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Simple skin-stretching device in assisted tension-free wound closure

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Abstract

Background—Numerous conventional wound reconstruction methods such as wound undermining with direct suture, skin graft, and flap surgery can be used to treat large wounds. The adequate undermining of the skin flaps of a wound is a commonly used technique for achieving the closure of large tension wounds; however, the use of tension to approximate and suture the skin flaps can cause ischemic marginal necrosis. The purpose of this study is to use elastic rubber bands to relieve the tension of direct wound closure for simultaneously minimizing the risks of wound dehiscence and wound edge ischemia that lead to necrosis.

Materials and Methods—This retrospective study was conducted to evaluate our clinical experiences with 22 large wounds, which involved performing primary closures under a considerable amount of tension by using elastic rubber bands in a skin-stretching technique following a wide undermining procedure. Assessment of the results entailed complete wound healing and related complications.

Results—All 22 wounds in our study showed fair to good results except for one. The mean success rate was approximately 95.45%.

Conclusion—The simple skin-stretching design enabled tension-free skin closure, which pulled the bilateral undermining skin flaps as bilateral fasciocutaneous advancement flaps. The skin-stretching technique was generally successful.

Keywords

Elastic rubber bands; simple skin-stretching device; tension-free wound closure; tension-relief wound closure

Large wounds are common problems related to traumatic defects, tumor ablations, pressure sores, and surgical debridement in wound complications and donor sites of rotation-

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advancement flaps. Several conventional wound reconstruction methods, such as wound undermining with direct suture, skin graft, and flap surgery can be used to treat large wounds. Adequately undermining the skin flaps of a wound is a commonly used technique for achieving the closure of large wounds; however, using tension to approximate and suture the skin flaps can cause ischemic marginal necrosis. Our study describes using elastic rubber bands as a potential skin-stretching device in assisted wound closure. The skin-stretching design enabled tension-free skin closure, pulling the bilateral undermining skin flaps as bilateral fasciocutaneous advancement flaps. Based on the viscoelastic properties of normal skin, a skin-stretching device can use constant traction and maintain approximation to facilitate closing large wounds without applying tension.

MATERIALS AND METHODS

A retrospective review was conducted of 22 patients who were treated from June 2004 to June 2011 with elastic rubber bands as a skin-stretching device in assisted tension-free wound closure (Table 1). The patient group comprised 15 men and 7 women with ages ranging from 22 to 88 years (mean: 62.73 y). Our experiences entailed applying the skin-stretching technique to 4 backs (18.2%), 1 chest wall (4.5%), 2 abdominal walls (9.1%), 6 buttocks (27.3%), and 9 hips (40.9%). The underlying diseases and conditions comprised tumor ablations in 2 cases (9.1%), surgical debridement in wound infections and complications in 6 wounds (27.3%), pressure sores in 10 cases (45.4%), and donor sites of rotation-advancement flaps in 4 cases (18.2%). The various locations of the tension wounds and underlying diseases and conditions are listed in Table 2. The defect sizes ranged from 6 × 4 cm to 25 × 15 cm (mean size: 9.59× 5.86 cm).

The average follow-up period was 10.5 months (range: 1 month–6 years). All patients were followed up in an outpatient clinic or through telephonic interviews. A completely healed wound is a favorable result, whereas an unhealed or infected wound is a poor result.

A rating from 3 to 4 on the pain scale indicated “tolerable to distress.” An oral pain killer relieved anchorage pain. However, the other patients seldom complained of anchorage pain, particularly in the cases of old CVA or spinal cord injury with paraplegia.

Furthermore, according to the Stony Brook Scar Evaluation Scale (SBSES) (Singer et al., 2007), it incorporates assessments of individual attributes with a binary response (1 or 0) for each scar component as well as overall appearance. The SBSES assessed the following five scar components: width, height or depth, color, suture marks, and overall appearance. Each scar was assigned a score of 0 or 1 for the presence or absence of the following: width greater than 2 mm, elevation or depression, discoloration, suture or staple marks, and overall poor appearance, with a total sum range of 0 (worst) to 5 (best). The SBSES has only recently been proposed for use in research, because it was designed to measure short-term rather than long-term wound outcomes. Although the scar scale provides short-term wound outcomes, it has potential for use in scoring long-term wound outcomes.

