Neurological evaluation after radical resection of sacral neoplasms

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Eight patients had a radical resection of sacral tumours, and bilateral severance of lumbosacral nerves was required. Their neurological deficits and disturbance of activities of daily living (ADL) were studied. The neurological deficits which occurred were motor dysfunction of the lower limbs, sensory disturbances, and urinary, faecal and sexual dysfunction. Bilateral preservation of the L5 nerve and above was necessary to permit the ability to walk, and bilateral preservation of the S2 nerve and above was necessary to spare urinary, faecal and sexual functions in order to establish ADL. To maintain normal ADL, bilateral preservation of the S2 nerve and above was necessary for walking, and bilateral preservation of the S3 nerve and above was necessary for urinary, faecal and sexual functions.

Keywords: sacral tumours; radical resection, severance of lumbosacral nerves; neurological deficit; activities of daily living.

Introduction

Radical resection is employed for the radical treatment of giant sacral tumours and tumours of relatively low malignancy possessing a high possibility of local recurrence.¹⁻¹² Radical sacral tumour resection is a surgical procedure presenting several problems because it is not only technically difficult but may also be associated with such sequelae as neurological dysfunction and instability of the pelvic girdle resulting from sacral amputation.^{2,7,13-16} Nowadays. radical sacral tumour resection and reconstruction of the sacrum is possible as a result of advancements in radiological imaging diagnosis and in surgical tech-niques.^{5,6,11,16-19} including embolisation to help to control intraoperative haemorrhage. and because of the development of instrumentation to obtain secure spinal fixation.^{12,20-22} Thus radical resection should be performed 'aggressively' to treat such sacral tumours although some neurological function must be sacrificed. Reconstruction of the sacrum with instrumentation was performed when it was felt that there would be postoperative instability of the pelvic girdle. However, the degree of neurological dvsfunction such as disturbance of motor function of the lower limbs, of urinary, bowel and sexual function depended on the level and extent of spinal nerve severance. The degree of neurological dysfunction may become absolutely unacceptable in regard to the patients' postoperative ADL. The objectives of this study were to investigate the resulting neurological deficits relative to the level of spinal nerve severance, and to clarify these with ADL disturbance after bilateral severance of lumbosacral nerves.

Methods

The subjects of this study were eight patients who underwent radical sacral tumour resection with bilateral severance of the lumbosacral nerves during the 12 year period from 1981 to 1992. There were six males and two females, and their ages at the time of surgery were from 17 to 74 years with an average of 56 years. The pathological diagnosis in three cases was a chordoma and there were single examples of Ewing's sarcoma, chondrosarcoma, giant cell tumour, meningioma and ependymoma. Radical resection was performed on three Paraplegia 32 (1994) 396-406

patients, including those with the giant cell tumour, meningioma and ependymoma because of recurrence after a previous operation. Radical sacral tumour resection was performed in all of the cases with the addition of reconstruction of the sacrum in six cases. Autologous bone, hydroxyapatite or bone cement was used for reconstruction of the sacrum, and fixation instrumentation was employed in three cases (Figs 1-3). The levels of lumbosacral nerve severance were L4-S5 on the right side and L5-S5 on the left in one case, bilaterally L5-S5 in one case, bilaterally S1-S5 in two cases, bilaterally S2-S5 in one case, bilaterally S3-S5 in two cases, and S3-S5 on the right side and S4 and S5 on the left in one case. The follow up period ranged from 9 to 98 months with an average of 36 months (Table I). No signs of local recurrence were present at the final follow up. Neurological deficit was carefully evaluated. ADL disturbance was also evaluated. Although the presence of preoperative neurological deficit and the possibility of the effect of surgical manoeuvers may not be excluded, neurological deficit was considered to be related to the innervation of nerves in which neurological function was preserved.

Results

Motor function of the lower limbs

In the patient whose L4 nerve and below on the right side and L5 nerve and below on the left were severed (case 1), the quadriceps muscles were bilaterally grade 4; however, the right tibialis anterior muscle was grade 0 and the left was grade 2, and the extensor hallucis longus, gastrocnemius and flexor hallucis longus muscles were grade 0. The patient was able to stand up with support but could not walk. In case 2, where the L5 nerve and below were severed bilaterally, the right tibialis anterior muscle was grade 4 and the left was grade 3, the extensor hallucis longus and gastrocnemius muscles were grade 3, and the flexor hallucis longus muscles were grade 0. Application of a short leg brace on one side and the use of T-canes on both sides allowed this patient to walk. In the patients whose S1 nerve and below









Figure 1 (a) and (b). Caption on p. 398.





