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SACRAL RESECTION WITH PELVIC EXENTERATION FOR ADVANCED MALIGNANT TUMORS

RESSECÇÃO SACRAL COM EXENTERAÇÃO PÉLVICA EM TUMORES MALIGNOS AVANÇADOS

RESECCIÓN SACRA CON EXENTERACIÓN PÉLVICA EN TUMORES MALIGNOS AVANZADOS

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ABSTRACT

This narrative review summarizes the key surgical strategies, indications, and technical considerations involved in sacral resection combined with pelvic exenteration for the treatment of advanced malignant pelvic tumors. The integration of multidisciplinary planning, careful anatomical assessment, and innovations in minimally invasive and reconstructive techniques has contributed to increased feasibility and safety of these complex procedures. The review discusses patient selection, levels of sacrectomy, reconstruction options, and oncological outcomes based on current literature. ***Level of Evidence III; Review Article.***

Keywords: Surgical Procedures, Operative; Pelvic Exenteration; Sacrum; Orthopedic Procedures; Neoplasms; Surgical Oncology.

RESUMO

Esta revisão narrativa resume as principais estratégias cirúrgicas, indicações e considerações técnicas envolvidas na ressecção sacral combinada com a exenteração pélvica para o tratamento de tumores malignos pélvicos avançados. A integração do planejamento multidisciplinar, da avaliação anatômica criteriosa e das inovações em técnicas minimamente invasivas e reconstrutivas tem contribuído para maior viabilidade e segurança desses procedimentos complexos. A revisão aborda a seleção de pacientes, os níveis de sacrectomia, as opções de reconstrução e os desfechos oncológicos com base na literatura atual. ***Nível de Evidência III; Artigo de Revisão.***

Descritores: *Procedimentos Cirúrgicos Operatórios; Exenteração Pélvica; Sacro; Procedimentos Ortopédicos; Neoplasias; Oncologia Cirúrgica.*

RESUMEN

Esta revisión narrativa resume las principales estrategias quirúrgicas, indicaciones y consideraciones técnicas involucradas en la resección sacra combinada con la exenteración pélvica para el tratamiento de tumores malignos pélvicos avanzados. La integración de la planificación multidisciplinaria, una evaluación anatómica minuciosa y los avances en técnicas mínimamente invasivas y reconstructivas ha contribuido a una mayor viabilidad y seguridad de estos procedimientos complejos. La revisión aborda la selección de pacientes, los niveles de sacrectomía, las opciones reconstructivas y los resultados oncológicos basándose en la literatura actual. ***Nivel de Evidencia III; Artículo de Revisión.***

Descriptores: *Procedimientos Quirúrgicos Operativos; Exenteración Pélvica; Sacro; Procedimientos Ortopédicos; Neoplasias; Oncología Quirúrgica.*

INTRODUCTION

Pelvic exenteration (PE) is a major surgical procedure originally developed in 1948 as a palliative salvage option for patients with advanced recurrent cervical cancer. Due to its initially high rates of morbidity and mortality, PE remained restricted to a few specialized American centers for much of the 20th century.[1-3] However, with early advances in anesthesia, blood transfusion techniques, and intensive care medicine, outcomes gradually improved, leading to broader adoption of this challenging procedure. Over time, PE evolved from a desperate measure to a potentially curative intervention, now considered the standard of care for selected patients with locally advanced pelvic malignancies involving multiple pelvic organs.[4-11]

When pelvic malignancies extend posteriorly to involve the sacrum, sacral resection may be required in combination with PE to achieve complete tumor clearance.[4,5] Sacral resection combined with pelvic exenteration represents one of the most complex and extensive surgical interventions in oncologic pelvic surgery.[12] Although rarely indicated, this combined approach may offer the only curative or meaningful palliative option with the potential for local disease control in selected cases of gynecologic, colorectal, urologic cancers, and retroperitoneal sarcomas with central extension or bony invasion.[4]

In recent decades, significant progress in preoperative imaging, perioperative management, and reconstructive techniques has improved the safety and feasibility of these extended procedures, particularly in high-volume tertiary centers. A multidisciplinary approach involving oncologists, surgical teams from various specialties, radiologists, anesthesiologists, and rehabilitation specialists is essential for optimizing both oncologic and functional outcomes.[13-17]

This review aims to summarize the current strategies employed in sacral resection associated with pelvic exenteration, focusing on patient selection, preoperative planning, surgical techniques, reconstructive approaches, and clinical outcomes reported in contemporary literature.