Surgical technique

After debridement or excision of the lesion, adequate undermining of the wound's skin flaps is performed. However, approximating and suturing these large wounds could involve a degree of tension, which might cause ischemic necrosis along the skin edges. Determining which large defects are suitable for skin-stretching methods entails assessing the wound size as well as the mobility and quality of the neighboring cutaneous condition. We suggest that pinching the bilateral skin flaps may facilitate assessing their mobility and suitability for stretching by hands. Following the primary closure of large wounds, four hemostatic forceps were applied to maintain adequate tension in the elastic rubber bands extending across the sutured wound (Fig. 1A), and skin staples or nylon thread was used to tack the sterile elastic rubber bands, anchoring them to the normal skin at 2–8 cm from the wound margin (Fig. 1B). The anchoring distance varied according to the defect size of the lesion and the anatomic location. Thus we used a skin-stretching device that facilitates healing under relatively tension-free conditions for assisted wound closure.

The brand of skin stapler used in our hospital is Weck® VISISTAT® Skin Stapler 35W. The staples are 6.5 mm wide × 4.7 mm long, but the anchorage depth is <5 mm. When we applied the skin staples directly on the back, putting extra stitches using 3-0 nylon for attaching the skin staplers to the skin was recommended in order to reinforce the anchor sites and prevent the skin staplers from being pulled out. Moreover, severing the rubber bands with skin staples without cutting the skin is difficult and requires caution.

Although establishing appropriate skin-stretching conditions on both sides of a wound is crucial, excessive tension should be avoided. The undue elastic pressure could injure normal skin flaps. Patients perceive pain from staple anchorage due to excessive tension on the elastic rubber bands. The elastic rubber bands can be looped as necessary when they applied to larger wound defects. It was suggested that the elastic rubber bands were generally left in place for approximately 10–28 days (mean: 19.36 days), depending on the anatomic locations.

Case report

Case 1—A 76-year-old man with an old CVA was a long term bed-ridden patient. He had a stage IV large pressure sore on the right hip, approximately 20 × 7 cm^2 in size (Fig. 2A), with an underlying large infected dead space, approximately 25 × 15 cm^2 in size (Fig. 2B). Following serial debridement and negative pressure wound therapy, the large wound of right hip presented tension wound suture. The skin-stretching device was used to reduce the tension at the wound edge (Fig. 2C). The wound healed completely on Day 54 after the operation. The surrounding scars of the anchorage areas were reasonable and acceptable (Fig. 2D).

Case 2—A 60-year-old man, who was diagnosed with liposarcoma of the upper back, underwent a wide excision with a 3-cm surgical margin. After total resection, a large wound approximately 19 × 8 cm^2 in size was observed on the back (Fig. 3A).

After the wound was undermined and closed, the simple skin-stretching device was applied to provide tension-relief and assist wound closure (Fig. 3B). The wound healed completely 1 month after wound closure. However, the short-term outcome of the surrounding scars of the anchorage areas was poor (Fig. 3C).

Case 3—A 41-year-old woman presented with a stage IV pressure sore of the sacral area with an underlying infected bursa and dead space. The pressure ulcer was extensively debrided and subjected to subsequent reconstruction using the left unilateral gluteus maximus myocutaneous flap. However, the donor-site of the left buttock developed a large infected wound (8×5 cm^2 in size) following serial debridement (Fig. 4A). This large wound exhibited tension wound closure; therefore, we applied the proposed skin-stretching device to decrease the closure tension of the flaps at the harvest donor site (Fig. 4B). The wound was completely healed 4 week after wound closure. However, the short-term outcome of the surrounding scars of the anchorage areas was poor (Fig. 4C).

RESULTS

Of the 22 patients in the study, 21 (95.5%) patients were able to have their tension wounds closed by applying the proposed skin-stretching device; nevertheless, for ultimate wound healing, the wound of one (4.5%) patient required a bilateral, bipedicled abdominal skin flap in order to reconstruct a mid-abdominal, full-thickness defect with exposure of internal intestines.[1,2,3] No major complications were encountered in this study; minor complications comprised poor surrounding scars from extra staples or additional suture areas in 9 (40.9%) patients and pain from staple anchorage in 6 (27.3%) patients who were subjected to excessive rubber-band tension. Scars result from the healing process. However, these poor surrounding scars will become inconspicuous with time (Fig. 5A–D).

