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CASE REPORT

Tension-reduced closure of large abdominal wall defect caused by shotgun wound: A case report

Yan Li, Jia-Hua Xing, Zheng Yang, Yu-Jian Xu, Xiang-Ye Yin, Yuan Chi, Yi-Chi Xu, Yu-Di Han, You-Bai Chen, Yan Han

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Abstract

BACKGROUND

Large abdominal wall defect (LAWD) caused by shotgun wound is rarely reported.

CASE SUMMARY

Herein, we describe a case of LAWD caused by a gunshot wound in which the abdominal wall was reconstructed in stages, including debridement, tension-reduced closure (TRC), and reconstruction with mesh and a free musculocutaneous flap. During a 3-year follow-up, the patient recovered well without hernia or other problems.

CONCLUSION

TRC is a practical approach for the temporary closure of LAWD, particularly in cases when one-stage abdominal wall restoration is unfeasible due to significant comorbidities.

Key Words: Free flap; Shotgun; Hernia; Large abdominal wall defect; Tension relief closure; Mesh; Case report

Core Tip: The large full-thickness abdominal defect caused by gunshot wound is often associated with infection, multiorgan injuries, and poor patient conditions. Tension-reduced closure is a useful method for the temporary closure of large abdominal wall defect, particularly in cases in which one-stage abdominal wall reconstruction is unfeasible.

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INTRODUCTION

Large abdominal wall defect (LAWD) is commonly caused by tumor resection, followed by infection, trauma, and radiation-induced injury[1]. LAWD caused by gunshot wound has been rarely reported in the previous literature[2]. Gunshot wounds often lead to full-thickness defects, infection, multiorgan injuries, and poor patient conditions making reconstruction of LAWD extremely challenging[3]. Conventional one-stage reconstruction with mesh reinforcement plus free flap may be unfeasible and staged reconstruction is required[4].

Tension-reduced closure (TRC) is a novel technique for the closure of large wounds by reducing the tension across the wound edges based on the theories of stress relaxation and mechanical creep for skin stretching[5]. Previous studies have shown that TRC is a simple, effective, and safe method for wound closure for a variety of reasons. However, no study to date has reported the use of TRC for LAWD caused by a gunshot wound. Here, we report a case of gunshot LAWD, who underwent staged abdominal wall reconstruction including debridement, temporary TRC, and definitive reconstruction with prosthetic mesh plus a free flap.

CASE PRESENTATION

Chief complaints

Abdominal wall hernia formation after abdominal gunshot wound.

History of present illness

A 44-year old man presented with a large abdominal bulge. He was robbed and shot in the abdomen in South Africa 1.5 years ago, resulting in open abdomen, hemorrhagic shock, infection, intestinal exposure, and severe multiorgan injures involving the transverse colon, greater omentum, spleen, diaphragm, and left kidney. Emergency surgeries including removal of bullets and foreign body, debridement, transverse colectomy, omentectomy, nephrectomy, and colostomy were performed at a local hospital in South Africa. The large full-thickness abdominal wall defect was initially covered by split-thickness skin mesh grafting on intestines harvested from the left thigh.

History of past illness

The patient had hepatitis and underwent left kidney removal after a gunshot wound on July 26, 2017.

Personal and family history

The patient denied a family history of infectious and genetic diseases.

Physical examination

The patient developed a large abdominal hernia and was referred to our hospital for abdominal reconstruction 1.5 years after the initial injury. A 26 cm × 28 cm full thickness abdominal defect covered with grafted skin mesh was found at the first consultation. The hernia was protruding when he was standing or lying on one side. Underlying peristalsis was observed. A colostomy stoma was located at 10 cm close to the skin grafts and connected with a colostomy bag.

Laboratory examinations

Laboratory examinations showed no significant abnormalities.

