Computer-aided surgical planning in the treatment of soft-tissue sarcoma

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ABSTRACT

INTRODUCTION Soft-tissue sarcoma resections are often highly complex procedures that demand meticulous pre-operative planning in order to maximise the potential for complete excision with clear margins, while preserving vital neurovascular structures and muscle groups.

SUBJECTS AND METHODS We present a computer-aided model for surgical planning using Microsoft Powerpoint as a tool for cross referencing magnetic resonance images and normal anatomical diagrams.

RESULTS Using this system the operator follows a sequence of pre-planned steps, minimising intra-operative decision making and unexpected adverse events. Four case studies are discussed.

CONCLUSIONS The visual plan optimises the potential to meet surgical and oncological goals, and serves as an excellent adjunct to the operation note for documentation of the procedure.

KEYWORDS

Soft-tissue sarcoma – Computer-aided model – Surgical planning

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The National Institute for Health and Clinical Excellence (NICE) *Improving Outcomes Guidance* model for the triple assessment of a suspected soft-tissue sarcoma includes clinical examination, radiological investigation by magnetic resonance (MR) imaging, biopsy and later computed tomography (CT) staging under the auspices of a multidisciplinary team.¹

Soft-tissue sarcoma surgery is unique to each patient and the extensive dissections required demand that detailed consideration be given to the surgical resection, the muscle groups within the zone of excision, vital neurovascular structures within and adjacent to the tumour, and the excision of overlying skin. Consequently, the reconstructive demands of the extirpative defect must be anticipated pre-operatively and built in to the overall operative plan. Complete tumour excision with adequate margins is the goal of all sarcoma surgery, although marginal resection with adjuvant therapy is often accepted for functional limb salvage.

Planning is central to the success of any sarcoma resection. A clear operative plan decreases operative time and stress and facilitates a systematic approach to tumour resection and soft tissue reconstruction.

Subjects and Methods

All sarcoma resections since 2002 undertaken by the senior author (CAS) have been planned pre-operatively using cross-sectional imaging with matched cross-sectional anatomical diagrams in multiple planes and at multiple levels. As a first stage, MR images are imported directly from the hospital PACS system or digitally photographed. Anatomical diagrams are retrieved from an archive or scanned from a reference text (Fig. 1). This technique allows for the surgeon's preference in selecting anatomical reference images; the authors regularly use *Grant's Atlas*² and *Last's Anatomy*.³

Next, the paired images are placed side by side within a Microsoft Powerpoint® file. Using Powerpoint drawing tools, the images are overlaid with labels to orientate the images. By visually comparing MR images with normal reference anatomy the important muscle groups and vital structures are identified and labelled (Fig. 2).

At the multidisciplinary team meeting, the anatomical relationships of the tumour and the margins of tumour excision are discussed and the tumour outline and planned resection are superimposed upon the MR images (Fig. 3). This process is repeated for as many slices in as many planes

as the surgeon requires (Fig. 4). Any reconstructive surgery that may be necessary is also planned using this technique.

As a final stage, the edited images are used to list the sequence of operative steps for extirpative and reconstructive components of the procedure. Both the graphical plan and operative sequence are displayed in the operating theatre as a constant reference source as dissection progresses.

Results

Case 1

A 24-year-old man with an intermediate grade myxoid

Figure 1 Stage 1 – MR images and anatomical diagrams are imported into Powerpoint.

Figure 2 Stage 2 – images are oriented, vital structures and muscle groups are identified.

Figure 3 Stage 3 – the tumour outline and resection line are overlaid.

liposarcoma within the adductor compartment of the left thigh. Computer-aided planning was undertaken in axial and coronal sections (Figs 3 and 4). The operation exactly followed the graphical plan preserving sartorius, the femoral vessels, hamstrings and the sciatic nerve, as demonstrated within the excision defect (Fig. 5). The nearest tumour margin was 10 mm and postoperative adjuvant radiotherapy was given to the tumour bed. At 18-month follow-up, this patient remains disease-free.

Case 2

A 79-year-old man with an intermediate grade leiomyosarcoma in the anterior compartment of the left thigh. From the computer-aided plan (Fig. 6), it was clear that the superficial femoral vessels were involved and would require *en-bloc* excision and reconstruction. The operative sequence (Fig. 7) demonstrates pre-operative markings, the defect following excision, and following skin reconstruction with a pennant flap. As anticipated from the graphical plan, vastus

Figure 4 Stage 3 – the process is repeated in the coronal plane.

Figure 5 Case 1 – post resection.

lateralis, gracilis, the femur and the Dacron graft vascular reconstruction are visible within the excision defect along with the inset flap. The nearest tumour margin was 1 mm at the site of the sub-periosteal resection off the femur. Postoperative adjuvant radiotherapy was given to the tumour bed. Although this patient did not develop locally recurrent disease, he died 4 years postoperatively due to pulmonary metastatic disease.

Case 3

A 26-year-old man with an alveolar soft part sarcoma in the medial foot. In view of the three-dimensional complexity of the local anatomy, detailed computer-aided planning was undertaken in both sagittal and coronal planes as demonstrated by the graphical plan (Fig. 8). The operative sequence (Fig. 9) demonstrates the planned sub-periosteal tumour excision and reconstruction with a sural nerve graft (to restore sensation to the medial plantar area) and a free latissimus dorsi flap for soft tissue reconstruction. The nearest tumour margin was 3 mm at the site of the sub-periosteal resection. Postoperative adjuvant chemotherapy was given. At 2-year follow-up, this patient is free of recurrent local disease, although he has developed cerebral metastases.

Case 4

A 70-year-old woman with a large pleomorphic, high-grade sarcoma spanning the anterior and posterior compartments of her right thigh (Fig. 10). Computer-aided planning was undertaken with the aim of performing a sub-periosteal dissection off the femur while preserving the adductor compartment, superficial femoral vessels and sciatic nerve (Fig. 11). The operative sequence demonstrates pre-operative markings and the excision specimen (Fig. 12); and the excision defect in both anteroposterior and lateral views (Fig. 13). The nearest tumour margin was 2 mm at the site of the sub-periosteal resection off the femur. No adjuvant therapy

Figure 7 Case 2 – operative sequence.

Figure 8 Case 3 – intra-operative graphical plan.

Figure 9 Case 3 – operative sequence.

was given due to a postoperative femoral fracture. At 5-year follow-up, this patient remains disease-free.

Figure 10 Case 4 – large anterior and posterior right thigh sarcoma.

Figure 12 Case 4 – pre-operative markings and excision specimen.

Discussion

The authors' technique of computer-aided planning uses Microsoft Powerpoint® as a framework for image manipulation. This software performs all required functions, is readily available in most plastic surgery departments and the majority of surgeons are familiar with its use. Although the drawing tools are a feature not used in most presentations, their functionality is consistent with the entire Microsoft Office Suite and Microsoft's on-line help and tutorials are easily accessed and user-friendly.

Sarcoma resections are often lengthy, complex procedures and the adequacy of the tumour clearance is a major determinant of outcome.⁵ The visual plan optimises the potential to meet surgical and oncological goals, and serves as an excellent adjunct to the operation note for documentation of the procedure. The detail contained in the plan is easy to assimilate and provides nursing staff and physiotherapists with clear information regarding those structures that have been removed and those that remain, thereby helping to guide postoperative care and rehabilitation regimens.

Figure 11 Case 4 – computer-aided operative plan.

Figure 13 Case 4 – excision defect and following reconstruction with a pennant flap.

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