

Reconstructive options in pelvic tumours

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Background: Pelvic tumours present a complex problem. It is difficult to choose between limb salvage and hemipelvectomy.

Method: Forty three patients of tumours of pelvis underwent limb salvage resection with reconstruction in 32 patients. The majority were chondrosarcomas (20 cases) followed by Ewing sarcoma. Stage II B was the most common stage in malignant lesions and all the seven benign lesions were aggressive (B3). Surgical margins achieved were wide in 31 and marginal in 12 cases. Ilium was involved in 51% of cases and periacetabular involvement was seen in 12 patients. The resections done were mostly of types I & II of Enneking's classification of pelvic resection. Arthrodesis was attempted in 24 patients. Customized Saddle prosthesis was used in seven patients and no reconstruction in 12 patients. Adjuvant chemotherapy was given to all high-grade malignant tumours, combined with radiotherapy in 7 patients.

Results: With a mean follow up of 48.5 months and one patient lost to follow up, the recurrence rate among the evaluated cases was 16.6%. Oncologically, 30 patients were continuously disease free with 7 local recurrences and 4 deaths due to disseminated disease and 2 patients died of other causes. During the initial years, satisfactory functional results were achieved with prosthetic replacement. Long-term functional result of 36 patients who were alive at the time of latest follow up was satisfactory in 75% who underwent arthrodesis and in those where no reconstruction was used. We also describe a method of new classification of pelvic resections that clarifies certain shortcomings of the previous systems of classification.

Conclusion: Selection of a procedure depends largely on the patient factors, the tumour grade, the resultant defect and the tissue factors. Resection with proper margins gives better functional and oncological results

Key-Words: Pelvic Resection; Classification; Reconstruction; Outcomes; Complications.

Introduction

Management of pelvic tumours is a challenging problem and the concept of limb salvage is a worthwhile alternative^{1,2} to external hemipelvectomy, providing an adequate clearance with a useful functioning extremity. If satisfactory margins can be achieved by the excision of a pelvic tumor, salvage of the limb is justified from both an oncological and a functional standpoint³. Though technically demanding, limb salvage is increasingly possible with advances in imaging technology, making accurate pre-operative assessment of the tumor extent that helps in deciding the extent of resection. Choosing the appropriate reconstructive option from the five categories of reconstruction procedures^{4,5} is another exigent task that is decided by multifarious factors.

The complex classification systems^{6,7} of pelvic resection are impractical, as the tumours do not confine to the bony pelvic segments. Tumour resections most often involve soft tissues and later functional outcomes very much depend on the extent of their resection. This has not been mentioned. Disruption of the pelvic ring and / or the line of weight bearing were not considered. Margin of resection and type of reconstruction have not been pointed out. Hence the existing classification systems remain complex and confusing for the interpreter.

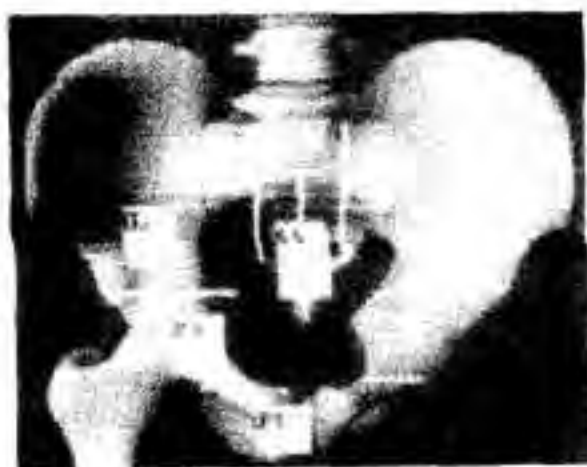
We evaluate our experience, the complications encountered and the outcomes of limb salvage highlighting the functional outcome of reconstructive procedures performed after resection of aggressive and malignant pelvic tumours and also describe a new classification.

