

# Non-surgical wound closure—a simple inexpensive technique

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## Abstract

**Background** Primary suture closure of wounds is often the optimal solution for soft tissue defect closure because of its simplicity and satisfactory outcome, yet it may be impeded by high-tension closure. The customary application of skin grafts, flaps, free tissue transfer, or tissue expansion is often associated with relatively more complex surgical reconstructive procedures, significant morbidity and extended hospitalization and prolonged recovery period.

**Methods** We retrospectively investigated all patients who underwent wound closure using a mechanical wound closure device between 2014 and 2016 in a tertiary hospital center. The device consisted of stainless steel hooks, sutured over the opposite wound edges, and rubber bands for generating tension which is gradually increased. Approximated wound margins were sutured or allowed to heal by secondary intention.

**Results** The mechanical device was applied in 50 patients. There were 38 males and 12 females. Wound size ranged from 3 to 25 cm. In most of the patients there was a satisfactory wound margin approximation. However, in 6 patients skin hook cut through from wound margins occurred due to excessive rubber band tension. In 5 patients, it was decided to also apply negative-pressure wound therapy along with the device. After application of the wound closure device, a residual raw area remained in other 4 patients in whom a split thickness graft was applied. During follow-up, hypertrophic scar and wound dehiscence were found in 5 patients.

**Conclusions** The mechanical wound closure device herein presented is a simple and inexpensive technique that allows a significant reduction in surgical costs and surgery-related morbidity.

Level of Evidence: Level IV, therapeutic study.

**Keywords** Wound healing · Wound closure · Non-surgical · Rubber band

## Introduction

Primary suture closure of wounds is often the optimal solution for soft tissue defect closure because of its simplicity and satisfactory outcome, yet it may be impeded by high-tension closure. The customary application of skin grafts, flaps, free tissue transfer, or tissue expansion is often associated with relatively more complex surgical reconstructive procedures, significant morbidity, and extended hospitalization and prolonged recovery period. The concept of tissue expansion is an ingenious method of wound closure based on the utilization of the viscoelastic properties of the skin by mechanical creep. It provides excellent quality and matching skin texture and color for coverage of soft tissue loss [1, 2].

Skin stretching, however, is a common surgical procedure to grow extra skin through controlled mechanical overstretching. It creates skin that matches the color, texture, and thickness of the surrounding tissue while minimizing scars and risk of rejection. When the skin is stretched beyond its physiological limit, mechanotransduction pathways are activated. This leads to cell growth as well as to the formation of new cells. In some cases, this may be accomplished by topically applied tissue-stretching devices. These have the benefit of being inexpensive and do not require a surgical procedure to

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**Table 1** Traumatic wounds

No. of patient	Age (in years)/sex	Mode of injury/wound	Site of wound	Size of wound (cm)	Duration of wound closure (days)
1.	12/M	RTA	Upper 3rd leg wound	12 × 9	7
2.	60/M	RTA	Lower 3rd leg wound	15 × 5	6
3.	45/M	RTA	Distal forearm wound	7 × 5	5
4.	40/M	RTA	Wound midline back	11 × 9	6
6	20/M	RTA	Ankle wound	6 × 5	8
7	22/F	RTA	Middle 3rd leg wound	10 × 7	9
8	26/M	RTA	Leg wound	10 × 4	7
9	30/F	RTA	Wound upper 3rd leg	10 × 7	10
10	20/M	RTA	Wound dorsum of foot	8 × 6	6
11	26/M	RTA	Wound forearm	10 × 8	10
12	15/F	RTA	Wound arm	18 × 7	11
13	21/M	RTA	Wound chest	15 × 12	12
14	40/M	RTA	Wound back	10 × 8	8
15	36/M	RTA	Wound posterior aspect thigh	12 × 10	6
16	38/M	RTA	Wound midline abdomen	10 × 6	7
17	16/M	Fall from height	Wound scalp	10 × 7	8
18	40/M	RTA	Wound calf region	13 × 9	12
19	33/M	RTA	Wound anterior aspect leg	8 × 6	7
20	18/F	RTA	Wound middle leg	6 × 5	7
21	46/M	RTA	Lacerated wound lower leg	10 × 4	8
22	26/M	RTA	Wound dorsum of foot	5 × 4	7
23	40/F	RTA	Wound dorsum of hand	6 × 5	6
24	32/M	RTA	Wound anterior chest wall	10 × 8	9
25	55/M	RTA	Lacerated wound leg	10 × 6	9

implant them under the skin. Stretching the skin beyond normal expansion invokes several mechanotransduction pathways which increase mitotic activity and promote collagen synthesis. As a result, the skin surface area increases. Scar excision, followed by direct wound closure, gives the best outcome as it results in a smaller scar [3]. However, large defect closure after burn scar excision can be challenging owing to high skin tension. Hence, it is often done as a multistep procedure for large burn scars [4]. Mechanical skin stretching is a relatively new technique that is gaining increasing scrutiny, especially in the field of wound healing [5].