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METHODOLOGY

This narrative literature review aimed to describe and analyze the indications, surgical techniques, complications, and prognosis of sacrectomy associated with pelvic exenteration in the treatment of locally advanced pelvic tumors. A comprehensive bibliographic search was conducted in the PubMed/MEDLINE, SciELO, and LILACS databases, covering publications from 2000 to 2024.

Search terms included: "sacrectomy," "pelvic exenteration," "sacral resection," "sacrectomy AND spinopelvic reconstruction," and "sacrectomy AND soft tissue." To ensure broader coverage of the topic, additional descriptors and combinations were also used, such as "reconstructive surgical procedures," "myocutaneous flap," "sacroiliac joint," "spinopelvic fixation," "pelvic neoplasms," "colorectal neoplasms," "gynecologic neoplasms" and "locally advanced neoplasms". The descriptors included are under the Medical Subject Headings (MeSH).

Inclusion criteria comprised clinical studies, case series, clinical trials, systematic reviews, narrative reviews, and expert opinions that addressed the combined technique of sacrectomy with pelvic exenteration, particularly in the context of colorectal, gynecologic, or retroperitoneal sarcomas, and that provided data on surgical outcomes or complications.

Exclusion criteria included isolated case reports lacking technical detail and publications in languages other than English.

Two independent reviewers performed the article selection. Initial screening involved title and abstract review, followed by full-text assessment of eligible studies. Extracted data included operative techniques, level of sacrectomy, spinopelvic reconstruction strategies, soft tissue management, complication rates, neurologic function, and patient survival.

DISCUSSION

Patient Selection and Preoperative Assessment

The decision to perform sacral resection in combination with pelvic exenteration requires careful patient selection, as these procedures are associated with significant morbidity and functional consequences. The primary indication is the presence of a locally advanced or recurrent malignant tumor, most commonly rectal cancer, with direct invasion of the sacrum, where *en bloc* resection of the tumor and involved sacral bone is required to achieve a complete (R0) resection. This approach is considered when the tumor is fixed posteriorly and cannot be cleared from the sacrum without bone resection. Appropriate candidates are typically those with central disease without evidence of distant metastasis and with a performance status adequate to tolerate a prolonged and complex surgery.[1,4,12,18-22]

Comprehensive preoperative assessment should begin with a detailed clinical history and physical examination, including neurologic evaluation of sacral nerve function. Cross-sectional imaging – preferably magnetic resonance imaging (MRI) – is essential to assess the extent of tumor invasion into the sacral bone, the involvement of adjacent soft tissues, and the proximity to or encasement of critical neurovascular structures. MRI provides superior contrast resolution of pelvic tissues and sacral invasion patterns, whereas computed tomography (CT) may be useful for evaluating cortical bone destruction and aiding in surgical planning.[23-25]

Positron emission tomography (PET)/CT can be employed to rule out distant metastatic disease and to assess metabolic activity, which may guide both resectability and prognosis. In cases where the sacral involvement is equivocal or high-level, additional imaging with CT myelography or nerve conduction studies may be considered to delineate better the relationship of the tumor to sacral nerve roots and spinal canal.[26,27]

Functional status should be evaluated using standardized tools such as the Eastern Cooperative Oncology Group (ECOG) performance status or the American Society of Anesthesiologists (ASA) classification. Nutritional assessment, cardiopulmonary evaluation, and optimization of comorbidities are also critical to reducing perioperative risk. A multidisciplinary tumor board discussion is strongly recommended to ensure consensus regarding indications, anticipated morbidity, and the availability of postoperative support, including rehabilitation and stoma care.

