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WOUND CLOSURE BY USING TY-RAPS: AN INNOVATIVE TOP-CLOSURE.

Plastic Surgery

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ABSTRACT

Different surgical techniques and devices have been utilized for the closure of wounds but they are very expensive. We developed a new, easy and inexpensive dermatotraction technique based on the simple use of Ty-Raps by using biomechanical properties of the skin. In this article, we evaluated its feasibility, the costs, outcomes and the mean time to closure of wound. We concluded that the Top-Closure by Ty-Raps is an innovative technique for wound closure of medium to large skin defects. Complications and donor site morbidities were nil. We appreciate its low cost, general availability and effectiveness.

KEYWORDS

Top-closure, Ty-Raps, Wound closure, Dermotraction.

INTRODUCTION

Many techniques have been applied for closure of large skin defects: skin grafts, local flaps, tissue stretching and expansion, free flaps and closure by secondary intention. Some of these modalities carry considerable morbidity, leading at times to excessive tension and complications during wound closure with prolonged hospital stay, complexity and risks associated with lengthy healing time and are costly to the patient. Previously designed skin stretching devices reported the use of dermatotraction techniques but finally commercially designed devices tend to be expensive and need to be preordered, which can be logistically and financially challenging.

Tension is a principal force experienced by the skin, and with optimal amplitude and waveform, it may aid in facilitating its growth and expansion for early wound closure. Extensible connective tissues (e.g., skin, blood vessels, and fascia) contain networks of fibrous collagen and elastin within the extracellular matrix and in an amorphous matrix, and are affected during mechanical loading[1]. The epidermal and dermal layers of skin consist largely of collagen (about 75% of dry weight) and elastin (4% of dry weight) fibers embedded and floating in a gel-like base.[2] The reorientation of interwoven network of elastin and mainly collagen fibers provide skin the ability to stretch and expand[3], hence displaying a viscoelastic nature with their nonlinear stress–strain curves[4].

Biomechanical properties of the skin, specifically mechanical creep and stress relaxation, allow skin to stretch beyond its inherent extensibility within a relatively short period of time. Mechanical creep is the phenomenon where skin will stretch and elongate with time as long as force is applied. If the skin is stretched to a constant distance in a state of stress relaxation, it will expand, leading to a gradually reduced tension on the skin. As a result of skin stretching and elongation, wound closing tension decreases, allowing primary closure of relatively large defects[5].

Considering all these drawbacks of current closing technique of difficult wounds, we felt the need for a new method that had to be effective, easily applicable, readily available and inexpensive. All these conditions are met with surgical use of Ty-Raps for the delayed closure of extremity wounds. In this article, we present the results of a study using this novel technique, and we evaluate its feasibility, the costs of material and the mean time to closure of wound.

MATERIALS AND METHODS

In this study, a total of 30 patients were enrolled between the years 2015 – 2017 and having surgical wounds over various parts of the body which cannot be closed primarily due to tension on the wound margins. Each patient was pre-counselled and later provided an informed consent.

The criteria for **inclusion**

Patients having surgical wound which cannot be closed by primary suturing.

The criteria for **exclusion**·

- Unavailable/non-viable surrounding soft tissue or skin.
- Circumferential wound of extremity.
- Unrealistic attitude of patients.
- Psychiatric patients.
- Patient not willing for follow-up.
- Presence of active infection.

Parameters Measured

- The time to closure of the wound.
- The time to removal of the Ty-Raps.
- The complications related to the procedure.
- A cost analyses was calculated

Following approval by the institutional ethics committee, the Top Closure by using Ty-Raps was applied in the patients of various surgical wound (Table 1).

Practical Considerations and Technique

The Ty-Rap system consists of a combination of two commercially available Ty-Raps. A Ty-Rap is a cable tie made of a sturdy nylon tape with an integrated gear rack and on one end a ratchet within a small open case. Once the pointed tip of the Ty-Rap has been pulled through the case and past the ratchet, it is prevented from being pulled back (**Figure 1A**).