Materials and methods

Between the years 1990 and 2002, forty-three patients underwent limb-sparing pelvic resections. Eighteen patients were females and 25 were males; their age ranged from 11 years to 55 years with a maximum of 14 patients in the third decade. The follow up period ranged from 12 months to 159 months (Mean 48.5 months). Pre-operative staging was done using roentgenography, CT scan, Technetium bone scan and MRI. Angiography was done in four patients.

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Fig 1. Antero-posterior view of the pelvis indicating the levels of resection



Diagnosis and Grade: Chondrosarcomas (21 cases) predominated the series followed by Ewing's sarcoma (6 patients); none of the sarcomas presented with metastasis. Rare presentations included a case of Paget's sarcoma and a case of haemangiopericytoma. The commonest stage that presented was II B (Table I) of the Enneking's staging system for musculo-skeletal tumours⁷. All four Giant cell tumours and three other benign lesions were of Stage B3.

Resection & Reconstruction: Bony resections were done as those classified by Enneking and Dunham^{8,9}. Soft tissue resections were done appropriately depending on the extent and margin of resection, based on Mayil and Bose classification. Thirty-seven patients had periacetabular resections and the acetabulum was retained in the rest (Table II). Wide oncological margins were achieved in high-grade lesions (31 patients) and marginal margins in all benign lesions (7), metastatic lesions (2) and low-grade or intra-compartmental sarcomas (3 patients).

Of the 32 cases reconstructed (Table III), arthrodesis at various levels was attempted in 24 patients using routine orthopaedic implants (Fig 3,4). Seven patients underwent customised, cemented saddle prosthetic replacement, made of surgical stainless steel 316 L (Fig 5). Free fibular autograft was used to bridge the skeletal defect in two cases. Eleven patients did not undergo any reconstructive procedure (Fig 6).

Neoadjuvant treatment was given for 11 patients of osteosarcoma and Ewing's sarcoma. Pre-operative chemotherapy was combined with pre-operative radiotherapy in 7 cases. One giant cell tumour and a case of haemangiopericytoma underwent resections after embolotherapy.

Mayil and Bose classification: We have developed a classification of pelvic resections based on the anatomical segments resected, including the bony as well as soft tissue resections and the nomenclature is user friendly.

Fig 2. Lateral view of the pelvis indicating the levels of resection



Nomenclature

(With reference to figure number 1 - Schematic diagram of Mayil & Bose Classification of Pelvic resections)

IL	Iliac segment
PA	Periacetabulum
PU	Pubis
PF	Proximal femur
SA	Sacrum
IL+PA	Iliac and peri-acetabular resection
IL+PA+PU	Entire hemi-pelvis is resected

Definition of Principles

Principle 1 - Pelvic resection

1. A line drawn from the anterior inferior iliac spine to the sciatic notch demarcates the ilium (IL) from the periacetabulum (PA)
2. A line drawn from the pubic ramus at the lower border of the acetabulum to the ischial ramus divides the periacetabulum (PA) from the pubis (PU)
3. A line drawn vertically along sacroiliac joint demarcates the ilium (IL) from the sacrum (SA)
4. When the complete segment of bone is resected it is indicated as IL, PA, PU.
5. When only a part of the bone concerned is removed the letters denoting are slashed like IL, PA, PU.
6. Combined resections are indicated as follows
 - a. IL+PA : Iliac and partial periacetabular resection
 - b. IL+PA+PU : Entire hemipelvis is resected

