ASPECTS OF CURRENT MANAGEMENT

The management of complex soft-tissue defects after spinal instrumentation


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Wound dehiscence after spinal instrumentation presents a challenging problem to the surgeon. Soft-tissue complications after operation are most commonly seen in patients with poor nutritional status, in the presence of injury to the spinal cord, following multiple operations and in malignant spinal disease. Patients with spinal metastases who undergo surgical stabilisation are often treated by multimodality therapy including radiation, arterial embolisation of feeding vessels and systemic corticosteroids. Recurrent metastases may require re-operation for eradication of the tumour or decompression of the spinal cord. All of these factors contribute to the formation of a scar which significantly compromises wound healing. The routine use of high-dose systemic corticosteroids compromises wound healing even further.

The recruitment of richly-vascularised tissue is often necessary to provide healing and serviceable skin cover for exposed instrumentation. Usually, the decision for the specific type of soft-tissue reconstruction is left to the plastic surgeon. However, the spinal surgeon should be familiar with the preparation of a suitable site for a soft-tissue graft and the soft-tissue flaps available in order to plan reconstruction.

Factors influencing infection

Risk factors may be intrinsic to the patient, the procedure and the post-operative care and management. Immunocompromised patients are at an increased risk of infection at the site of the operation. An immunocompromised state may be because of various factors including malnutrition, the use of steroids, rheumatoid arthritis, diabetes, cancer, obesity and smoking (nicotine use).

A condition which impairs the immune status or interferes with wound healing predisposes the patient to potential infection. A leading cause of such impairment is malnutrition. Klein et al. noted that 25% of patients about to undergo elective lumbar fusion were found to be malnourished preoperatively according to clinical and laboratory evaluation. Several markers of malnutrition have been identified, including a serum albumin level of less than 3.5 g/dl, a history of recent weight loss greater than 10 lb, skin test anergy, an arm muscle circumference less than 80% of normal and a total lymphocyte count of less than 1500 cells per ml. Other criteria used in determining a patient’s nutritional status should include the level of transferrin, creatinine indices, height-width ratios and skinfold thickness.

Obesity is another form of malnutrition which predisposes patients to infective complications. Poor vascularity and the decreased immune defence of adipose tissue provide a hospitable environment for bacteria to propagate in the setting of fat necrosis. Also, as a result of the size of these patients, surgical exposure is often more difficult, requiring longer operative times which increase the risk of infection.

Poorly-controlled diabetes predisposes to spinal infection. Approximately 17% of the diabetic population will experience a post-operative complication, with about two-thirds acquiring an infection. The co-morbidities associated with diabetes, such as cardiovascular disease, hypertension, and renal failure further increase the risks of infection by compromising soft-tissue viability.

Thorough documentation of the past medical history may reveal concomitant conditions which increase the relative risk of infection. It is imperative that these patients are counselled pre-operatively so that potential post-operative complications may be anticipated. Rheumatoid arthritis, the use of steroids, radiation therapy, adrenocortical insufficiency, and pre-existing neoplasms have all been cited as risk factors without hard evidence to support these views. In a review of 100 consecutive patients with spinal tumours stabilised through both anterior and posterior approaches, the rate of infection was approximately 4%.
This rate was comparable with that obtained for spinal fusions with instrumentation in non-oncological cases.\textsuperscript{31} It is advisable to wait for two to three weeks after surgery before beginning radiotherapy because of possible interference with wound healing. If radiotherapy is carried out initially, a waiting period of six to 12 weeks is preferred before elective surgery can be contemplated in order to prevent soft-tissue compromise.

Trauma patients have multiple risk factors including malnutrition and open injuries which predispose to wound infection. This increased risk has been shown by the higher rates of infection in patients who are treated surgically for thoracolumbar trauma. \textcite{Stambough and Beringer, McAfee et al, Rechtine et al, Cahill and Chrin} have shown wide variations in rates of infection ranging from 2\% to 15\%, with an overall rate of approximately 10\%.\textsuperscript{34-39} \textcite{Vaccaro et al} investigated infection in patients with injury to the spinal cord and found a rate of 20\% in complete cord lesions.

**Initial management of exposed spinal instrumentation**

Before soft-tissue reconstruction, local control of the tissue bed must be obtained. Improving the patient's primary disease and nutritional status, debriding all necrotic and nonviable tissue and obtaining healthy margins for flap cover are initial measures which should be performed early and aggressively.\textsuperscript{41} Multiple debridements, the administration of prolonged intravenous antibiotics and nutritional supplementation are essential in the management of these debilitated patients.