The TopClosure® Tension Relief System (TRS) is an innovative method that enables the employment of both mechanisms of stress relaxation and mechanical creep for skin stretching. Its use has been previously reported to enable the primary closure of medium to large soft tissue defects [6, 7].

The aim of this article was to analyze our experience with mechanical wound closure device for upper and lower limbs, anterior and posterior trunk, and scalp defect or wound repair and try to determine risk factors for developing complications and reconstruction outcome predictors when this mechanical wound closure is employed.

## Patients and methods

In this study, a total of 50 patients were enrolled between the years 2014 and 2016, aged between 05 and 75 years and having wounds over various parts of the body.

Wounds were managed by using a mechanical wound closure device which contains stainless steel 96 hooks and rubber bands. Steel hooks were sutured at full-thickness skin edges of wound or defect with a non-absorbable suture material (not greater than 5 mm from the wound edges); alternatively, steel hooks were sutured at a margin of an adhesive tape, and the tape was applied over the skin of the wound edges which were engaged by rubber bands on the steel hooks at both edges of the wound. The tension was applied gradually between the two wound edges (frequency depending upon the laxity of the skin, age of the patient, and part of the body involved). However, in chronic wounds, the time required for stretching was prolonged, which was thought to be secondary to fibrosis and edema along the skin margin.

The stretching force was spread over a wide area, thus preventing local tissue damage. There was no undermining

**Table 2** Amputated stumps of limbs

No. of patient	Age (in years)/sex	Mode of injury/wound	Site of wound	Size of wound (cm)	Duration of wound closure (days)
1	20/M	Postoperative	Amputation stump below-knee leg	8 × 8	10
2	25/M	Postoperative	Amputated stump forearm	8 × 8	8
3	36/M	Postoperative	Hip disarticulation with exposed acetabular bone	25 × 25	20
4	18/F	Postoperative	Amputated stump arm	10 × 10	7
5	22/M	Postoperative	Amputated stump mid foot	10 × 3	9
6	40/M	Postoperative	Shoulder disarticulation	12 × 10	10
7	39/M	Postoperative	Amputation at mid thigh	14 × 13	12
8	24/F	Postoperative	Amputation at metatarsal joint great toe	3 × 3	7
9	48/M	Postoperative	Amputation at mid palm level	8 × 3	5

**Table 3** Postoperative partial flap necrosis

No. of patient	Age (in years)/sex	Mode of injury/wound	Site of wound	Size of wound (cm)	Duration of wound closure (days)
1	75/F	Postoperative distal part of flap necrosis	Propeller flap of leg wound	3 × 3	8
2	5/F	Postoperative flap distal margin necrosis	Cross leg flap for dorsum of foot wound	6 × 3	8
3	25/M	Postoperative local transposition fasciocutaneous flap	Distal part of flap necrosis –flap for middle part of leg	3 × 2	5
4	9/M	Postoperative flap margin necrosis	Cross leg flap for dorsum of foot	5 × 3	5
5	35/M	Postoperative flap tip necrosis	Reverse sural flap	4 × 4	5
6	17/M	Postoperative fasciocutaneous flap tip necrosis	Mid leg wound	4 × 3	10

of the wound edges while applying the mechanical wound closure device, which may affect the viability of the newly stretched integument. Approximated wound margin was sutured or allowed to heal by secondary intention.

The device can be applied either preoperatively, intraoperatively, or postoperatively under sterile conditions (steel hooks were autoclaved, and rubber bands were sterilized by using glutaraldehyde solution). While gradually increasing tension over the wound, patient experiences pain, which may help in the judgment of the amount of

tension to be applied to the wound. If the wound was dirty, a negative-pressure wound therapy (NPWT) was applied over the mechanical wound closure device simultaneously. The tension over the wound was gradually increased after removal of the NPWT.