Most of the patients reported ratings from 3 to 4 on a comparative pain scale at anchorage sites on the trunk, particularly within 2 or 3 days after surgery. The comparative pain scale was developed in 2002 by Jack Harich.[4]

DISCUSSION

The viscoelastic properties of mechanical creep and stress relaxation in the skin[6] were described more than 40 years ago. Based on the viscoelastic properties of normal skin, a skin-stretching device can use constant traction and maintain approximation to facilitate closing large wounds without applying tension. Many surgical designs[7–11] are available for treating large wound closures, but most special devices based on these designs require additional equipment and materials to achieve gradual wound closure. Using skin-traction beyond this level was reported by Escalera,[12] who attached rubber bands to staples applied to the skin edges. Various types of skin-stretching device have been described, such as the 4 Kirschner pins that Bashir[13] inserted around a wound. The silver wires were looped around the crossing points of the K-pins and passed through the skin to the center of the wound, where they were twisted on each other. The Sure-Closure Skin-Stretching System was first introduced by Hirshowitz et al.[14] Lee[15] developed another novel device for achieving and maintaining wound closure that entailed the serial tightening of loop sutures. Marek[16]

described a technique that involves using spinal needles, in which towel clips and the natural stretching ability of the skin enable the primary closure of wounds.

We applied a skin-stretching technique to relatively large wounds, thus performing primary closures under a considerable amount of tension following a wide undermining procedure. Determining the extent of undermining is necessary. Quantifying the extent of wound undermining to compromise the circulation of skin flap is difficult. In general, we performed extensive wound undermining until wound approximation and closure occurred by pinching bilateral skin flaps to enable the wound to suture before applying the skin-stretching device. However, if the stretching skin flap showed a pale color without bleeding, the simple skin-stretching device could not be applied.

If despite extensive wound undermining, wound approximation and closure by pinching bilateral skin flaps cannot be achieved, other optimal skin-stretching devices, skin grafts, or regional flaps should be used instead of the simple skin-stretching device.

The simple skin-stretching technique could be applied at multiple anatomic locations such as the scalp, upper back, lower back, hip, buttock, anterior chest wall, abdominal wall, upper extremities, and lower extremities.

We selected 22 patients whose wounds were mainly located on the trunk because these anatomic areas could be easily subjected to more extensive wound undermining than other areas could. Moreover, most of the patients could tolerate anchorage pain on trunk to a greater extent than on the scalp or distal leg. The comparative pain scale score for anchorage pain on the scalp and distal leg is approximately 5–6 (highly distressing to intense). Wound size was not the primary factor in deciding whether or not the skin-stretching device should be used for allowing wound closure or assisting in tension wound closure. Therefore, the decision to apply the skin-stretching device was more subjective than objective.

In our study, we chose to use the elastic rubber bands in our simple skin-stretching appliance for assisted tension-relief wound closure because the rubber bands are soft and elastic and provide the dynamic expansion and contraction necessary for harnessing undermined skin flaps as advancement flaps.

The easy-to-use device offers problem-free, convenient use for the back and buttocks in particular. Suitable and efficient utilization of the skin-stretching system has facilitated reducing the demand for skin grafting or local flaps for certain high-tension wounds. We also placed a bulky dressing on suture wounds as a reproducible tie-over dressing[17] to compress the underlying dead space of the back and to decrease seroma formation.

The main advantages of using elastic rubber bands for the skin-stretching method are that it is a simple, safe, easy-to-learn, easy-to-use, time-saving, and reliable technique that does not necessitate acquiring any extra, expensive equipment. The elastic rubber bands provide a dynamic, elastic quality and are strong enough to support effectively and securely stabilizing the skin flap. The common disadvantages of the skin-stretching method included the following: (1) surrounding wounds and scars from the extra staples or additional suture areas, (2) pain from staple anchorage when there is excessive tension on the elastic rubber

bands, and (3) undue elastic pressure can injure normal skin flaps. The method cannot be applied to either scarred areas or skin flaps with insufficient undermining; reconstructing such large defects can be performed by employing other optimal skin-stretching devices[18,19] or by using skin grafts, regional flaps, or even free flaps.