Radiation-related tissue injury damages the microcirculation leading to poor perfusion and impaired wound healing.\textsuperscript{42} In patients with metastatic compression of the spinal cord, the rate of complications in major wounds after surgery within a post-irradiated field is nearly fourfold greater than that observed in patients who have had early surgery followed by radiation.\textsuperscript{43} The surgeon should not limit debridement because of the potential size of the defect, since successful cover is achieved only when there are healthy wound margins.

Revision of the wound with wide undermining of the skin and direct closure has been shown to be ineffective.\textsuperscript{44} Granulation tissue, delayed secondary wound healing and multiple skin-graft procedures are often time-consuming or ineffective in providing adequate long-term soft-tissue cover over metal implants. When dura is exposed, muscle or myocutaneous flaps are necessary to resurface the wound and protect vital neurological structures.\textsuperscript{1}

Loose fragments of bone, gelfoam, fat grafts or other non-essential materials should be thoroughly excised. Only those pieces of bone graft which are loosened during salvage or which appear to be engulfed in purulent material should be removed.\textsuperscript{20,45-48} It is rare that bone graft has to be removed, particularly during the phases of debridement. Once appropriate cultures have been obtained, antibiotics may be administered. Initially, broad-spectrum cover is recommended, with the eventual goal of tailoring the choice of antibiotic to the appropriate bacteriological sensitivities.

**Anatomical approach to flap availability**

The salvage of exposed metal devices by cover with muscle or musculocutaneous flaps has been well described after debridement of dehisced tissue overlying total knee and shoulder prostheses.\textsuperscript{2,41} Muscle flaps conform well to the surgical defect and provide cover either as a musculocutaneous flap or as a recipient bed for a skin graft. When harvesting the flap, it is necessary to obtain full mobilisation of the muscle to obliterate the dead space adequately, using as many layers as needed. Muscle flaps have the ability to completely fill the debrided cavity with well-vascularised tissue and have a greater bactericidal activity compared with that of random skin and fasciocutaneous flaps.\textsuperscript{5,49,50}

The simplest way to understand the availability of soft-tissue flaps for complex spinal reconstruction is through a regionalised approach as described by \textcite{Casas and Lewis}. (Fig. 1). In most cases, defects in the upper third of the back may be reconstructed by a turnover paraspinal or trapezius muscle flap. This may be combined if necessary with a latissimus dorsi muscle flap. For defects in the middle third of the back, reconstruction is typically accomplished by a latissimus or reverse latissimus muscle flap and for those in the lower third of the back by either a latissimus, gluteus muscle flap, omental flap or free-flap transfer.
Specific muscle flaps

Turnover paraspinal muscle flap. Typically, paraspinal muscles have been sutured together during the previous operation and generally fall within the field of radiotherapy. Scar tissue compromises the local blood supply and pliability of these muscles for transposition. However, if the paraspinal muscles are available for mobilisation, the most common technique used is that of Wilhemi et al\(^\text{52}\) (Fig. 2). First, skin flaps are elevated at the lateral border of the paraspinous musculature. The proper plane of dissection is superficial to the thoracolumbar fascia. Once a distinct plane has been located by blunt dissection, division of the thoracolumbar fascia by cautery and further blunt dissection reveals the segmental muscle perforators based laterally. With these lateral vessels under direct vision, dissection proceeds along the medial undersurface of the paraspinous muscles, which are carefully elevated off the transverse processes and ribs. This elevation of the medial muscles is critical for allowing the paraspinous muscles to ‘unfold’ like an accordion and be advanced toward the midline.

Trapezius muscle flap. Similar to the pectoralis flap used after a median sternotomy, the trapezius is harvested easily through the existing midline incision, with or without an inferior or superior extension as needed.\(^\text{9,41,50,53}\) The trapezius muscle flap has a type II pattern of muscle circulation as proposed by Mathes and Nahai\(^\text{54}\) through the transverse cervical artery as the dominant pedicle and minor pedicles supplied by the dorsal scapular and perforating posterior intercostal vessels with a branch of the occipital artery. Nevertheless, as demonstrated by Nichter, Morgan and Harman\(^\text{55}\) the trapezius may have an inconsistent vascular anatomy and a diverse nomenclature which may promote confusion (Fig. 3). Mobilisation of the trapezius is carried out from a caudal-to-cephalad direction. Attachments to the scapular spine are left intact unless the flap is needed to reach the upper cervical spine. Further wound reinforcement can be obtained by re-approximation of the paraspinous muscles over the trapezius flap.