The preoperative discussion with the patient must include a transparent explanation of the goals of surgery, potential complications, possible functional deficits (including motor and sensory loss, bowel and bladder dysfunction), and the likely need for permanent diversions or reconstructive procedures. Informed consent must reflect the complexity and individualized nature of the operation.

Surgical Planning and Techniques

Surgical planning for sacral resection with pelvic exenteration must be meticulous and individualized, based on tumor location, extent of sacral involvement, and patient-specific anatomical and functional considerations. The ultimate objective is to achieve complete oncologic resection (R0) with negative margins while preserving neurological function and optimizing postoperative recovery.[20-22] Palliative pelvic exenteration may be considered in highly selected cases for symptom control (e.g., intractable pain, fistula, bleeding, or obstruction) when other modalities have failed and the patient's life expectancy and functional status justify the morbidity of the procedure. However, palliative exenteration is rare and should be reserved for cases where disease-related morbidity is otherwise uncontrollable.[18,28]

Pelvic exenteration may be classified as total, anterior, or posterior, depending on the organs resected.[29] *Total pelvic exenteration* involves the *en bloc* removal of all pelvic organs, including the urinary bladder, rectum, and reproductive structures. Anterior pelvic exenteration entails the resection of the urinary bladder and reproductive organs while sparing the rectum. *Posterior pelvic exenteration* includes removal of the rectum and reproductive organs with preservation of the bladder. In many cases involving sacral resection, total pelvic exenteration is required due to the central location and extent of disease. Urological and colorectal reconstruction planning must be integrated into the operative strategy. Options include permanent urinary diversion (e.g., ileal conduit), continent urinary reservoirs, and end colostomy or ileostomy, depending on residual anatomy and patient preference. (Table 1)

A thorough review of preoperative imaging is critical for defining the cranial extent of sacral invasion, which in turn dictates the level of sacral resection required. According to Fourney et al., sacral resections can be classified based on the most proximal nerve root sacrificed: low (S4), middle (S3), high (S2 or unilateral S1), total (bilateral S1–S5), and hemicorporectomy (translumbar).[30] The level of sacrectomy (high vs. low) is determined by the extent of sacral involvement, with distal (≤S3) resections associated with lower morbidity and better functional outcomes, but higher (≥S2) resections may be necessary for oncologic clearance in select cases.[4,16,21,31] The overriding indication is the need to achieve an R0 resection, as margin status is the most important predictor of survival and disease-free interval in this setting.[4,20,211,31] Resections below the S2 level generally preserve most autonomic functions, whereas resections at or above S2 may lead to significant motor and sphincteric deficits. High sacrectomy (at or above S2) often requires a posterior

Table 1. Classification of Pelvic Exenteration Based on Organ Resection.

Type of Exenteration	Organs Removed	Organs Preserved	Indications
Total	Bladder, rectum, uterus, ovaries/vagina (if present)	–	Tumors involving both the anterior and posterior pelvis
Anterior	Bladder, uterus, ovaries/vagina (if present)	Rectum	Anterior pelvic malignancies (e.g., bladder, uterus)
Posterior	Rectum, uterus, ovaries/vagina (if present)	Bladder	Posterior pelvic malignancies (e.g., rectal, uterine)

approach in addition to the standard anterior dissection of pelvic exenteration, and occasionally may necessitate *en bloc* vertebral or vascular resection. In a systematic review, Zoccali et al. reported that functional ambulation was preserved in 56.2% of patients when both S2 roots were spared, 94.1% when both S3 roots were spared, and 100% with more distal resections. Bladder and bowel function were absent when both S2 roots were sacrificed. Bladder function was preserved in 25% of cases with one S2 root spared, 39.9% with both S2 roots spared, 72.7% with one S3 root spared, and 83.3% with both S3 roots spared. Bowel dysfunction occurred in 50% of patients with both S2 roots spared and 70% with one S3 root spared, but was present in only 6% when both S3 roots were preserved. Sparing even one S4 root resulted in 100% preservation of bladder and bowel function. Unilateral sacral nerve root resection preserved bladder function in 75% and bowel function in 82.6% of cases.[32]