CONCLUSIONS

This simple skin-stretching technique can be used in cases entailing assisted tension wound closure of a relatively large wound, which might complicate performing tension-free wound closure by using conventional methods. The skin-stretching device can provide tension-free skin closure by pulling bilateral undermining skin flaps as advancement flaps, thus decreasing the use of additional skin grafting or regional flap surgery. The literature contains many skin-stretching options that can also be used in treating large wounds. We advocate incorporating elastic rubber bands into a simple skin-stretching method; the advantages include ease of use, low cost, and reliability in improvising a wound closure appliance, which can be used without difficulty or inconvenience, particularly for the back and buttocks. Using elastic rubber bands to design a simple skin-stretching device is one of the ideal methods for use as required in assisted high-tension wound healing.

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Figure 1A.

Figure 1B.

Figure 1.

Figure 1A. Following the primary closure of large wounds, four hemostatic forceps were applied to maintain adequate tension in the elastic rubber bands extending across the sutured wound.

Figure 1B. Skin staples or nylon thread was used to tack the sterile elastic rubber bands, anchoring them to the normal skin at 2–8 cm from the wound margin.

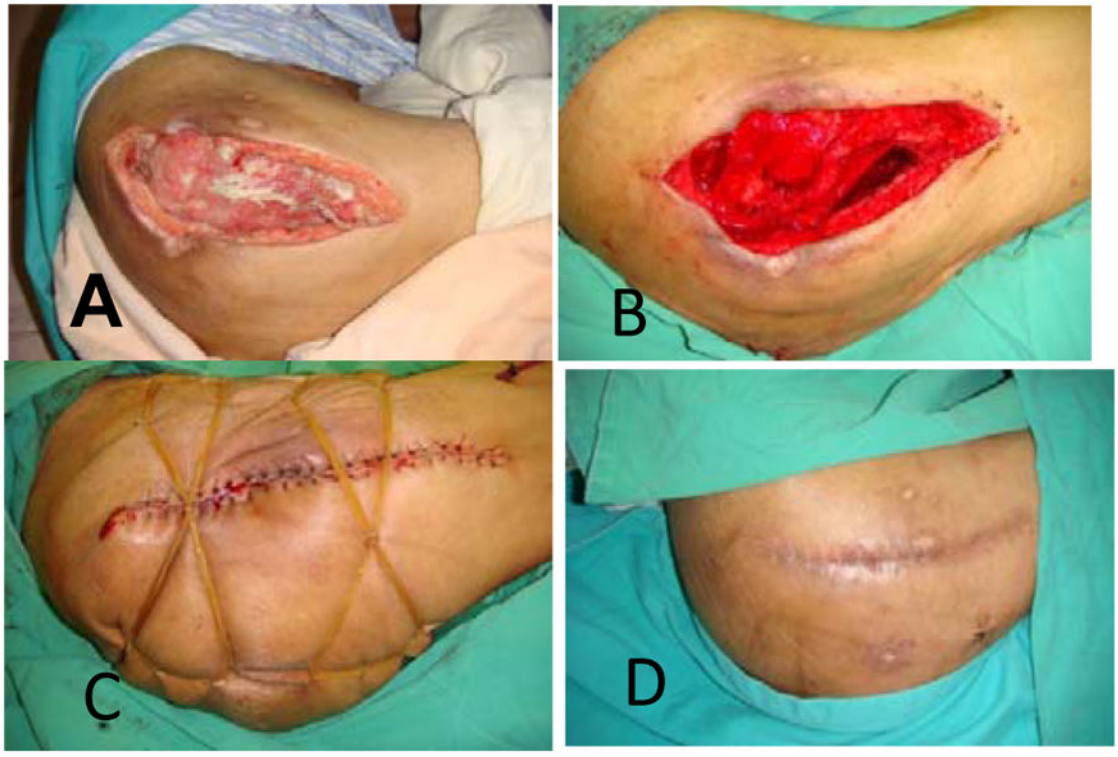

Figure 2A–D. A 76-year-old man suffered a stage IV large pressure sore of the right hip, approximately 20 × 7 cm^2 in size, with the presence of underlying large infected dead space, approximately 25 ×15 cm^2 in size

(A) Right hip wound (20 × 7 cm^2)

(B) Right hip wound (25 × 15 cm^2) following serial debridement and infection control.

(C) The simple skin-stretching device used in assisted tension-free wound closure

(D) The wound was completely healed on Day 54 after the operation.

The surrounding scars of anchorage areas showed fair and acceptable.

SBSES=3: Width: 0, Height: 1, Color: 1, Marks: 0, Appearance: 1.

