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## Original Article

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# Appropriate Wound Closure after Malignant Soft Tissue Tumor Excision : Need for Flap Surgery in Recurrent Tumors

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### Abstract

In recent years, multidisciplinary treatment advances have made limb salvage possible even in cases of recurrent malignant tumors. The key to prevent deep infection is successful wound closure. We investigated reconstruction techniques and clinical outcomes after wide resections of soft tissue tumors in 146 patients. There were 103 properly resected primary tumors, 15 improperly resected primary tumors, and 28 recurrent tumors. Among 107 cases in which direct wound closure was performed, 105 epithelialized without additional surgery other than secondary suturing, while 2 required additional surgery. In contrast to the 80% of properly resected primary tumor cases that employed direct wound closure, among improperly resected primary tumors, only 33% employed direct wound closure, while flaps were required in 40%. All recurrent cases that required reconstruction employed skin flap surgery. In improperly resected cases, preparing for skin reconstruction is essential. In recurrent cases, preparation must be made for flap reconstruction.

**Keywords** : malignant soft tissue tumor, unplanned resection, reconstruction, reconstruction ladder, wound closure

### Introduction

In recent years, multidisciplinary treatment advances have made limb salvage possible even in cases of recurrent malignant bone and soft tissue tumors<sup>1)</sup>. Successful wound closure is the key to prevent deep infection<sup>2)</sup>. A possible factor affecting wound closure is a history of tumor treatment. The term “unplanned excision” was first described by Giuliano and Eilber<sup>3)</sup> and later by Noria et al.<sup>4)</sup>, to describe tumor resection without preoperative diagnostic modalities and without the intent to achieve tumor-free margins. As soft tissue sarcomas are rare and unsuspected, inadequate or inappropriate evaluation and treatment by plastic, general, and orthopedic surgeons is common<sup>5)</sup>, occurring in up to 50% of the

cases<sup>5)-7)</sup>. However, the degree to which these procedures adversely affect definitive treatment is uncertain<sup>8)</sup>.

In unplanned excision, the prior incision as well as any involved surrounding tissue needs to be excised during an additional wide resection. In many cases, reconstruction is required after unplanned excision due to skin loss resulting from the wide resection<sup>9)10)</sup>. In recurrent tumor cases, there may be scarring, loss of surrounding tissue volume, and/or deep tumor progression. Therefore, skin reconstruction is likely to be necessary when wide resection is performed. However, little is known about which reconstruction technique should be used in such cases. Moreover, when the skin defect after sarcoma resection is large and there is doubt whether direct closure is possible,

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**Table 1** Patient characteristics

Characteristic	Proper first resection (n = 103)	Improper first resection (n = 15)	Recurrent tumor (n = 28)
Sex, n			
Male	61	10	12
Female	42	5	16
Age, mean $\pm$ SD, y	58.5 $\pm$ 20.8	62.5 $\pm$ 20.9	69.2 $\pm$ 18.1

There was no significant difference in the mean age among groups.

to our knowledge, there is no guideline pertaining to the direct closure of the defect.

In order to practice appropriate wound closure, we classified cases of malignant soft tissue tumor surgery performed at our hospital as either surgery for a primary tumor, surgery following an unplanned excision, or surgery for a recurrent tumor, and then examined the postoperative outcomes according to the chosen surgical technique : direct wound closure, placement of a skin graft, or skin flap surgery.

### Materials and Methods

We retrospectively reviewed 146 patients who underwent wide resection of malignant soft tissue tumors between January 2014 and February 2018. There were 83 male and 63 female patients, with a mean age of  $60.9 \pm 20.8$  years (range, 4–93 years ; Table 1). We classified the cases into 3 groups—properly resected primary tumor (surgery for a primary tumor), improperly resected primary tumor (surgery following an unplanned excision), and recurrent tumor (surgery for a recurrent tumor)—according to each patient’s treatment history, and retrospectively examined the cases according to whether or not skin reconstruction was performed, the type of reconstruction technique, and the postoperative outcomes.

Institutional review board approval and patient consent were obtained.