Mechanical wound closure devices are contraindicated under the following conditions:

- When non-viable or atrophic tissue is present at or near the wound edges

**Table 4** Postelectric burn wounds

No. of patient	Age (in years)/sex	Mode of injury/wound	Site of wound	Size of wound (cm)	Duration of wound closure (days)
1	20/M	PEB wound	Mid arm	12 × 8	12
2	26/M	PEB wound	B/L leg	12 × 11	14
3	35/M	PEB wound	Mid thigh	15 × 12	7
4	20/M	PEB wound	Back region	14 × 11	10
5	34/F	PEB wound	Mid forearm	10 × 7	9
6	29/M	PEB wound	Lower-part thigh	9 × 8	11

*PEB* postelectric burn

**Table 5** Others

No. of patient	Age (in years)/sex	Mode of injury/wound	Site of wound	Size of wound (cm)	Duration of wound closure (days)
1	15/F	Fall from height	Scalp wound	5 × 4	8
2	70/M	Pressure sore	Trochanteric region	8 × 7	8
3	50/F	Animal bite injury	Lateral aspect arm	12 × 9	10
4	32/M	Pressure sore	Trochanteric region	10 × 9	12

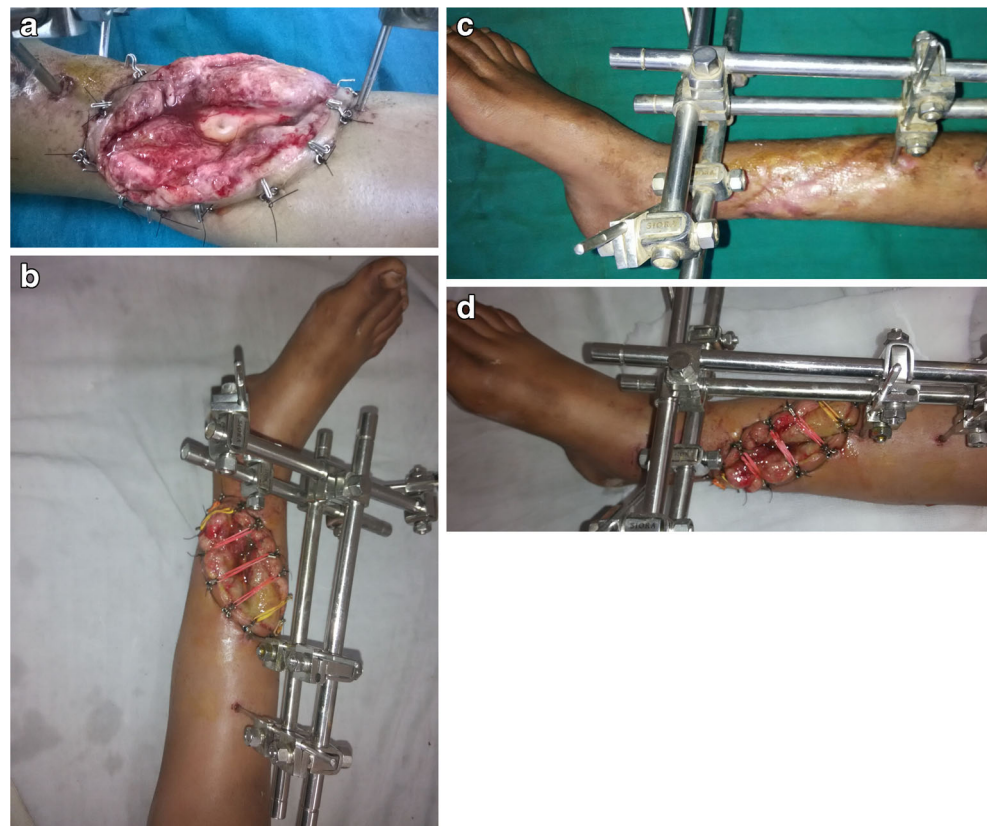
- When previous radiation therapy has been given in the wound area
- When any sign of active infection is present.

## Results

The mechanical wound closure device was applied in 36 patients admitted to the plastic surgery ward while 14 patients were managed on an ambulatory basis. Among 50 patients, there were 38 males and 12 females.