The trapezius flap based along the paramedian axis of the descending branch of the transverse cervical vessels was initially described by Demergasso and Piazza in 1979.\(^\text{56}\) Chun et al\(^\text{41}\) more recently described the successful use of a distally-based trapezial musculocutaneous flap which uses the midline spinal incision along with the donor-site wound...
primary advantage is that the distal trapezius is often spared from the radiation exposure experienced by the more proximal cervicothoracic area.

Latissimus flap. The latissimus muscle is the principal flap for reconstruction of the spine.\textsuperscript{2,12,57,58} Anatomical studies have shown that latissimus dorsi has a dual blood supply. The dominant vascular branch is from the thoracodorsal artery, a branch of the subscapular artery. The latissimus dorsi muscle also receives a significant supply from the segmental paraspinal vessels which enter the muscle near the midline. When latissimus dorsi is detached at its insertion into the humerus, its vascular supply becomes based on the secondary segmental paraspinal vessels. The resulting flap is referred to as a reverse latissimus dorsi flap (Fig. 4).\textsuperscript{12}

Mobilisation of the flap is first done by exposing the lateral edge of the muscle proximally towards the humerus. The thoracodorsal neurovascular bundle is exposed, tied off, and detached. The detached proximal part of latissimus dorsi is dissected away from the belly of teres major and mobilised in

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**Figure 3a** – Photograph of a 48-year-old woman who underwent posterior spinal decompression of metastatic breast cancer with instrumental stabilisation from C3 to T10. After one month, the upper thoracic wound dehisced after external radiation. The dotted line represents the pedicle (blood supply) of the flap. **Figure 3b** – Diagram showing use of the distal trapezius musculocutaneous flap. **Figure 3c** – Photograph showing that the trapezius musculocutaneous donor incision was incorporated into the flap in a V-Y fashion.
the medial and lateral directions. The spinal perforator vessels are found about 5 cm from the midline and three large intercostal perforator vessels arise from the 9th, 10th, and 11th intercostal spaces. After the proximal muscle belly has been turned back and tucked into the defect, it is advisable to suture the muscle to the edges of the defect.

**Superior gluteal artery flap.** This is one of the most challenging reconstructive soft-tissue flaps designed for reconstruction of spinal wounds (Fig. 5). The technique should not be attempted unless the surgeon has had significant experience with the management of sacral pressure sores. A line is drawn between the superolateral aspect of the sacrum and the posterosuperior iliac spine. From a point which bisects this line, a second line is drawn towards the greater trochanter, representing the path of the superior gluteal artery as well as the long axis of the flap. A distal skin paddle overlying the greater trochanter is elevated along with the superior half of gluteus maximus. The muscle is taken off the posterior iliac spine and elevated off gluteus medius. Care is taken not to injure the inferior gluteal vessels. A true island flap is raised, with the flap connected only by its vascular pedicle. This is required for the 160° turn that the flap must make to move from the trochanter to the lower spine.

**Rectus flap.** The transpelvic rectus flap was originally described for vaginal and pelvic reconstruction. Loessin et al. described 15 patients who required a rectus flap to cover sacral and perineal wound defects after abdominal-perineal resection and radiation therapy. The rate of complications was 30% and a mean of 5.3 procedures were required before final closure was obtained. Kroll et al. reported a series of seven patients with closure of wound defects after abdominal-perineal resection using a rectus muscle flap. One flap failed and one patient developed a small abdominal hernia at the donor site.

Technically, a vertical rectus abdominis myocutaneous flap is designed on the abdominal wall. The flap is made as large as possible and is detached from the pubis to ensure adequate reach to cover the wound. Special care is taken to create a large tunnel for the flap to prevent any risk of pressure to the pedicle, which might compromise blood flow. Once the flap has been harvested, it is placed securely in the pelvis and inset into the sacral defect. The transpelvic vertical rectus abdominis myocutaneous flap is a reliable method of reconstructing large sacral defects in patients in whom local flap closures are contraindicated. However, the use of this flap is generally avoided in patients who have undergone a laparotomy and in those with stomas which might compromise the local blood supply and vascularity of the soft tissue.