### Wound closure technique

Essentially, we followed the reconstruction

ladder when closing wounds after tumor excision<sup>11</sup>). When the skin defect was predicted to be large, and the possibility of direct closure was doubtful at the preoperative planning stage, we made preparation for reconstruction using a skin flap or skin graft. The preoperative plan was later adjusted as appropriate during surgery. After undermining the surrounding soft tissue, we attempted to close the wound directly using relatively small sutures, such as 3–0 nylon or 3–0 Surgilon braided nylon sutures (Medtronic, Minneapolis, MN, USA). We limited the size of the temporary sutures to avoid too much tension at the time of direct wound closure. When the wound did not separate with movement of the joints or trunk, we closed the wound directly in the direction of lowest tension. If the tension was too much, and the wound could not be closed using temporary sutures, we attempted to cover the capsular ligament and tendons, blood vessels, and nerves with skin or muscle. If this worked out, a skin graft was placed over the muscle. If those tissues could not be covered, flap surgery was selected.

### Statistical analyses

Differences in clinical characteristics between groups were compared using 1-way analysis of variance and Fisher’s exact test. The significance level was set at  $P < 0.05$ .

### Results

There were 103 properly resected primary

**Table 2** Reconstruction techniques

Technique	Proper first resection (n = 103)	Improper first resection (n = 15)	Recurrent tumor (n = 28)
Direct closure	82 (80.0)	5 (33.0)	20 (71.0)
Skin graft	8 ( 7.8)	4 (26.7)	0
Skin flap (pedicle, free)	13 (12.6)	6 (40.0)*	8 (29.0)*

All values are n (%).

\*There was a significant difference in the use of the skin flap technique between the Improper first resection and Recurrent tumor groups.

(p value = 0.00052).

**Table 3** Average operating time for each reconstruction technique with SD (minutes)

Free flap	Pedicle flap	Skin graft	Direct closure
605 ± 145.6	332 ± 73.0	202 ± 77.4	174 ± 127.0

**Table 4** Wound closure cases and rate of each Technique without a reoperation

Direct closure	105 cases	98.1%
Skin graft	10 cases	83.3%
Skin flap (pedicle, free)	25 cases	92.6%

tumors, 15 improperly resected primary tumors, and 28 recurrent tumors. There was no significant difference in the mean age among groups (Table 1).

As shown in Table 2, the reconstruction techniques for the primary tumor cases included 82 cases of direct wound closure (80%), 8 skin graft cases (7.8%), and 13 cases of skin flap surgery (12.6%). Among the cases of additional wide resection of improperly resected primary tumors, there were 5 cases of direct wound closure (33%), 4 skin graft cases (26.7%), and 6 cases of skin flap surgery (40% ; Table 2). Among the recurrent tumor cases, there were 20 cases of direct wound closure (71%), 0 skin graft cases, and 8 cases of skin flap surgery (29% ; Table 2). While direct wound closure was employed in 80% of primary tumor cases, among improperly resected primary tumors, only 33% were closed directly and flaps were required in 40% (Table 2).

The frequency of skin reconstruction was significantly different between cases of additional wide resection for unplanned excision and primary tumors. All recurrent cases that required reconstruction employed skin flap surgery.

Recurrent cases required flap coverage significantly more often than primary cases. The mean operating time was 605 minutes for free-flap reconstruction, 332 minutes for pedicle-flap reconstruction, 202 minutes for skin graft, and 174 minutes for direct closure (Table 3). Differences between groups were statistically significant when analyzed by 1-way analysis of variance.

Of the 107 cases in which direct wound closure was performed, 105 (98.1% ; Table 4) epithelialized without any additional surgery other than secondary suturing. Two patients requiring additional procedures suffered from infections that developed in the dead space. A de-epithelialized flap and muscle flap were used to fill the

wound. Ultimately, epithelialization was observed in all cases.

Of the 12 skin graft cases, epithelialization was obtained in 10 cases (83.3% ; Table 4). 1 properly resected primary tumor case and 1 improperly resected primary tumor case involving the shoulder area underwent repeat skin flap surgery at 10 and 30 months postoperatively. When last observed at follow-up, epithelialization was observed in both cases.

Flap surgery was performed due to insufficient muscle coverage. Among the 27 cases in which skin flap surgery was performed, 25 cases (92.6% ; Table 4) closed without a reoperation. In 1 primary tumor case, skin flap surgery was repeated due to partial necrosis of the flap. In 1 recurrent tumor case, dehiscence was observed on the 20<sup>th</sup> postoperative day and additional flap surgery was performed. In another recurrent case, there was skin breakdown caused by tumor recurrence.