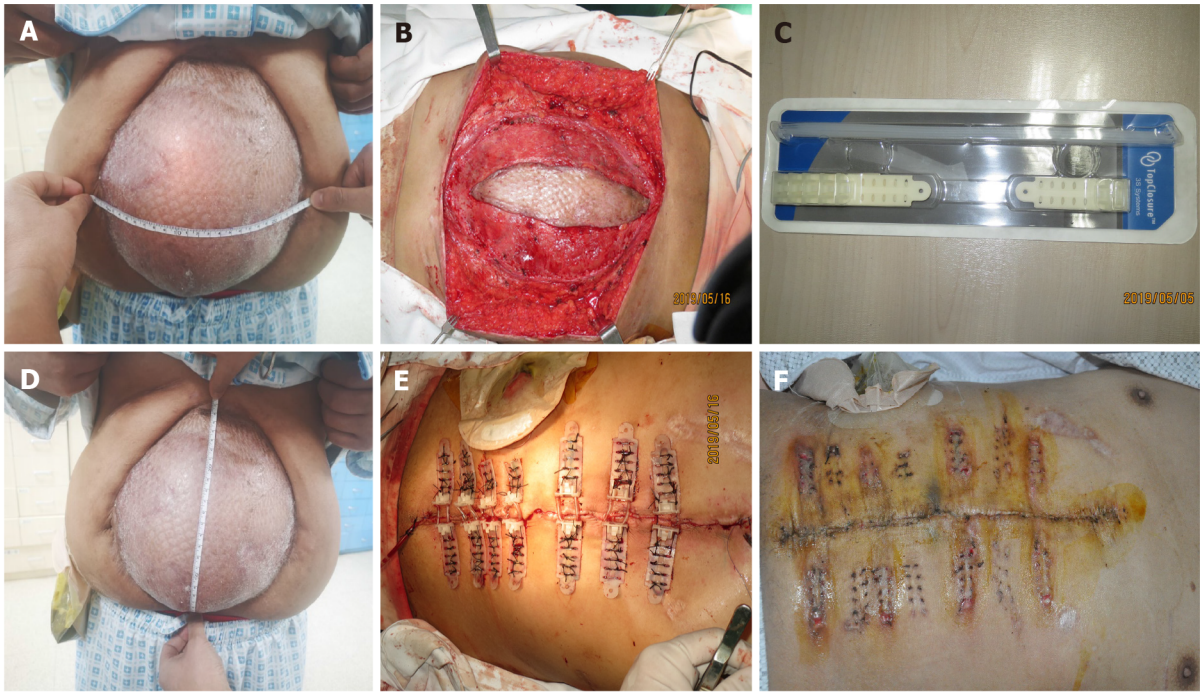

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Figure 1 The patient's first preoperative, intraoperative, and postoperative conditions in our department. A: Length of the abdominal bulge when the patient was standing; B: Width of the abdominal bulge when the patient was standing; C: Grafted skin of the abdomen was carefully removed; D: Immediate primary closure was achieved, utilizing 7 Top Closure® and 8 mm sets; E: Top Closure® 1S 8 mm sets; F: Tension Relief System was removed 3 wk after installation.

Imaging examinations

Ultrasound examination results were consistent with changes in the abdominal wall defect after trauma.

FINAL DIAGNOSIS

The final diagnosis were postoperative abdominal wall trauma, abdominal wall defect, and abdominal wall hernia.

TREATMENT

TRC

One-stage abdominal reconstruction was unfeasible due to the patient's comorbidities and poor condition. The colostomy stoma may increase the risk of infection. Therefore, we carefully removed the grafted skin. The area of LAWD was 21 cm × 22 cm after the removal of the grafted skin. The operation duration was prolonged to 5.5 h due to the large area of severe adhesion between the grafted skin and viscera. Oliguria (urine volume < 90 mL) occurred during surgery owing to the mononephrous dysfunction, right renal pelvis stone, and ureteral obstruction diagnosed by ultrasonography. To reduce operation duration and surgical risks, a temporary TRC of the defect was performed using the Tension Relief System (TRS, Top Closure® 1S 8 mm sets, IVT Medical Limited, Israel). Briefly, seven pairs of attachment plates were placed 2 cm away from the wound edges and anchored with 3-0 silk sutures (Mersilk, Ethicon, United States) and staples (PROXIMATE, Ethicon, United States). Incremental approximation of wound edges was archived by pulling the bridging approximation straps through a lock/release ratchet mechanism (Figure 1). The patient developed hydronephrosis with a maximum blood creatinine level up to 511.3 μmol/L. He underwent hemofiltration dialysis and renal pelvis catheterization for 2 wk. The change in urine volume and creatinine is shown in Figure 2. The abdominal wound healed well without dehiscence or necrosis and TRS was removed 3 wk after installation.

Mesh reinforcement and anterolateral thigh flap reconstruction

Five months later, the patient underwent abdominal wall reconstruction with mesh reinforcement and a free anterolateral thigh (ALT) musculofascial flap to definitively repair his hernia (Figure 2). The original incision was reopened. Component separation was performed. The 15 cm × 20 cm peritoneal