Figure 1 Case 1. 58 year old female with chondrosarcoma of the sacroiliac bone on the right side. (a) Preoperative Gd-DTPA enhanced T1-weighted coronal MRI. (b) Preoperative Gd-DTPA enhanced T1-weighted sagittal MRI. (c) Preoperative T1-weighted axial MRI at the level of S1 and S2. (d, e) The sacroiliac reconstruction with ISOLA and bone cement was performed following radical tumour resection.

were severed bilaterally (cases 3 and 4), the extensor hallucis longus and gastrocnemius muscles were grade 4, and the flexor hallucis longus muscles were grade 3. These patients required to use handrails when descending stairs, but were able to walk on flat surfaces. In the patient whose S2 nerve and below were severed bilaterally (case 5), a slight decrease in muscle strength was present in both legs before surgery. Muscle strength a



b



Figure 2 Case 7. 71 year old male with chordoma of the sacrum. (a) Preoperative Gd-DTPA enhanced T1-weighted sagittal MRI showed a large presacral tumour mass. (b) T1-weighted sagittal MRI showed no evidence of local tumour recurrence at 27 months after radical tumour resection.

Radical resection of sacral neoplasms 399

did not change and the patient was able to walk after the operation. In the patients whose S3 nerve and below were severed bilaterally (cases 6 and 7) and whose S3 nerve and below on the right side and S4 nerve and below on the left were severed (case 8), a decrease in muscle strength of the lower limbs did not occur and walking was normal (Table II).

Reflexes

The right patellar reflex was lost and the left was decreased in case 1, but that reflex was present in all of the cases whose L4 nerves were preserved bilaterally (cases 2–8). The ankle jerk was absent after bilateral severance of the S1 nerves (cases 1–4), but was present when the S1 nerves were preserved bilaterally (cases 5–8). The anal reflex was spared in case 8 but was lost in the other cases in which the S3 nerve and above were severed bilaterally (Table II).

Sensation

Hypaesthesia and anaesthesia occurred at spinal levels below the nerve severance level. Sensory disturbance occurred from one spinal segment above the level of nerve severance in three cases (cases 2, 4 and 5). Sensation of the penis or labia were spared, and, although analgesia occurred, touch sensation in the perianal region was slightly preserved after severance of the S3 nerve and below (cases 6-8) (Table II).

Urinary function

Urinary dysfunction occurred in all of the patients. Case 8 had normal sensation, but this was replaced by a sense of fullness of the lower abdomen in patients whose S3 nerve and above were severed. Residual urine was present in all of the patients, but only a small amount was found in case 8. All patients had urinary incontinence with the exception of case 8. In cases 6 and 7, urinary incontinence was minimal. Micturition was almost normal in case 8. The other patients were able to micturate by manual abdominal pressure. An indwelling catheter was

S1





Figure 3 (a)–(d). Caption on p. 401.

e



Figure 3 Case 8. 74 year old male with chordoma of the sacrum. (a) Preoperative T1weighted coronal MRI. (b) Preoperative T1weighted sagittal MRI. (c) Preoperative CT at the level of S1 and S2. (d, e) The reconstruction of the sacrum with Spine system[®] and hydroxyapatite was performed following radical tumour resection.

unnecessary, but medication and intermittent self catheterisation were necessary (Table III).

Bowel function

With the exception of case 8, bowel dysfunction occurred in all of the patients. The normal defaecation desire was replaced by a sense of fullness or uneasiness in the lower abdomen. Constipation also occurred. In patients whose S2 nerve and below were severed (cases 1-5), anal sphincter tone was lost and diapers became necessary because of faecal incontinence. However, the patients were able to defaecate with manual assistance and abdominal pressure when the faeces was solid. After bilateral severance of the S3 nerve and below (cases 6 and 7), the tone of the external anal sphincter remained and defaecation of solid faeces was possible, but clothing was soiled by soft faeces because of faecal incontinence (Table III).