The choice of surgical approach – anterior, posterior, or combined – depends on the level and volume of the sacral resection, surgeon experience, and tumor anatomy.[33] For low sacral involvement (below S3), an anterior-only approach may suffice. However, for higher-level disease, a combined abdominoperineal or abdominoposterior approach is preferred, providing adequate exposure for precise osteotomies and nerve root preservation or sacrifice when needed. When combined with pelvic exenteration, sacrectomy is typically performed in the prone position after the completion of the abdominal and perineal phases. For sacral resections at or below the S3 level, a combined abdominolithotomy approach is generally preferred (Figure 1). This technique offers improved access to the lateral pelvic compartment, enhanced vascular control, better exposure of the lumbosacral plexus, and facilitates lateral dissection of the sciatic nerve. However, it provides limited access to posterior muscular and ligamentous attachments and may complicate the positioning of the vertical rectus abdominis myocutaneous (VRAM) flap for high sacral defect reconstruction.[4,5]

For high or total sacrectomies involving retroperitoneal organ invasion, there is consensus on the use of combined anterior-posterior approaches. During the anterior phase, vascular control and identification of the anterior cortical resection plane are critical. If a VRAM flap is planned, it should be prepared as the final step of the anterior approach prior to closure.[33]

In selected centers, minimally invasive or robotic-assisted approaches have been explored for the anterior component of pelvic exenteration, offering improved visualization and potentially reduced morbidity.[34-38] However, the posterior sacral resection continues to rely primarily on open techniques due to the complexity of bony dissection and need for tactile feedback.

Hemostasis is a major concern during sacral resection, particularly in high-level osteotomies where the presacral venous plexus and iliac vessels may be involved.[39] Preoperative embolization, temporary vascular control, and meticulous dissection are essential to minimize intraoperative bleeding. Bone bleeding from the sacrum itself can be managed using hemostatic agents, electrocautery, or bone wax. In an anatomical study of seven cadavers, Ishii et al. identified the presacral venous plexus, the dorsal venous complex, and the internal iliac veins as the structures with the highest risk of bleeding during pelvic exenteration with sacrectomy.[40] Preoperative angiography may be employed to identify highly vascularized tumors. Based on this assessment, endovascular embolization, planned vessel ligation during the anterior surgical approach, or a combination of both strategies can be implemented to reduce intraoperative bleeding.[41]

In a systematic review evaluating outcomes of pelvic exenteration with sacrectomy for recurrent rectal adenocarcinoma, Sasikumar et al. reported a mean estimated blood loss of 3,700 mL (range 1,725–6,000 mL). Blood loss varied according to the level of sacrectomy, with high sacrectomies associated with greater loss (4,487 mL; range 3,200–7,500 mL) compared to low sacrectomies (2,630 mL; range 1,725–5,750 mL) (20). Similarly, Yamada et al., in a retrospective study published in 2002, analyzed 20 patients undergoing pelvic exenteration with sacrectomy for rectal adenocarcinoma. The authors reported a mean blood loss of 1,070 ± 721 mL in primary cases and 3,990 ± 2,289 mL in recurrent cases.[42]

Sacrectomy with lumbopelvic stabilization is typically performed in three distinct phases: (1) anterior exposure and mobilization of pelvic structures, (2) posterior sacral tumor resection, and (3)

