemic chemotherapy[a]			0.70
Yes	21 (33.9)	17 (29.3)	
No	41 (66.1)	41 (70.7)	
Neoadjuvant pelvic radiation[a]			0.59
Yes	9 (14.5)	6 (10.3)	
No	53 (85.5)	52 (89.7)	
Adjuvant pelvic radiation[a]			0.41
Yes	19 (30.6)	13 (22.4)	
No	43 (69.4)	45 (77.6)	
ASA classification[b]	2.7 ± 0.6	2.7 ± 0.5	0.70
Number of surgical stages[a]			0.31
1 Stage	59 (95.2)	52 (89.7)	

2 Stage	3 (4.8)	6 (10.3)	
Stage 1 operative duration, minutes[b]	484.0 ± 206.0	545.0 ± 149.0	0.07
Stage 1 estimated blood loss, mL[b]	3172.0 ± 3376.0	1998.0 ± 1679.0	**0.02**
Cumulative orthopaedic oncology surgeons[b]	1.5 ± 0.6	1.8 ± 0.9	**0.04**
Multidisciplinary surgical team involvement			
Surgical oncology/general surgery[a]			0.10
Yes	21 (33.9)	11 (19.0)	
No	41 (66.1)	47 (81.0)	
Plastic surgery[a]			0.67
Yes	17 (27.4)	13 (22.4)	
No	45 (72.6)	45 (77.6)	
Urology[a]			0.16
Yes	22 (35.5)	13 (22.4)	
No	40 (64.5)	45 (77.6)	
Vascular surgery[a]			0.78
Yes	8 (12.9)	6 (10.3)	
No	54 (87.1)	52 (89.7)	
Other surgical specialty[a]			1.00
Yes	2 (3.2)	1 (1.7)	
No	60 (96.8)	57 (98.3)	
Navigation used[a]			**<0.0001**
Yes	21 (33.9)	54 (93.1)	
No	37 (59.7)	4 (6.9)	

Abbreviations: SD, standard deviation; BMI, body mass index; ASA, American Society of Anesthesiologists; EBL, estimated blood loss.

Bold *p*-values indicate statistical significance ($p < 0.05$).

[a] Fisher's exact test.

[b] Mann–Whitney U test.

[c] Chi-square test.

Table 2. Clinical outcomes comparing no implant reconstruction and 3D custom endoprosthetic reconstruction for pelvic tumors.

Variable	**No Implant (n = 62)**	**3D Custom (n = 58)**	***p*-value**
	n (%) or Mean ± SD	*n (%) or Mean ± SD*	
Length of hospital stay, days[a]	19.3 ± 16.4	23.3 ± 47.0	0.54
Discharge location[b]			**0.003**

Home	10 (16.1)	22 (37.9)	
Rehab	33 (53.2)	30 (51.7)	
SNF	13 (21.0)	6 (10.3)	
Other	6 (9.7)	0 (0.0)	
Unplanned readmission within 90 days[c]			0.85
Yes	23 (37.1)	23 (39.7)	
No	37 (59.7)	34 (58.6)	
All-cause reoperation[c]			0.17
Yes	38 (61.3)	43 (74.1)	
No	24 (38.7)	15 (25.9)	
Time to first reoperation, days[a]	266.0 ± 629.0	254.0 ± 402.0	0.92
Indication for first reoperation[b]			**0.02**
Deep periprosthetic infection	8 (12.9)	9 (15.5)	
Superficial wound infection	9 (14.5)	7 (12.1)	
Aseptic wound dehiscence/issue	11 (17.7)	7 (12.1)	
Tumor recurrence or progression	4 (6.5)	4 (6.9)	
Prosthetic dislocation/instability	0 (0.0)	9 (15.5)	
Mechanical implant failure	0 (0.0)	3 (5.2)	
Aseptic loosening	0 (0.0)	3 (5.2)	
Other	8 (12.9)	4 (6.9)	
Type 1 failure: soft tissue[c]			0.25
Yes	17 (27.4)	22 (37.9)	
No	45 (72.6)	36 (62.1)	
Time to Type 1 failure, days[a]	108.0 ± 160.0	67.0 ± 121.0	0.72
Type 1 required surgery[c]			0.20
Yes	16 (94.1)	16 (72.7)	
No	1 (5.9)	5 (22.7)	
Type 2 failure: aseptic loosening[d]			—
Yes	0 (0.0)	9 (15.5)	
No	62 (100.0)	49 (84.5)	
Time to Type 2 failure, days[d]	—	605.0 ± 318.0	—
Type 3 failure: structural[c]			**<0.001**
Yes	1 (1.6)	12 (20.7)	
No	61 (98.4)	46 (79.3)	
Time to Type 3 failure, days[d]	99.0 ± NaN	302.0 ± 258.0	—
Type 3 required surgery[c]			0.47
Yes	1 (100.0)	6 (50.0)	
No	0 (0.0)	6 (50.0)	
Type 4 failure: deep infection[c]			0.69
Yes	16 (25.8)	17 (29.3)	
No	46 (74.2)	41 (70.7)	