Figure 3A–C. A 60-year-old man was diagnosed with liposarcoma of the upper back. He underwent a wide excision with a 3-cm surgical margin

(A) Back wound (19 × 8 cm^2)

(B) The simple skin-stretching device that used elastic rubber bands in assisted tension-relief wound closure.

(C) The wound was completely healed by the 1-month follow-up after wound closure. The short-term outcome of surrounding scars of anchorage areas showed poor.

“SBSES=1: Width: 0, Height: 1, Color: 0, Marks: 0, Appearance: 0.”

Figure 4A–C. A 41-year-old woman suffered a stage IV pressure sore of the sacral area with underlying infected bursa and dead space. The pressure ulcer was widely debrided, followed by reconstruction with the left unilateral gluteus maximus myocutaneous rotation-advancement flap

(A) The donor-site of the left gluteal area developed a wound infection with the presence of large open wound (8×5 cm^2) following serial debridement.

(B) The simple skin-stretching device that used elastic rubber bands reduced the tension at the donor-site closure.

(C) The wound was completely healed by the 4-week follow-up after wound closure. The short-term outcome of surrounding scars of anchorage areas showed poor. “SBSES=1: Width: 0, Height: 1, Color: 0, Marks: 0, Appearance: 0.”

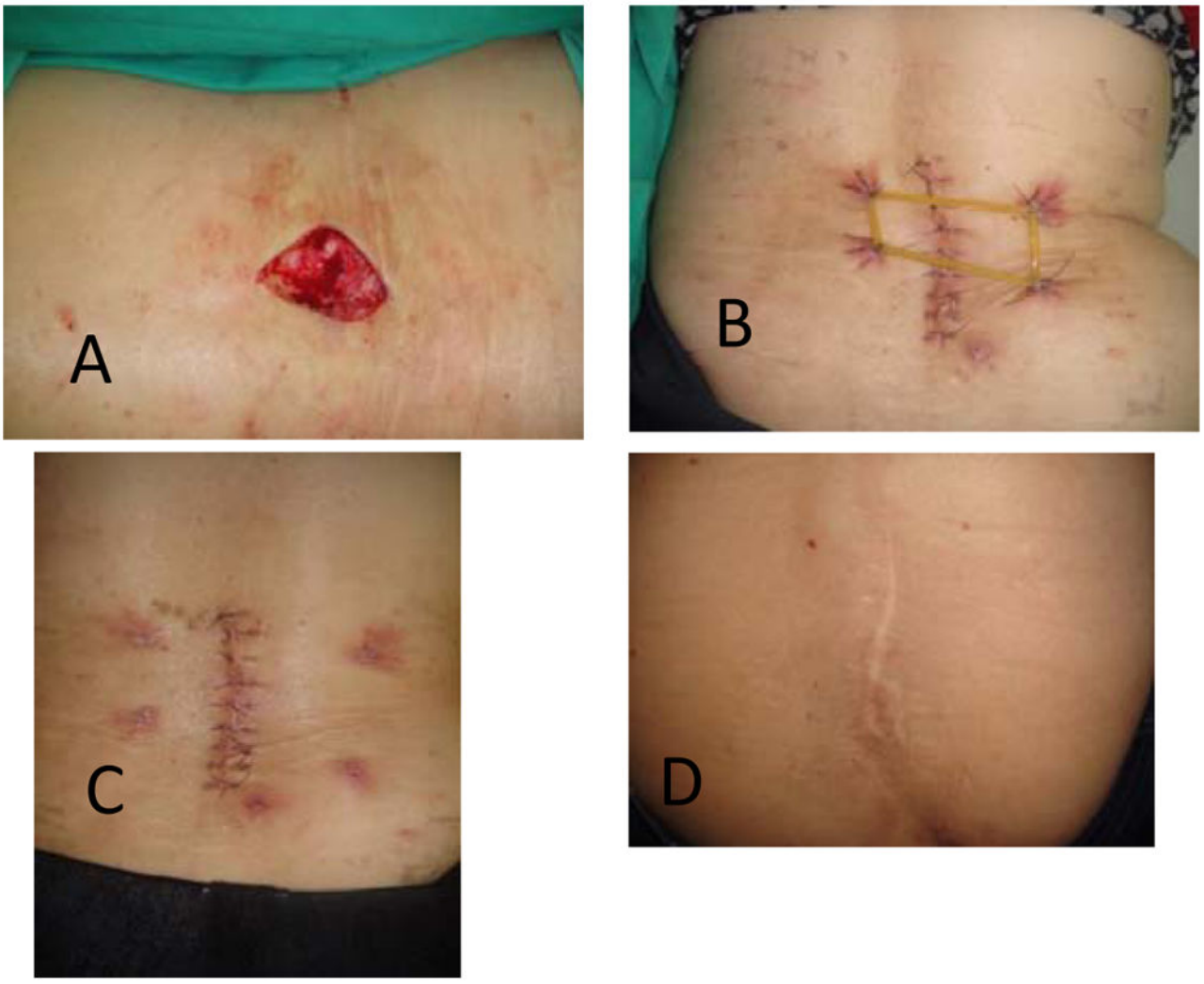

Figure 5 A–D. A 50-year-old woman with an infected wound, resulting from an epidural catheter infection, on the lower back with an underlying infected, large dead space

(A) An infected wound of the lower back with underlying large dead space (6 × 4.5 cm^2) following serial debridement.

(B) The simple skin-stretching device that used elastic rubber bands reduced the tension at wound closure.

(C) The wound was completely healed by the 24-day follow-up after wound closure. The short-term outcome of the surrounding scars of anchorage areas was poor.

(D) After a 6-year follow-up, the surrounding scars of the anchorage areas of the lower back became inconspicuous (long-term outcome).