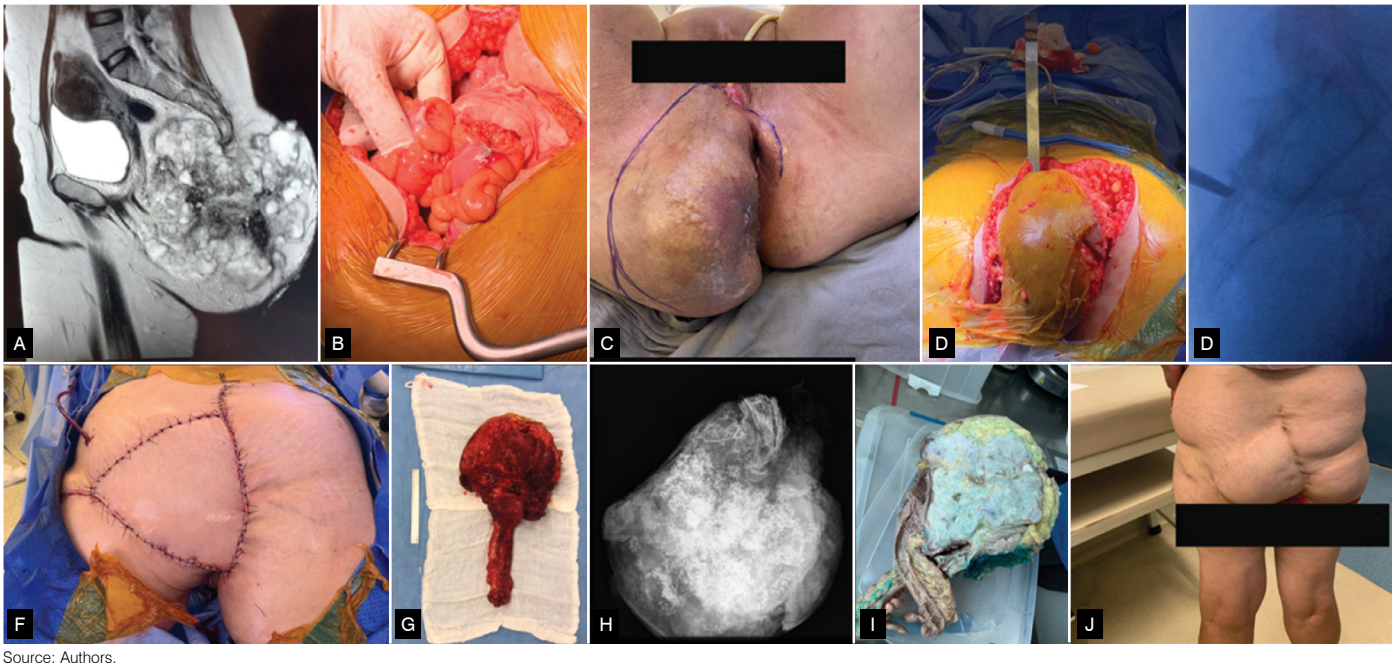

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Figure 1. Female patient, 45 years old. Right gluteal mass associated with an active fistula for approximately 10 months. Final diagnosis: sacral chondrosarcoma. a) Sagittal MRI showing sacral tumor with invasion of the rectum and posterior vaginal wall; b) Anterior approach with vascular control and rectal resection followed by terminal colostomy; c) Abdominolithotomy approach with posterior vaginal wall resection; d) Posterior approach for sacral exposure; e) Sacral resection at the S3 level; f) Pelvic floor reconstruction using a V–Y advancement flap; g) Resected surgical specimen; h) Postoperative radiograph of the surgical specimen; i) Histopathological analysis confirming the diagnosis; j) Clinical outcome at 2-year follow-up.

lumbopelvic fixation and reconstruction. In certain cases, a staged approach is adopted, wherein the anterior phase is completed in the initial operative session, followed by the posterior resection and stabilization in a subsequent procedure. This staged strategy has been associated with improved perioperative outcomes, optimized utilization of hospital resources, and reduced overall cost of care, particularly in high-complexity cases requiring extensive dissection and reconstruction.[43-45]

Reconstruction and Postoperative Management

Following sacral resection in combination with pelvic exenteration, reconstructive efforts must address not only restoration of pelvic floor integrity but also effective soft tissue coverage and preservation of functional outcomes. The reconstructive strategy should be tailored according to the level of sacrectomy, extent of organ and neurovascular involvement, and the anticipated need for adjuvant therapy.