### Discussion

Various wound closure techniques are available to the reconstruction surgeon. A fundamental principle of wound closure is the concept of the "reconstruction ladder<sup>11)</sup>," and the choice of closure should start with a simple approach, such as direct closure. However, there is little knowledge about the extent of skin defect that can be closed directly without complications. Furthermore, there is little information about the features of skin reconstruction for cases with prior treatment, such as recurrent tumors or additional wide resection for unplanned excision.

First, we focused on the decision making for direct closure. To our knowledge, there is no guide to determine whether the skin defect after sarcoma resection can be closed directly. In this study, after undermining the surrounding soft tissue, we attempted to close the wound directly using relatively small sutures as temporary sutures. When the wound remained closed and stable and did not separate with movement of the

joints or trunk, we closed the wound directly in the direction of lowest tension. Direct closure under this threshold of skin tension resulted in 100% closure for primary tumor resection and additional wide resection, and 90% closure for recurrent tumor wide resection without secondary procedures except secondary sutures. Two patients requiring additional procedures suffered from infections in the dead space, and there was no lack of skin. Thus, we consider these judgements for safe wound closure after tumor excision to be appropriate. Until now, these judgements were made on the basis of the surgeon's experience and opinion alone. We believe that the small temporary sutures provide some reference for safe direct wound closure. However, there remains the possibility that tighter closure after resection is acceptable.

In the 2 patients who developed infections in the dead space, a de-epithelialized flap and muscle flap were used to fill the wound, and epithelialization was observed in both cases. Contrary to the recurrent tumor cases, in the primary tumor or unplanned excision cases, there was no case of dead space infection that required flap reconstruction. In recurrent tumor cases, there may be scarring, loss of surrounding tissue volume, and/or deep tumor progression. Because of the rigidity of the scar tissue and the loss of soft tissue volume in these cases, mechanical closure of the dead space was impossible. Conservative treatment for the dead space infections also became difficult because of the scar tissue and large soft tissue defects, which required secondary flap filling. There was no shortage of skin in these 2 cases. We should pay more attention to the dead space created during sarcoma wide resection in recurrent cases.

If the wound could not be covered with skin graft, flap surgery was performed. In this study, in the reconstruction of recurrent tumor cases, all procedures employed flap surgery. Flap coverage requires more sophisticated techniques and longer operating time. However, it seemed

difficult to close the wound in recurrent cases because the rigid scar tissue and loss of soft tissue volume made it impossible to cover the capsular ligament and tendons, blood vessels, and nerves with skin or muscle.

Regarding prior treatment (as previously reported<sup>9)10)</sup>, additional wide resection after unplanned tumor excision tends to be more extensive than primary resection because tumor bed excision is recommended in most cases<sup>8)12)~14)</sup>. While direct wound closure was employed in 80% of properly resected primary tumor cases, only 33% of wounds were closed directly in improperly resected primary tumors, while flap surgery was required in 40%. These results are similar to those of a previous report by Arai et al.<sup>10)</sup>. These findings clearly show the negative effect of unplanned excision. These patients underwent longer, and more invasive surgeries compared to patients who were treated appropriately. This negative impact of unplanned excision should be useful information to plastic, general, and orthopedic surgeons.

Our hospital's judgements regarding direct wound closure after wide resections of malignant soft tissue tumors were generally appropriate. In improperly resected cases, preparing for skin reconstruction is essential. In recurrent cases, preparation must be made for flap reconstruction.

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(和文抄録)

## 悪性軟部腫瘍切除後の適切な創閉鎖：再発症例での皮弁の必要性

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近年, 悪性骨軟部腫瘍の集学的治療の進歩により再発症例においても患肢温存が可能になってきている. 創閉鎖の成否は深部感染の予防の鍵を握っている.

今回我々は, 146 人の軟部腫瘍広範切除後患者の再建法と臨床成績を調査した.

初回適切切除は 103 例, 初回不適切切除は 15 例, 再発は 28 例であった.

直接縫合が行えた 107 症例のうち 105 例は二次縫合以外の追加手術なしで上皮化したが, 2 例で追加再手術を要した. 適切切除症例では 80% で直接縫合が行えたのに対して, 不適切切除症例では 33% しか直接縫合が行えず, 40% で皮弁を要した. 再発例で再建を要する場合は全て皮弁術であった. 不適切切除症例は皮膚再建の準備が必要である. 再発症例は皮弁による再建を準備すべきである.

**キーワード** : 悪性軟部腫瘍, 不適切切除, 再建, リコンストラクションラダー, 創閉鎖