Time to Type 4 failure, days[a]	133.0 ± 223.0	350.0 ± 472.0	0.05
Type 4 required surgery[c]			1.00
Yes	15 (93.8)	16 (94.1)	
No	1 (6.3)	1 (5.9)	
Type 5 failure: tumor recurrence[c]			0.69
Yes	16 (25.8)	17 (29.3)	
No	45 (72.6)	40 (69.0)	
Time to Type 5 failure, days[a]	387.0 ± 371.0	513.0 ± 362.0	0.13
Type 5 required surgery[c]			0.30
Yes	5 (31.3)	9 (52.9)	
No	11 (68.8)	8 (47.1)	
Length of follow-up, days[a]	1475.0 ± 1742.0	891.0 ± 684.0	0.98
Post-operative nerve injury[c]			1.00
Yes	15 (24.2)	14 (24.1)	
No	47 (75.8)	44 (75.9)	
Implant removed for any reason[d]			—
Yes	—	9 (15.5)	
No	—	49 (84.5)	
Weightbearing status at final follow-up[b]			0.30
NWB	14 (22.6)	8 (13.8)	
PWB	6 (9.7)	4 (6.9)	
TDWB	5 (8.1)	2 (3.4)	
WBAT	37 (59.7)	44 (75.9)	
WBAT at final follow-up[c]			0.08
Yes	37 (59.7)	44 (75.9)	
No	25 (40.3)	14 (24.1)	
Mobility aid used at final follow-up[c]			1.00
Yes	41 (66.1)	38 (65.5)	
No	21 (33.9)	20 (34.5)	
Type of mobility aid used[b]			0.58
Cane	6 (14.6)	9 (23.7)	
Crutches	5 (12.2)	1 (2.6)	
Walker/rollator	11 (26.8)	13 (34.2)	
Predominant/fulltime wheelchair	6 (14.6)	6 (15.8)	
Some wheelchair	11 (26.8)	8 (21.1)	
Other	1 (2.4)	1 (2.6)	
Developed new metastatic disease[c]			0.85
Yes	22 (35.5)	19 (32.8)	
No	40 (64.5)	39 (67.2)	
Disease status at final follow-up[b]			0.17
ANED	23 (37.1)	30 (51.7)	

AWED	15 (24.2)	7 (12.1)
Dead (other cause)	2 (3.2)	4 (6.9)
DOD	22 (35.5)	17 (29.3)

Abbreviations: SD, standard deviation; SNF, skilled nursing facility; NWB, non-weightbearing; PWB, partial weightbearing; TDWB, touch-down weightbearing; WBAT, weightbearing as tolerated; ANED, alive no evidence of disease; AWED, alive with evidence of disease; DOD, dead of disease.

Bold *p*-values indicate statistical significance ($p < 0.05$).

[a] Mann–Whitney U test.

[b] Chi-square test.

[c] Fisher's exact test.

[d] Not applicable; comparison not performed (events in one group only or insufficient data).