Structural Reconstruction and Spino-Pelvic Stabilization

Biomechanical studies demonstrate that resections extending above the S1–S2 junction can significantly compromise lumbopelvic stability, increasing the risk of postoperative sacral fractures.[46] According to Varga et al., lumbopelvic fixation should be considered in the following scenarios: high sacrectomy (above the S1 foramen), total sacrectomy, extended total sacrectomy, and cases with unilateral involvement of the sacroiliac joint. Involvement of more than 50% of the sacroiliac joint mandates mechanical reconstruction.[47]

Spino-pelvic fixation techniques vary but commonly include pedicle screw instrumentation from L3 to L5. Three principal strategies have been described: spino-pelvic fixation (SPF), posterior pelvic ring fixation (PPRF), and anterior column reconstruction (ACR). Bederman et al. found that SPF is universally applied, often in combination with one or both of the other techniques. The addition of ACR was associated with a trend toward reduced implant failure.[48]

Techniques include the modified Galveston technique with dual iliac fixation,[46] four-rod constructs,[49] and the Closed Loop Technique.[33] Reconstruction techniques employing four longitudinal support rods (two on each side) in combination with bilateral iliac screw fixation at the spinopelvic junction have demonstrated effective mechanical stabilization of the lumbopelvic region. This four-rod configuration has been shown to significantly reduce motion at the L5–pelvis interface, thereby increasing the likelihood of achieving robust osseous fusion.[50,51] For PPRF, options include transiliac rods, structural grafts, and iliac crest cages. Gallia et al. described using a horizontal femoral allograft between the iliac crests.[52] ACR may involve vertical strut grafts (e.g., fibula), expandable cages, or anterior plating from L5 to the iliopectineal line.[53,54] The free vascularized fibula flap represents a reliable option to promote bony union following sacrectomy. Unlike nonvascularized structural grafts, vascularized bone grafts retain their blood supply, minimizing extensive remodeling and preserving structural integrity over time. In a retrospective study published in 2021, Asaad et al. reported successful bony union in 88% of patients (n=10), with a mean time to union of 6.3 months.[55]

More recently, Morales-Codina et al. proposed the use of a sacral replacement prosthesis created from a 3D anatomical model with a titanium core and porous coating. Finite element analysis demonstrated a reduction in stress across both the implants and adjacent bone structures, though clinical studies are still needed.[56]

Soft Tissue Reconstruction

Extensive defects resulting from combined organ and sacral resections pose substantial reconstructive challenges due to devascularized tissue, dead space, and contamination risk.[17,54,57] Myocutaneous flaps offer robust coverage, promote healing, and reduce perineal wound complications, which are reported in up to 66% of cases.[58]

The vertical rectus abdominis myocutaneous (VRAM) flap remains the most widely used reconstructive option. Based on the inferior epigastric vessels, it provides a large, well-vascularized, non-irradiated tissue volume capable of obliterating dead space and covering exposed bone or implants. Importantly, VRAM also minimizes the risk of herniation of intra-abdominal contents into the posterior cavity. However, potential drawbacks include weakening of the abdominal wall and limited availability for future ostomy placement.

Risk factors for flap complications include obesity and prior radiotherapy. Houdek et al. reported that prior abdominal surgery was not associated with increased flap failure in their cohort of 87 patients undergoing VRAM reconstruction after sacrectomy.[17]

When VRAM is not feasible, gluteal flaps, gracilis, posterior thigh flaps, and free flaps are alternatives. Gluteal flaps, based on the superior and inferior gluteal arteries, may be compromised in pelvic exenteration due to internal iliac vessel ligation or tumor infiltration. In such cases, free flaps, such as the latissimus dorsi muscle flap, are reliable options due to their consistent anatomy and long vascular pedicle.[58]

Postoperative Management and Surveillance

Postoperatively, patients require comprehensive, multidisciplinary care. Early mobilization, thromboprophylaxis, nutritional support, and wound surveillance are essential. Complications such as infection, dehiscence, and fistula formation are common, particularly in irradiated fields or when primary closure is under tension. Adjunctive measures like prophylactic antibiotics and negative-pressure wound therapy may mitigate these risks.