The nylon tape of one of the Ty-Raps is cut close to the ratchet. Therefore 1 single unit comprises two Ty-Raps, first Ty-Rap is secured to wound margin by surgical staples and another Ty-Rap which was initially cut close to ratchet is passed from the pointing end of first Ty-Rap which moves in single direction and can't be pulled back. Similarly the Ty-Rap system is secured to the skin with surgical staples at an interval of 2 cm (**Figure 1B**).

The Ty-Raps are tightened until light traction of the skin is noticed, and this procedure is repeated with dressing of wound every 24 hours to 48 hours to allow gradual controlled stretching of the underlying skin

until full approximation of the skin edges is achieved **(Figure 1C)**. After the completion of this procedure, the margins are sutured with nonabsorbable suture materials. At the end of the procedure, the wound is dressed in the usual manner with non-compressive dressing. The wound is allowed sufficient time to heal, and the Ty-Raps can be removed at the discretion of the treating surgeon.

Both tightening and removal of the Ty-Raps can be done as a bedside or ambulatory procedure without the need for additional analgesic medication, local anaesthetics or prolonged hospital stay

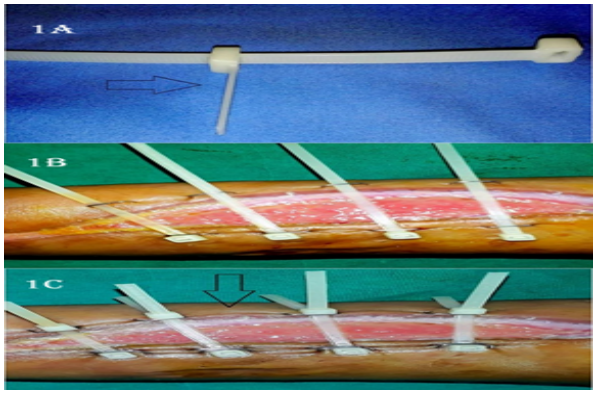

Figure 1A. Showing initially cut Ty-Rap close to rachet is passed from the pointing end of first Ty-Rap which moves in single direction. Figure 1B. Ty-Rap system is secured to the skin with surgical staples at intervals of 2 cm. **Figure 1C.** The Ty-Raps are tightened until light traction of the skin is noticed

RESULT

Total 30 patients were included from October 2015 to August 2017 as shown in Table1. Application of Ty-Raps and there outcomes in various wounds are shown in Figure 2 to Figure 5. Among these 24 were male and 6 were female patients. Mean age was 32.86 years (range, 10–64 years). Wound size ranged from 3 to 8cm in width and 6 to 16 cm in length. All wounds were closed by using the Ty-Raps that was applied as the initial surgical procedure. Time to wound closure was quite variable depending on the size and site of the wound. The mean time from the application of Ty-Raps to complete closure of the wound was 6.93 days (range, 6–10 days), and the mean time from the application to removal of the Ty-Raps was 10.13 days (range, 9–16 days). Both the application and the tightening of the Ty-Raps were well tolerated by all patients, and no procedure had to be discontinued because of patient discomfort. Also, none of the patients developed skin necrosis, and no Ty-Raps had to be preliminary removed. All wounds (100%) healed without complications.

The mean cost was Indian rupees 342.66 (range, Indian rupees 220 to 500). For a regular wound of 15 cm, one needs approx. 20 Ty-Raps (10 assembled systems) at an expense of Indian rupees 60 and one surgical stapler with each 35 staples pin costs Indian rupees 280, so the total costs to close a wound of 15 cm with the use of Ty-Raps was 340 Indian rupees. The Cost of extra suture materials required for final closure of the wound were not included and calculated.

Table 1: Summary of the patients undergone Top-closure.