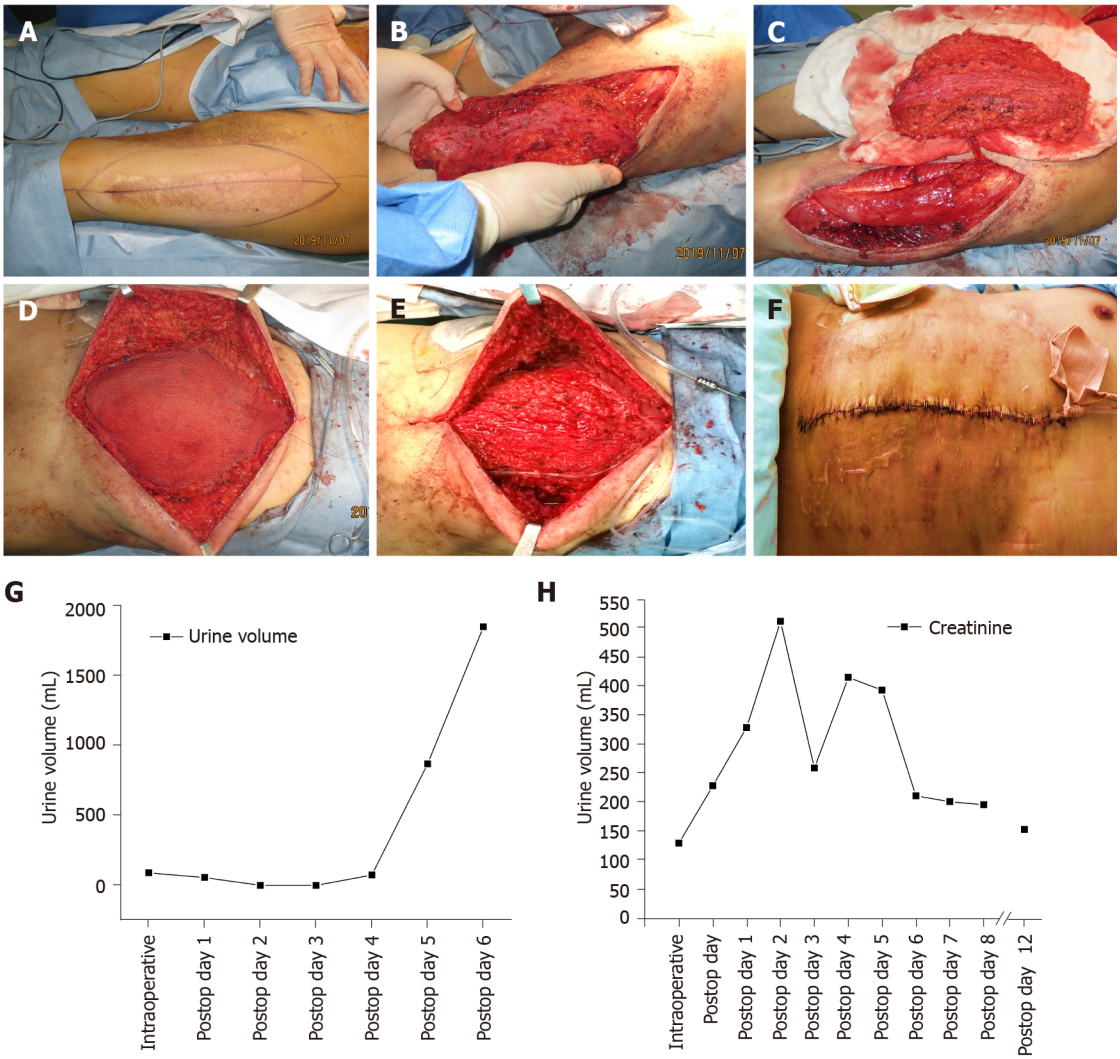

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Figure 2 The patient's surgical procedure and the dynamic changes in biochemical indicators. A: The anterolateral thigh perforator (ALT) flap was designed preoperatively according to the size of the defect in the recipient area; B: The skin and subcutaneous tissue were incised and the ALT flap was separated from the surrounding tissue; C: The ALT flap was freed and the tip was broken; D: Mesh was used to reinforce the abdominal wall hernia; E: ALT flap was grafted to the abdomen and vascular anastomosis was performed; F: The abdominal wound was closed and the abdominal skin was sutured; G: The patient's volume of urine changes over time; H: The patient's creatinine values over time.

defect was repaired with a 20 cm × 20 cm hydrophilic mesh (Covidien, United States). The coverage ranged from the xiphoid and 2 cm inferior to the costal arch to 10 cm superior to the pubic symphysis vertically, and bilateral aponeurosis of external obliques horizontally. The mesh was secured with lock-stitch PDS II suturing. A 15 cm × 20 cm ATL musculofascial flap was elevated. The pedicle of descending branch of the lateral circumflex femoral artery was 14 cm. The microvascular anastomosis was performed on a branch of the superficial epigastric artery (Figure 2). The ALT flap was covered on the prosthetic mesh to repair the soft tissue defect (Figure 3).

OUTCOME AND FOLLOW-UP

The patient was followed for 3 years. He recovered well and reported significant improvement in quality of life without signs of hernial recurrence (Figure 4).