Neurologic assessment should include evaluation of bladder, bowel, and lower extremity motor function (Figure 2). Early engagement of rehabilitation teams – comprising physiotherapy, urology, and pain management – is vital to maximize functional recovery and adapt to permanent deficits.

Long-term follow-up includes imaging surveillance and monitoring of tumor markers based on histologic subtype and resection margins, aiming to detect early signs of recurrence.

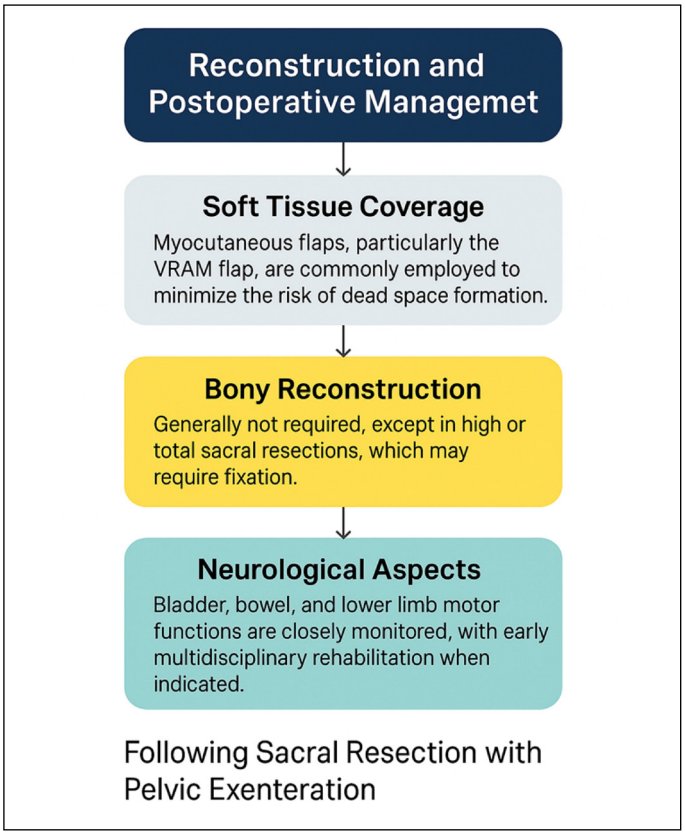

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Figure 2. Flowchart outlining key aspects of reconstruction and postoperative management following sacral resection with pelvic exenteration.

Outcomes and Prognosis

The outcomes following sacral resection with pelvic exenteration are highly variable and depend on several key factors, including tumor biology, extent of resection, preservation of neural structures, and the adequacy of oncologic margins. While these procedures can offer a potential cure or meaningful palliation for select patients, they are associated with considerable morbidity and long-term functional consequences, reflecting the complexity and radicality of the procedure. Complications can be categorized as perioperative, early postoperative, and late or long-term, with both general and procedure-specific risks.

Major perioperative and early postoperative complications include

Significant intraoperative bleeding, particularly from the presacral venous plexus and internal iliac veins, occurs due to their proximity to the surgical field and complex anatomy.[40]

Pelvic sepsis and infected pelvic collections, which are common and can lead to chronic sinus formation and fistulae (entero-perineal, entero-cutaneous, or urinary fistulae).[59-61]

Wound complications, including perineal wound breakdown and infection, are frequent, especially in the context of prior radiotherapy or extensive soft tissue resection.[62]

Empty pelvis syndrome (EPS), a constellation of complications such as pelvic sepsis, sinus formation, fistulae, and small bowel obstruction, is a leading cause of major morbidity after exenteration with sacrectomy. The risk of EPS is significantly increased by sacrectomy, total cystectomy, internal iliac vessel ligation, and infralevator exenteration.[59,61]

Neurologic deficits, particularly following high sacrectomy (at or above S2), include bladder, bowel, and sexual dysfunction, as well as lower limb motor or sensory loss.[4]