Sexual function

This was studied in the male patients. Erection and ejaculation were lost after bilateral severance of the S1 nerve and above. A weak erection occurred but ejaculation was not possible after bilateral severance of the S2 nerve and below (case 5). After bilateral severance of the S3 nerve and below (cases 6 and 7), dripping of semen occurred instead of normal ejaculation. In case 8 whose S3 nerves were preserved bilaterally, erection and ejaculation were maintained at close to preoperative levels (Table III).

Discussion

Surgical treatment is indicated for primary vertebral and spinal tumours of the sacrum that are benign or are of relatively low malignancy and possess a strong possibility of local recurrence, such as giant cell tumour, chordoma, chondrosarcoma, meningioma, and ependymoma, because conservative therapy is ineffective.¹⁻¹² Patients with sacral tumours often die because of distal metastases.^{4,6,11} Therefore, radical sacral tumour resection is the surgical procedure of choice, but severance of some sacral nerves cannot be avoided when radical sacral tumour resection is performed. High sacral amputation is, as is also total resection of the sacrum, associated with instability of the pelvic girdle and with neurological dysfunction.^{7,13-16} The advancement in instrumentation has allowed reconstruction of the sacrum if instability of the pelvic girdle is likely to occur postoperatively. At present, postoperative neurological dysfunction is the greatest problem because it is a permanent complication.

The major types of postoperative neurological dysfunction associated with radical sacrum tumour resection are motor disturbance of the lower limbs and urinary, faecal and sexual dyfunction. There are only a few reports on the relationship between neurological dysfunction and ADL.^{1,3,12} Gunterberg *et al* gave a detailed report on a

Case	Age	Sex	Pathological diagnosis	Surgical procedure	Severed lumbosacral nerves	Follow up period (months)
1	58	F	Chondrosarcoma	Radical resection and right sacroiliac reconstruction with ISOLA and bone cement	Right L4–S5 Left L5–S5	12
2	66	М	Meningioma	Radical resection and reconstruction of the sacrum with autologous bone	Bilateral L5-S5	42
3	54	М	Giant cell tumour	Radical resection and reconstruction of the sacrum with autologous bone	Bilateral S1-S5	15
4	33	F	Ependymoma	Radical resection and reconstruction of the sacrum with Harrington instrumentation and autologous bone	Bilateral S1–S5	98
5	17	Μ	Ewing's sarcoma	Radical resection and reconstruction of the sacrum with bone cement	Bilateral S2-S5	11
6	72	Μ	Chordoma	Radical resection	Bilateral S3-S5	68
7	71	М	Chordoma	Radical resection	Bilateral S3-S5	30
8	74	М	Chordoma	Radical resection and reconstruction of the sacrum with Spine system [®] and hydroxyapatite	Right S3–S5 Left S4–S5	9

 Table I Surgical cases of radical resection for sacral tumours

L = lumbar, S = sacral.

Case	Severed	Muscle strength							Reflex			Sensation	
	lumbosacral nerves		IP	QR	ТА	EHL	GC	FHL	PTR	ATR	AR		
1	Right L4-S5	Right	5	4	0	0	0	0	_	_	_	Sensory loss of Right L4–S5	
	Left L5-S5	Left	5	4	2	0	0	0	±	_	-	Sensory loss of Left L5–S5	
2	Bilateral L5-S5	Right	5	5	4	3	3	0	+	_	-	Hypaesthesia of bilateral L4	
		Left	5	5	3	3	3	0	+	-	-	Sensory loss of bilateral L5–S5	
3	Bilateral S1-S5	Right	5	5	5	4	4	3	<u>+</u>	_		Hypaesthesia of bilateral S1	
		Left	5	5	5	4	4	3	<u>+</u>	_	-	Sensory loss of bilateral S2–S5	
4	Bilateral S1-S5	Right	5	5	5	4	4	3	+	-	_	Hypaesthesia of bilateral L5	
		Left	5	5	5	4	3	2	±	-	-	Sensory loss of bilateral S1–S5	
5	Bilateral S2-S5	Right	5	5	5	5	4	4	+	±	-	Hypaesthesia of bilateral S1	
		Left	5	5	4	4	4	4	+	±	—	Sensory loss of bilateral S2–S5	
6	Bilateral S3-S5	Right	5	5	5	5	5	5	+	<u>+</u>	-	Hypaesthesia of bilateral \$3	
		Left	5	5	5	5	5	5	<u>+</u>	<u>+</u>	-	Sensory loss of bilateral S4–S5	
7	Bilateral S3-S5	Right	5	5	5	5	5	5	+	±	_	Hypaesthesia of bilateral \$3	
		Left	5	5	5	5	5	5	+	±	-	Sensory loss of bilateral \$4-\$5	
8	Right S3-S5	Right	5	5	5	5	5	5	+	+	_	Hypaesthesia of bilateral S4–S5	
	Left S4-S5	Left	5	5	5	5	5	5	+	+	+		