**Latissimus free flap.** Complex problems may be presented by chronic osteomyelitis because the inflammatory process destroys the neighbouring tissue and induces fibrotic changes. A well-vascularised muscle flap is required for closure of a refractory wound in spinal surgery. When used for an extensive defect in the lumbosacral area the pedicled latissimus dorsi flap is restricted by its pedicle at the axilla. The reversed latissimus dorsi flap is not reliable in this situation because the paralumbar perforator vessels have been destroyed. As an alternative, the latissimus dorsi flap can be transplanted into the defect by lengthening the pedicle with an interpositional vein graft or by transferring the muscle as a free flap to new recipient vessels. Free-tissue transfer is reliable because the most vascularised part of the flap is placed over the critical area of the wound. Other free flaps may achieve the same purpose but are technically more difficult. For example, the rectus abdominis flap and the rectus femoris flap require repositioning the patient during surgery.

**Omental flap.** In 1963, Kiricuta described three variants for mobilisation of the omentum including extra-abdominal use for the treatment of vesicovaginal fistula. The most commonly reported use of omental flaps in extra-abdominal defects are in breast cancer and/or radionecrosis. Rarely have omental flaps been used for cover of the lower back. In 1994, Giordano, Griffet and Argenson used omental flaps based on the left gastroepiploic vessels to
cover the lower back after a post-operative infection following the treatment of Pott’s disease. Le Fourn et al reported a similar case, but the flap was based on the right gastroepiploic pedicle. There are two main advantages in using the left gastroepiploic pedicle. First, the endoscopic harvest is easier from right to left with less risk of iatrogenic splenic injury. Secondly, it is technically easier to pass the omentum through the left abdominal wall as compared with the right where the flap must pass just beneath the renal pedicle. The main disadvantage of the omental flap is the need for a combined anterior and posterior approach which increases morbidity and creates problems in positioning. Potential complications secondary to the laparotomy include possible obstruction of the small bowel, hernia of the ventral wall and fluid-electrolyte disturbances. These problems have limited the use of omental flaps in the cover of complex spinal wounds.

**Vacuum-assisted closure (VAC).** This is a relatively new technique in which controlled negative pressure is used to provide evacuation of wound oedema, to increase blood flow, to decrease bacterial load and to increase the formation of granulation tissue. It has been successfully used in the management of complex open wounds of the limbs, pressure ulcers, wounds of the abdominal wall and open sternal wounds. VAC (KCI Medical, San Antonio, Texas) is applied after thorough mechanical debridement. An open-pored polyurethane sponge foam is cut and fitted into the wound. A plastic sealant then covers the sponge and extends several centimetres beyond the margins of the wound to create an air-tight seal, with a tube connecting the sponge to the negative pressure device. The sponge is compressed under subatmospheric pressure (-125 mm Hg), continuously or intermittently.

Recently, VAC has been used in the management of complex soft-tissue defects after spinal reconstruction. Mehbood et al described the technique in 20 consecutive patients who had sustained deep wound infections after spinal instrumentation. They found that a mean of 1.8 (1 to 8) irrigation and debridement procedures were undertaken before placement of the VAC device. After placement, wound closure required a mean of seven days (five to 14) with retention of the spinal instrumentation in all patients. No wound became septic during the course of the treatment and all had their wounds closed primarily.

Several porcine models have confirmed the efficacy of vacuum-assisted wound closure. The effect of VAC on blood flow was studied in pigs in which Doppler-measured blood flow increased fourfold when 125 mm Hg of subatmospheric pressure was applied. The rate of formation of granulation tissue was also significantly increased with
both continuous (26%) and intermittent (103%) application. Additionally, bacterial loads were also statistically lower in porcine wounds treated with VAC for at least four days.

VAC treatment offers a promising alternative to muscle flap reconstruction of complex wound infections. It may reduce the need for multiple debridements, avoid the cost and morbidity of harvesting soft-tissue flaps and provide successful clinical outcomes. Further research of this promising technology is required before its widespread clinical application.

Conclusion

The management of wound infections and dehiscence in association with spinal instrumentation presents a daunting challenge. Wound problems should be managed early and aggressively. Debridement of wound margins and necrotic tissue, and the creation of a healthy tissue bed despite the potential for a large defect are mandatory for the successful transposition of a muscle flap. A thorough understanding of the regional geography of flap cover in the posterior spine will help the surgeon in planning complex wound cover and the retention of instrumentation. The promotion of primary wound healing in these debilitated patients who undergo palliative surgery immensely improves their quality of life and allows an early discharge from hospital.

References

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Fat necrosis in free and pedicled TRAM

The management of complex soft-tissue defects after spinal instrumentation


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