RECONSTRUCTIVE OPTIONS IN PELVIC TUMOURS

TABLE 1. Clinical Data of 43 patients of Pelvic Tumours

Sl No	Age / Sex	Site	Diagnosis	Surgical Stage	Mayil & Bose type of resection	Follow up in months	Chemo/RT	Oncological Complication	Biological Complication	Oncological Result	Functional Outcome
1	25/M	PA	Ewing sarcoma	II B	IL+PA, S3, W, AR	155	Pre-op CT & RT	Local Recurrence	Nil	NED	Excellent
2	45/M	IL	Chondrosarcoma	IB	IL+PA, S1, W, AR	155	No	Local Recurrence	Nil	NED	Poor
3	33/F	IL	Chondrosarcoma	IB	IL+PA, S1, W, RO	113	No	Local Recurrence	Nil	NED	Good
4	40/F	PA	Chondrosarcoma	IA	IL+PA, S0, M, RO	75	No	No	Cardiac	DOC	NA
5	24/M	PU	Chondrosarcoma	II A	PU, S0, Ob, W, RO	107	No	No	Nil	CDF	Good
6	40/M	IL	Haemangiopericytoma Embolectomy	II B	IL+PA+PU, S3, W, RO	97	Pre-op CT &	No	Nil	CDF	Good
7	20/M	IL	Chondrosarcoma	II A	IL, S1, W, RO	62	No	Local Recurrence	Nil	DOC	NA
8	24/M	IL	Ewing sarcoma	II B	IL+PA, S3, W, RO	NA	Pre-op CT & RT	NA	Haemorrhage	DOC	NA
9	30/F	IL	Chondrosarcoma	IB	IL+PA, S1, W, AR	56	No	Lost	Inf - Secondary Suture	Lost	Lost
10	18/F	IL	GCT	B 3	IL+PA, S1, M, RO	81	No	No	Flap Necrosis	CDF	Good
11	26/F	IL	GCT	B 3	IL+PA+PU, S3, M, RO	77	Pre-op RT & Embolectomy	No	Nil	CDF	Good
12	29/M	PU	Chondrosarcoma	II B	PA+PU, S2, W, PR	77	No	No	Nil	CDF	Excellent
13	11/F	IL	Ewing sarcoma	II B	IL+PA, S3, W, AR	43	Pre-op CT & RT	Dist Mets	Nil	DOC	NA
14	44/M	IL	Chondrosarcoma	II B	IL+PA+S14, S2, W, AR	39	Pre-op CT & RT	Sec. C spine	Inf - Implant removal	DOC	NA
15	16/F	IL	Malignant Fibrous Histiocytoma	II B	IL+PA, S1, W, AR	56	Post op CT	No	Screw Removal	CDF	Fair
16	33/F	PU	Chondrosarcoma	IA	PA+PU, S0, M, PR	96	No	Local Recurrence	Inf - Prosthesis Removed	NED	Poor
17	55/F	PU	Chondrosarcoma	II A	PA+PU, S0, W, PR	53	No	No	Vasc Thrombectomy Pyrene	CDF	Good
18	27/F	PU	Osteosarcoma	II B	PA+PU, S3, Ob, W, PR	63	No	No	Inf - Prosthesis Removed	CDF	Good
19	30/M	PA	GCT	B 3	PA+PU, S0, M, PR	60	No	No	Nil	CDF	Good
20	27/M	IL	Ewing sarcoma	II B	IL+PA, S2, W, AR	47	Post op CT	No	Nil	CDF	Good
21	10/M	IL	Ewing sarcoma	II B	IL+PA, S1, W, AR	41	Post op CT	No	Nil	CDF	Good
22	28/F	PU	Chondrosarcoma	IB	PU, Ob, W, RO	40	No	No	Nil	CDF	Good
23	36/F	IL	Chondrosarcoma	IB	IL+PA+PU, S3, W, RO	40	No	No	Nil	CDF	Fair
24	24/F	PA	Chondrosarcoma	IB	IL+PA, S1, W, AR	37	No	No	Nil	CDF	Good
25	17/M	PA	Ewing sarcoma	II B	IL+PA+PU, S1, W, RO	37	Post op CT	No	Nil	CDF	Excellent
26	50/M	PU	Chondrosarcoma	IA	PU, Ob, M, AR	34	No	Local Recurrence	Infection	NED	Poor
27	13/M	PA	ABC	B 3	IL+PA, S0, M, AR	32	No	No	Nil	CDF	Good
28	23/M	IL	Osteosarcoma	II A	IL+PA, S0, W, AR	30	No	No	Nil	CDF	Good
29	52/M	IL	Metastases	NA	IL+PA, S0, M, AR	26	Pre op CT	No	Nil	CDF	Poor
30	51/M	IL	Chondrosarcoma	IB	IL+PA, S1, W, AR	26	Pre op CT & RT	No	Nil	CDF	Good
31	40/M	IL	Metastases	NA	IL+PA, S1, M, PR Dist. Mets	7	Pre op CT & RT	Loc. Rec &	Nil	DOC	NA
32	34/M	IL S4	Mesenchymal Chondrosarcoma	II B	IL, S1, W, AR	25	Pre & Post op CT	No	Nil	CDF	Good
33	25/F	IL PA	Mesenchymal Chondrosarcoma	II B	IL+PA, S1, W, AR	26	Pre & Post op CT	Local Recurrence	Nil	NED	Good
34	35/F	PU	Chondrosarcoma	IB	IL+PA, S2, W, PR	24	No	No	Nil	CDF	Good
35	35/M	PU PA	Chondrosarcoma	IB	PA+PU, S2, W, AR	23	No	No	Nil	CDF	Good
36	13/F	IL	Osteochondroma	B 3	IL, S0, M, AR	23	No	No	Nil	CDF	Good
37	18/F	PA	Chondroblastoma	B 3	IL+PA, S0, M, AR	16	No	No	Nil	CDF	Good
38	21/F	IL	GCT	B 3	IL+PA, S0, M, AR	15	No	No	Nil	CDF	Good
39	32/M	IL	Chondrosarcoma	II A	IL, S1, W, RO	15	No	No	Infection	CDF	Fair
40	50/M	PA	Recurrent Chondrosarcoma	II B	IL+PA, S1, W, AR	14	Pre op CT & RT	No	Flap Necrosis	CDF	Fair
41	63/M	PA	Chondrosarcoma	IB	IL+PA, S1, W, AR	14	No	No	Nil	CDF	Good
42	73/M	PA	Page's Osteosarcoma	II A	IL+PA+PU, S2, W, AR	13	No	No	Nil	CDF	Poor
43	24/M	IL	Chondrosarcoma	II B	IL+PA, S2, W, AR	12	No	No	Nil	CDF	Good