Number of muscle strength = grade of MMT (5 = normal, 4 = good, 3 = fair, 2 = poor, 1 = trace, 0 = zero), IP = iliopsoas, QR = quadriceps, TA = tibialis anterior, EHL = extensor hallucis longus, GC = gastrocnemius, FHL = flexor hallucis longus, AR = anal reflex.

Case	Severed	Urinary function				unction	Sexual function				
	lumbosacral - nerves	Normal uriesthesia	Residual urine	Inconti- nence	Normal defaecation sensation	Consti- pation	Inconti- nence	Sphincter tonus	Erection	Ejacula- tion	Sensibility of penis
1	Right L4–S5 Left L5–S5	_	+	+	-	+	+	_			
2	BilateralL5-S5	_	+	+		+	+	_	-	-	
3	Bilateral S1-S5	_	+	+	_	+	+	-	_	_	_
4	Bilateral S1-S5	_	+	+	_	+	+	-			
5	Bilateral S2-S5	_	+	+	_	+	+	-	<u>+</u>	_	• <u> </u>
6	Bilateral S3-S5	_	+	±	_	+	±	<u>+</u>	<u>+</u>	<u>+</u>	+
7	Bilateral S3-S5	_	+	±	_	+	±	<u>+</u>	<u>+</u>	<u>+</u>	+
8	Right S3–S5 Left S4–S5	+	±	_	+	-		+	+	+	+

Table III Urinary, faecal and sexual functions in patients after bilateral severance of lumbosacral nerves

+ = present, $\pm =$ weak or decreased, - = absent.

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biomechanical study of pelvic strength and neurological dysfunction after radical sacral tumor resection.^{7,13-16} However, the relationship between the level of sacral amputation and neurological deficits is not well described because it would appear that few patients have been studied and reported. We have investigated the neurological deficits relative to the level of bilateral several of the lumbosacral nerves and clarified the relationship with ADL.

The neurological deficits relative to the level of spinal nerve severance and their relationship with disturbances of ADL such as walking, urinary function, faecal function and sexual function were as follows. After bilateral severance of the L5 nerve and below, walking was possible with support, but intermittent self catheterisation and diapers became necessary, and sexual function was lost. After bilateral severance of the S1 nerve and below, walking independently was possible. After bilateral severance of the S2 nerve and below, a weak erection occurred but ejaculation was not possible. After bilateral severance of the S3 nerve and below, walking was normal and, although intermittent self catheterisation occasionally became necessary, urinary incontinence was minimal. Faecal incontinence did not occur with solid faeces but did occur with soft faeces. Regarding sexual function, a slightly reduced erection was established and dripping of semen occurred instead of normal ejaculation. After unilateral preservation of the S3 nerve, urinary, faecal and sexual dysfunction were almost nonexistent. Our results indicate that the L5 nerve and above must be preserved bilaterally to allow walking and the S2 nerve and above must be preserved to permit urinary, faecal and sexual function. These are the minimal requirements to maintain ADL. But bilateral preservation of the S2 nerve and above is necessary for walking and bilateral preservation of the S3 nerve and above is necessary to maintain urinary, faecal and sexual functions.

It is understood that sparing of as many lumbosacral nerves as possible in radical sacral tumour resection is essential to preserve as much neurological function as possible. It is also important to give a thorough explanation to the patient preoperatively so that he/she appreciates the possible neurological effects of radical sacral neoplasm surgery.

Conclusion

Neurological deficits relative to the level of bilateral spinal severance of lumbosacral nerves necessary for the surgical excision of sacral neoplasms were studied in eight patients. We conclude that it is necessary to bilaterally preserve the L5 nerves and above with regard to walking, and bilaterally preserve the S2 nerves and above with regard to urinary, faecal and sexual function in order to establish ADL.

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