"SBSES=4: Width: 1, Height: 1, Color: 1, Marks: 0, Appearance: 1."

Table 1

Patient Summary

Case No.	Sex/Age (years)	Cause of wound	Wound location	Defect size (Cm^2 in size)	Duration of Stretching time (days)	Result	surrounding scar
1	M/60	Tumor excision	Upper back	19 × 8	23	good	poor
2	M/77	Tumor excision	Upper back	6 × 6	10	good	fair
3	M/76	Wound complication	Low back	12 × 5	12	good	fair
4	M/59	Donor site	chest wall	12 × 5	15	good	fair
5	M/62	Wound complication	Abdominal wall	12 × 5	14	good	fair
6	M/41	Wound complication	Abdominal wall	16×13	27	Poor	poor
7	F/58	Wound infection	Left buttock	15×12	14	good	poor
8	M/56	Pressure sore	Right buttock	6 × 4	15	good	fair
9	F/41	Wound complication	Left buttock	8 × 5	23	good	poor
10	M/22	Donor site	Left buttock	6× 4.5	27	good	poor
11	F/82	Donor site	Left buttock	8 × 5	17	good	fair
12	M/66	Donor site	Left buttock	6 × 4	21	good	poor
13	M/75	Pressure sore	Right hip	25 ×15	28	good	poor
14	F/80	Pressure sore	Right hip	6 ×5	14	good	fair
15	M/82	Pressure sore	Left hip	8 × 4	25	good	fair
16	F/70	Pressure sore	Left hip	8 × 4	20	good	fair
7	M/64	Pressure sore	Right hip	5 × 4	21	good	fair
18	F/88	Pressure sore	Right hip	10 × 5	21	good	poor
19	M/44	Pressure sore	left hip	8 × 6	21	good	poor
20	M/81	Pressure sore	Right hip	7 × 5	21	good	fair
21	M/70	Pressure sore	Left hip	12 × 4	24	good	fair
22	F/50	Wound infection	Low back	6 × 4.5	20	good	fair

Table 2

General Characteristics of Patients (Categorical Variables) ($N = 22$)

Variables	Characteristics	Number of cases	Percentage(%)
Sex	Male	15	68.2
	Female	7	31.8
Age(yrs)	20–50	5	22.7
	51–70	9	40.9
	71–90	8	36.4
Cause	tumor excision	2	9.1
	wound complications	6	27.3
	donor site	4	18.2
	pressure sore	10	45.4
Location	Back	4	18.2
	anterior chest wall	1	4.5
	Abdominal wall	2	9.1
	buttock	6	27.3
	Hip	9	40.9
The duration of skin stretching (days)	10	1	4.5
	11–14	4	18.2
	15–18	3	13.6
	19–22	7	31.8
	23–28	7	31.8
Result	Fair to good	21	95.5
	Poor	1	4.5
Related complications	Poor surrounding scars	9	40.9
Related complications	Pain on anchorage	6	27.3