Wound size ranged from 3 to 25 cm. Time to wound closure was quite variable depending on the size and site of the wound. Mode of injuries are summarized in Tables 1, 2, 3, 4, and 5. In most of the patients there was a satisfactory wound margin approximation. However, in six patients, skin hook cut through from wound margins occurred due to excessive rubber band tension, requiring reapplication of hooks at a more proximal site. In five patients, it was decided to also apply negative-pressure wound therapy (NPWT) along with the device. The most common complaint after application of the device was pain, for which oral analgesics were prescribed. After application of the wound closure device, a residual raw area remained in other four patients in whom a split thickness

**Fig. 1** 12-year-old male, RTA (road traffic accident), leg wound



**Fig. 2** **a.** Post-traumatic wound leg in a 35-year-old male patient. **b.** after surgical debridement, **c.** application of hooks and rubber bands; and **d.** closure of the wound after 2-month treatment



graft was applied. Patients were regularly followed up, and when there was wound approximation, wound margins were sutured with non-absorbable sutures. During follow-up hypertrophic scar and wound dehiscence were found in five patients. Representative cases are displayed in Figs. 1, 2, 3, and 4.

In 5 patients, the NPWT was applied along with the mechanical wound closure device whereas in 45 patients, only the mechanical wound closure device was applied.

When skin hook cut through occurred from wound margin in 6 patients due to excessive rubber band tension, the hook was reapplied at the proximal site of the margin. In remaining 44 patients, there was a satisfactory wound margin approximation. Wound margins were sutured with non-absorbable suture after approximation or allowed to heal by secondary intention. Hypertrophic scar and wound dehiscence were present in 5 patients.

After application of wound closure device, the residual raw area was present in four patients in which split thickness graft was applied.

## Discussion

The skin constitutes a dynamic biological structure with unique biomechanical properties that has a role in successful skin stretching. The stretch is related to the viscoelastic nature of the skin. The skin possesses certain qualities like inherent extensibility, biologic creep, mechanical creep, and stress relaxation, which allow large defects to be closed without the use of flaps or grafts. Surgeons can visualize the inherent extensibility of skin when an excised ellipse of skin is closed primarily. Of course, this property varies from one anatomic site to another. The classic pinch test (lifting and folding the skin with one's fingers) can be utilized to estimate the amount of the skin that can be excised and still closed primarily [8]. When excising the skin with two converging semi-elliptical incisions, the length-to-width ratio of the skin ellipse is always an important consideration. The most preferred length-to-width ratio is 3:1. This, however, may be unobtainable for different reasons, making the other viscoelastic properties of the skin extremely important.



**Fig. 3** a. 36-year-old male, RTA, hip disarticulation with exposed acetabulum. b. application of hooks and rubber bands. c. total closure at 16th postoperative day after NPWT

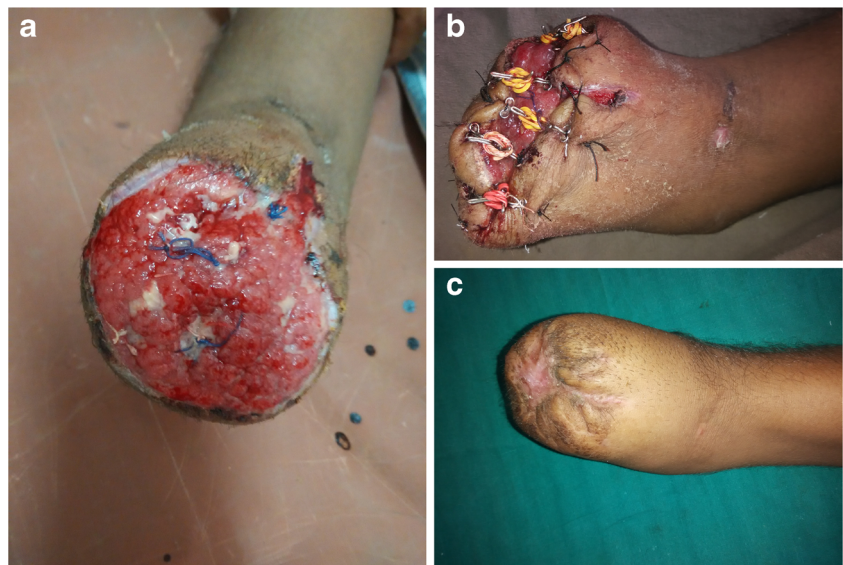
Biologic creep is evident in situations with slowly expanding subcutaneous forces such as tumor, obesity, and the gravid uterus or during the use of subcutaneous tissue expanders. This is not skin stretching, but rather a slow adaptation of tissue. The epidermis responds to expansion with increased mitotic activity in the basal cell layer, but the thickness remains constant. Also noted on histological examination are the thickening of the stratum spinosum and flattening of the rete pegs. The dermis is substantially affected by the expansion. The dermis decreases in thickness; however, there are an increased number of fibroblasts, myofibroblasts, and bundles of collagen that are formed.