Etiology	Site	Age (Years)	Defect Size (Length× Width Cm)	Tightening mm/Day (Mean)	Time From Application Of Ty-Raps To Complete Closure(Days)	Time From Application Of Ty-Raps To Removal Of Ty-Raps (Days)	Total Cost (Inr/Rupee)	Complication
Traumatic	Avulsion Dorsum Foot	38	8×3	4	7	10	220	Nil
Gangrene	Fore foot amputated stump	64	12×8	8	10	16	450	Nil
Traumatic	Avulsion Of Heel Pad With Sole	10	15×4	6	8	12	330	Nil
Traumatic	Soft Tissue Loss Of Sole Foot	35	6×4	6	7	10	300	Nil
Fasciotomy	Leg	40	16×6	10	6	9	500	Nil
Traumatic	soft tissue loss Of Sole	12	10×3	4	7	10	360	Nil
Traumatic	Avulsion Of Dorsum Foot	32	8×3	6	6	9	300	Nil
Traumatic	Avulsion Of Dorsum Foot	36	6×3	6	7	9	300	Nil
Traumatic	Scalp defect	42	8×4	6	6	9	300	Nil
Traumatic	Avulsion Of Heel	19	10×4	6	7	10	350	Nil
Traumatic	Tissue Loss Of Lateral Thigh	38	12×5	8	6	10	340	Nil
Traumatic	Soft Tissue Loss Of sole	28	8×3	6	6	9	340	Nil
Fasciotomy	Leg	29	12×5	10	7	10	360	Nil
Fasciotomy	Leg	35	15×5	10	8	10	360	Nil
Fasciotomy	Left Forearm	35	10×4	6	6	9	330	Nil
Gangrene	Fore foot amputated stump	64	12×8	8	10	16	450	Nil
Traumatic	Soft Tissue Loss Of Sole Foot	35	6×4	6	7	10	300	Nil
Traumatic	soft tissue loss Of Sole	12	10×3	4	7	10	360	Nil
Traumatic	Soft Tissue Avulsion Of Dorsum Foot	36	6×3	6	7	9	300	Nil
Traumatic	Soft Tissue Avulsion Of Heel	19	10×4	6	7	10	350	Nil
Traumatic	Soft Tissue Loss Of Lateral Sole	28	8×3	6	6	9	340	Nil
Fasciotomy	Leg	35	15×5	10	8	10	360	Nil
Traumatic	Avulsion Of Dorsum Foot	38	8×3	4	7	10	220	Nil
Traumatic	Avulsion Of Heel Pad With Sole	10	15×4	6	8	12	330	Nil
Fasciotomy	Leg	40	16×6	10	6	9	500	Nil
Traumatic	Avulsion Of Dorsum Foot	32	8×3	6	6	9	300	Nil
Traumatic	Avulsion Of Dorsum Foot	42	8×3	6	6	9	300	Nil
Traumatic	Soft Tissue Loss Of thigh	38	12×5	8	6	10	340	Nil
Electric burn	Scalp defect	29	10×7	10	7	10	360	Nil
Fasciotomy	Left Forearm	35	10×4	6	6	9	330	Nil

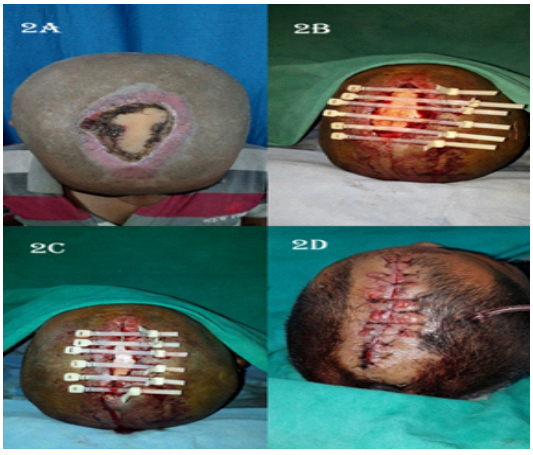

Figure2.(A) 29 year male with post electric burn central scalp defect. (B & C) followed by application and tightening of Ty-Raps. (D) Complete approximation of margin and secondary suturing of the defect.

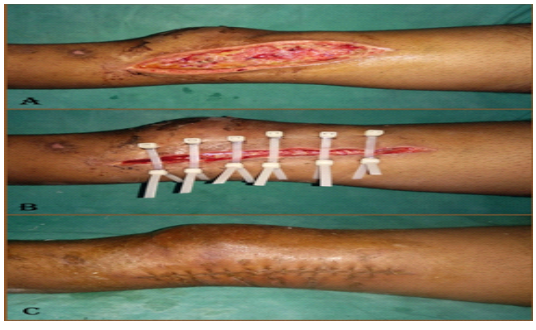

Figure 3.(A) fasciotomy wound on lateral aspect of knee.**(B)** followed by application and tightening of Ty-Raps. **(C)** Completely healed wound with linear scar in follow-up after Ty-Raps and suture removal.