Abbreviations: IL - Ilium, PA - Paranasal sinus, PU - Pubis, S 0 - Soft tissue not exposed, S 1 - Nerve points exposed, S 2 - Ducts exposed, S 3 - Forcs and glands exposed, Ob - Bladder exposed, W - Wide, M - Marginal, CT - Chemotherapy, RT - Radiotherapy, CDF - Continuously Disease Free, NED - No evidence of disease, DOC - Dist of Disease, DOD - Died of other causes.

Fig 3. Sacro-femoral arthrodesis after internal hemipelvectomy



Fig 4. Ischio-femoral arthrodesis following IL+PA type of resection

Principle II – Sacrum

1. Sacrum is vertically divided into two halves at the midline. Each half is further divided vertically into a quarter by a line passing through the sacral foraminae.
2. Sacrum is divided horizontally into two segments by a line drawn through the inferior border of the 2nd sacral foraminae

- SA – Total Sacrectomy
- SA/2 – One half of sacrum excised sagittally
- SA/4 – One quarter of sacrum excised sagittally
- SA – Part of sacrum below S₂ excised transversely (Horizontal slash)

Principle III – Pelvic ring

- O When the line of weight bearing and the pelvic ring is intact
- O When the line of weight bearing and the pelvic ring is disturbed, the letter is slashed. The site of slash denotes the level of disruption.