Mechanical creep allows the skin to gradually stretch beyond the limits of its normal extensibility. When a consistent, constant load is applied to an area of the skin, that skin increases in length over time. Gibson et al. [9] studied the

behavior of the skin under a load, finding that the microarchitecture of dermal collagen is an important inherent property of mechanical creep. Dermal collagen fibers in the relaxed state are normally arranged in a randomly oriented, convoluted pattern. The collagen fibers of the dermis form an intertwined meshwork, which adapts and changes pattern during stretching or relaxing of the skin. During the stretch, collagen fibers align in the direction of the stretching force. Presuturing and the use of skin stretching devices utilize this property [8, 10]. Initially, when skin is stretched, it will extend a certain distance with little increased load (“limit strain”). Once the majority of the fibers are rearranged parallel to the line of a stretch, the very little extension is obtained due to the fibers resisting further extension (“terminal stiffness”) [9, 11].

Finally, the last property that adds to skin viscoelastic nature is stress relaxation. This relates closely to mechanical

**Fig. 4** a. Reverse sural flap with partial necrosis in a 25-year-old male patient. b. application of hooks and rubber bands; and c. total closure of wound at 8 days postoperative day



creep. Stress relaxation occurs when the skin is stretched a given distance and that distance is held constant; the force required keeping it stretched gradually decreases [12].

### Advantages

1. Closure of defect or wound present over any parts of the body.
2. Gradually reduces the size of infected wounds which are not suitable for skin grafting or flap cover.
3. Repair with like tissue for esthetic appearance.
4. Repair of wounds where sufficient flap cover is not available.
5. Provides sufficient skin of ideal color, texture, and structure to close the defect without creating a secondary defect.
6. Wound closure when skin retraction or deficit presents, a major problem in gaining an edge-to-edge apposition.
7. Mobilizing wound edges over poorly vascularized deep structures, such as the bone.
8. More efficient and cost-effective in closing complex wounds, compared to conventional wound closure methods (flaps and grafts).
9. While it provides skin with a near-perfect match in color and texture, minimal donor site morbidity and scarring occur.
10. Provides tissue with specialized sensory function or adnexal characteristics.

### Clinical uses

1. Closure of open fasciotomies performed for acute compartment syndrome
2. Closure of amputation stump wounds
3. Wound closure involving exposed bone, joint, plates, and screws
4. Wound closure after open fracture
5. Overcoming tissue shortage or scar revision
6. Advancement of short flap due to flap tip or margin necrosis
7. Aids in small pressure sore wound closure

### Disadvantages

- Hypertrophic scars
- Wound dehiscence
- Incomplete wound closure
- Traction necrosis [10, 13]
- Pain

The mechanical wound closure devices used in this study were skin hook and rubber bands, which are very cost-effective in comparison to operative procedures where the patient has to bear the high cost. Also, the cost occurring due to long hospital stay is reduced with this procedure, most of the patients were discharged early after the application of this device and many were managed on an ambulatory basis.

Soft tissue expansion or skin stretching may be used for overcoming a shortage of tissue, for obtaining skin with desirable qualities, for the creation of flaps not otherwise possible, and for minimizing flap donor site problems. This paper presents a new mechanically assisted method of wound closure. This device provides the reconstructive surgeon another option in the treatment of complex wounds. It can serve as an important tool for immediate and delayed primary closure of a wide range of skin defects of various etiologies and as a simple alternative for skin grafts, flaps, microvascular free tissue transfer, and internal tissue expanders, particularly in patients who are not good candidates for anesthesia and prolong surgeries and not willing for surgery. The mechanical wound closure device herein presented is a simple and inexpensive technique that allows a significant reduction in surgical costs and surgery-related morbidity.

### Compliance with ethical standards

**Conflict of interest** G. S. Kalra, Manohar K. Malviya, Ghisulal M. Choudhary, Vipin K. Barala declare that they have no conflict of interest.

**Patient consent** Informed consent was obtained from all individual participants included in the study.

**Ethical approval** For this kind of retrospective study formal consent from a local ethics committee is not required.

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