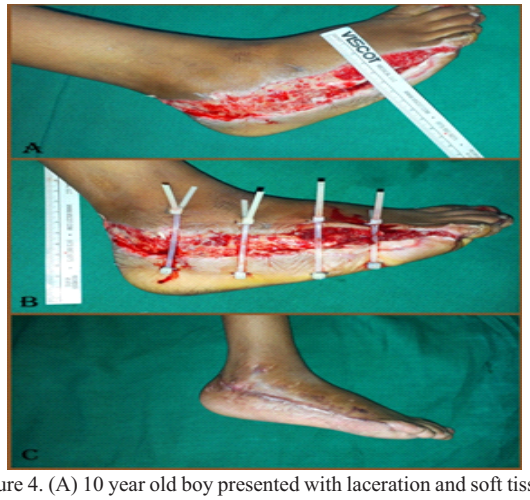

Figure 4. (A) 10 year old boy presented with laceration and soft tissue loss of lateral of right foot due to road traffic accident. (B) followed by application and tightening of Ty-Raps. (C) Completely healed wound with linear scar in follow-up after Ty-Raps and suture removal

Figure 5.(A) 35 years old man with post injection necrotising fasciitis followed by fasciotomy wound on flexor aspect of left forearm and application of Ty-Raps near wound margin **(B)** followed by tightening of Ty-Raps and decrease in width of defect is appreciated **(C)** Completely healed wound with linear scar in follow-up after Ty-Raps and suture removal.

DISCUSSION

A Ty-Rap is a cable tie made of a sturdy nylon tape with an integrated gear rack and on one end a ratchet within a small open case. Once the pointed tip of the Ty-Rap has been pulled through the case and past the ratchet, it is prevented from being pulled back; the resulting loop may only be pulled tighter. Ty-Raps made their way to operating theatres as cable ties for anaesthetic equipment or to secure the connection of intercostal drains to tubing. They are readily available for clinical use almost worldwide. Therapeutic use of Ty-Raps has been reported as early as 1976[6] and has since been used for the internal fixation of (periprosthetic) femur fractures[7] and even anal fistula[8].

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 and which increases in length over time. Gibson et al.[9] studied the behaviour 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[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].

Application of stress relaxation for skin stretching, stress relaxation is another biomechanical property of soft tissue which describes the time-dependent decay of stress as the applied strain is held constant. Stress relaxation allows skin to stretch intraoperatively beyond its inherent extensibility in a short period of time. As a result of skin stretching, wound closing tension decreases over time, allowing primary closure of relatively large defects[12].

The use of Ty-Raps for the delayed closure of wounds is a new technique and not previously published in the literature. A preassembled Ty-Rap system can be applied loosely in the acute phase, and it is long enough to avoid any risk of tension to the margins wound. Hence, after being tightened, the stiffness of the nylon prevents secondary retraction of the wound edges, and it is extremely strong, which makes it superior to the other techniques such as shoelace technique with Vessel Loops or the stitching technique with monofilament sutures. Needless to emphasize that caution should be undertaken not to over tighten the Ty-Rap system. In our experience, all the disadvantages of previously described methods are resolved with the introduction of Ty-Raps for the closure of wounds in surgical patients.

By considering our data, we regard the use of Ty-Raps a preferable alternative for the current closing techniques of the wounds. We value its low costs, general availability and effectiveness. In this study, both the application and the tightening of the Ty-Raps were well tolerated by our patients with a minimal need for secondary procedures. Knowledge of this technique is a useful adjunct to the existing surgical array for every trauma and plastic surgeon for the closure of wounds.

CONCLUSIONS

- This system allows closure over high-tension wounds without causing ischemia and necrosis.
- Ty-Raps closure of wounds as an alternative to skin grafts, skin flaps, tissue expanders or other expensive devices.
- This technique may help to secure the wound closure with minimal scarring and no donor site morbidity.
- We appreciate Ty-Raps low cost, general availability and effectiveness.
- An innovative and simple use of Ty-Raps for closure of wounds in gradual and controlled manner.
- Knowledge of this technique is a useful adjunct to the existing surgical array.

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