Urinary and enteric leaks, which are among the most devastating complications, may require reoperation or long-term diversion.[60]

Small bowel obstruction, often related to adhesions or EPS, sometimes necessitates further surgical intervention.[59,61]

Long-term complications include

Chronic pelvic or perineal sinus and persistent fistulae, which may require repeated interventions.[59,61]

Late small bowel obstruction and adhesive disease.[61]

Functional impairment, including permanent neurologic deficits, gait disturbance, and loss of sphincter control, especially after high sacrectomy.[4]

Reconstructive complications, such as flap failure or mesh-related morbidity, with perineal flaps are associated with higher rates of major reconstruction-related morbidity compared to biological mesh.[59]

The overall major complication rate after pelvic exenteration with sacrectomy is high, with series reporting major morbidity in 39–43% of patients and overall complication rates up to 74%.[31,62] The risk of complications is higher in the setting of recurrent malignancy, high sacrectomy, and prior radiotherapy.[59,63] Despite these risks, perioperative mortality is low (0 - 0,46%) in experienced centers.[4,62]

Oncologic Outcomes

Achieving negative surgical margins (R0 resection) remains the most significant prognostic factor for overall survival and disease-free survival. Locally advanced colorectal, gynecologic, or sarcomatous tumors that infiltrate the sacrum often require aggressive *en bloc* resection to achieve oncologic control. For colorectal cancer with sacral involvement, systematic reviews and large series report 5-year overall survival rates after R0 resection ranging from approximately 30% to 53% in mixed cohorts of primary and recurrent disease, with some series reporting disease-free survival rates of 43% at 5 years.[4,20,64-66] In a systematic review of 46 studies (n=1687), 5-year overall survival after R0 resection was 42.1%, with lower survival after R1/R2 resection.[64] Another multicenter study found no significant difference in 5-year overall survival between high and low sacrectomy (53% vs 44.1%), but positive resection margin was a strong independent predictor of mortality (hazard ratio 2.78, $p<0.001$).[65] Multiple studies confirm that positive margins are associated with higher rates of local recurrence and significantly reduced survival, with some series reporting no long-term survivors among patients with R1 resection.[67]

Neurological, Functional Outcomes and Quality of Life

Neurologic sequelae are closely tied to the level of sacral nerve root sacrifice. Preservation of at least one S2 root is generally associated with partial retention of bladder and bowel function. Sacrifice of both S2 roots frequently results in permanent neurogenic bladder and bowel dysfunction. Ambulatory function may be preserved in the majority of patients if both S1 roots are spared; however, higher sacral resections involving bilateral S1 or above can compromise gait and postural stability.

Functional recovery also depends on patient-specific factors, including age, preoperative performance status, and the intensity of postoperative rehabilitation. Multidisciplinary rehabilitation efforts, including neuro-urology, physical therapy, and pain management, are essential in maximizing quality of life after surgery.

Despite these challenges, studies show that carefully selected patients can experience meaningful improvements in symptoms, including relief from pain, mass effect, and bleeding. In palliative settings, surgical resection can improve local control and allow patients to regain autonomy.[64]

Long-term quality of life is variable and often reflects the balance between oncologic benefit and functional loss. Use of validated quality-of-life instruments and close longitudinal follow-up are critical to understanding patient outcomes and informing future decision-making.

CONCLUSION

Advances in surgical technique, perioperative care, and multidisciplinary management have significantly expanded the indications and improved outcomes for sacral resection combined with pelvic exenteration. Nevertheless, the procedure remains highly complex, with substantial risks of morbidity and functional impairment. The use of intraoperative navigation, 3D planning, and custom implants may improve resection accuracy and structural reconstruction. Robotic and laparoscopic approaches, though still limited in sacral surgery, are being explored for selected phases of the procedure to reduce morbidity and expedite recovery. The future of sacral resection with pelvic exenteration lies in integrating technological innovation with personalized care. Through careful patient selection, multidisciplinary collaboration, and evolving reconstructive and oncologic strategies, outcomes can continue to improve while preserving function and quality of life.

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