Principle IV – Extent of soft tissue excised

- S 0 Soft tissue not excised
- S 1 Ilio-psoas excised
- S 2 Gluteals excised
- S 3 Psoas and gluteals excised

Principle V – Margin achieved

- W Wide excision
- M Marginal excision
- C Contaminated excision

Principle VI – Organ resected

- Ob Bladder
- Ou Uterus
- Or Rectum

Principle VII – Reconstruction done

- R 0 No reconstruction
- AR Arthrodesis
- AL Allograft
- PR Prosthetic reconstruction

Results

Patients were followed up monthly for the first six months, six monthly thereafter both clinically and radiographically. One patient of Ewing's sarcoma died of massive haemorrhage due to femoral artery blow out, in the early postoperative period and another patient died of myocardial infarction at 75 months of follow up.

Table 2. Type of Surgical resection according to the location of the tumour and the resultant post-operative pelvic stability

Location	Type of resection	No. of patients	Pelvic stability	
			Maintained with reconstruction	Disrupted
Iliosacral	IL+PA	24	20	4
	IL	4	2	2
	IL+PA+S/4	1	1	0
	IL+PA+PU	5	2	3
Acetabular	PA+PU	6	6	0
Ischiopubic	PU	3	1	2
Total		43	32	11



Fig 5. Pelvic saddle prosthesis following PA+PU type of resection

Complications

Wound infection was seen in 6 cases, which resulted in removal of the pelvic saddle endoprosthesis in two patients and implant (wire) removal in one. The remaining three patients responded well to conservative management. The posterior gluteal flap necrosed in two and femoral arterial thrombosis complicated the post-operative period in one patient. Migration of the saddle endoprosthesis was a late complication observed in three patients amounting to a biological complication rate of 30%.

Oncological outcome

With one patient lost to follow up after 56 months, 30 patients had continuously disease free (CDF) follow up period. Four patients died of disease that included 2 cases of chondrosarcoma, one patient of metastatic renal cell carcinoma and a case of Ewing's sarcoma.

Local recurrences were met with in eight patients of which, resections (in 5 cases of chondrosarcoma) and radiotherapy (in a case of Ewing's sarcoma) rendered them with no evidence of disease at their latest follow up. One patient of metastatic renal cell carcinoma underwent marginal resection and saddle prosthetic replacement after pre-operative chemotherapy and radiotherapy developed fatal distant metastasis and had a local recurrence at 7 months follow up. Distant metastases in the form of spinal or lung secondaries were observed at 7, 39 and 43 months after resection in three patients that proved fatal in all of them. Of the eleven patients who developed oncological complications, the majority of patients had had lesions confined to the ilium (Table III). Radiotherapy increased our postoperative biological morbidity albeit achieving the



Fig 6. Internal hemipelvectomy without reconstruction

desired oncological clearance. One case of free fibular autograft done after resection of a low-grade chondrosarcoma of the pubis had a poor outcome due to infection and local recurrence.

Table 3. Oncological Outcome in relation to the location of the tumour

Location	No. of patients	Local Recurrence	Distant metastasis	Local Recurrence & Distant metastasis
Iliac only	22	3	2	1
Periacetabular	10	1	0	0
Pubis	8	2	0	0
Iliac extending to Acetabulum	1	1	0	0

Functional Outcome

Functional outcome was studied in 36 patients who were either continuously disease free or had no evidence of disease at the time of latest follow up, using Enneking's⁸ evaluation system (Table IV). During the initial years, satisfactory results were achieved in patients who had prosthetic replacement and poor results in those who had no reconstruction because of instability. But excellent to good long-term results were

Table 4. Functional Outcome following various reconstructive procedures in 36 patients of Pelvic tumours

Reconstruction	Functional Outcome				Lost	Death	Total
	Excellent	Good	Fair	Poor			
Arthrodesis	1	14	2	4	1	2	23
No reconstruction	1	12	2	0	0	3	11
Saddle Prosthesis	1	3	0	1	0	1	7
Subtotal	3	24	4	5	1	5	43
Total	36				7		43

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