DISCUSSION

Shotgun wounds, a high-energy firearm injury, often result in trauma contamination, extensive tissue contusions, and open injuries that make treatment difficult[6-8]. Current treatment principles regarding shotgun wounds include initial debridement followed by wound closure to prevent damage to deep

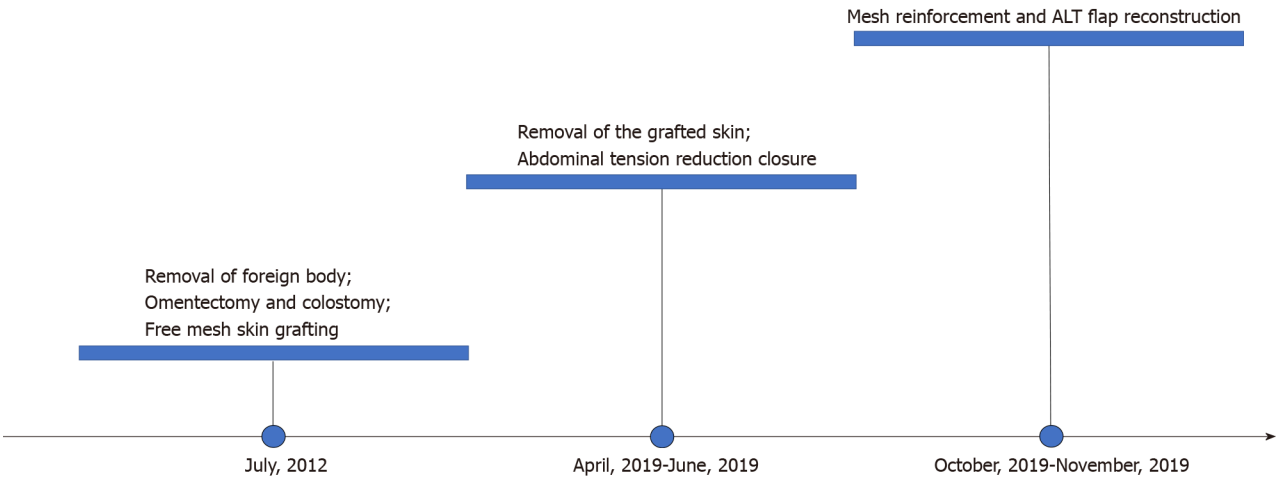

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Figure 3 Timeline of treatment events. ALT: Anterolateral thigh perforator.

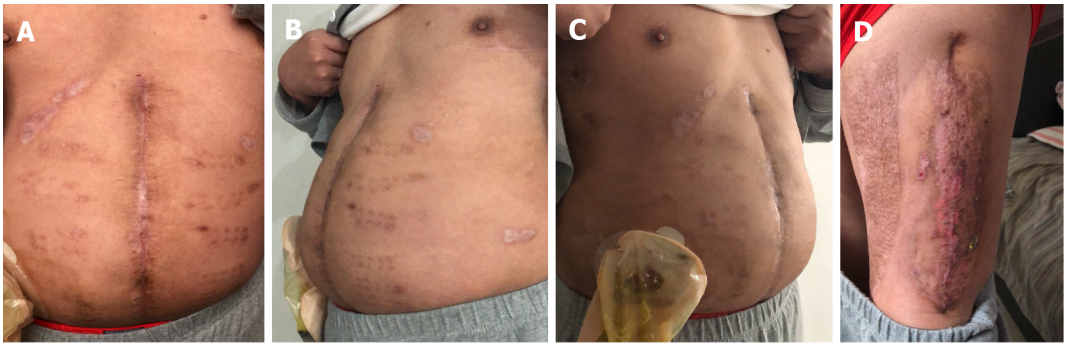

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Figure 4 One year following surgery, the patient recovered well and reported significant improvement in quality of life without signs of hernial recurrence.

tissue. However, closure of the wound should be delayed until 15 d in patients with more severe contamination[9]. Further treatment is feasible after the patient's vital signs have stabilized. The case that we report had a temporary local trauma closure due to multiple shotgun wounds throughout the body, resulting in a LAWD, multiple organ damage, and poor general condition. For the further resolution of the abdominal wall hernia, he came to our department for treatment.

Many techniques for reconstruction of LAWD have been reported, but this is to date the first case of staged reconstruction with temporary TRC and definitive reconstruction with mesh and a flap. Gu *et al*[10] summarized the methods for abdominal wall reconstruction, including suture[11], prosthetic material[12], component separation technique[13], autologous tissue reconstruction[14], and abdominal wall expansion[15]. However, none of these methods could be used during the first reconstructive surgery owing to the patient's poor conditions. Therefore, we used a commercial TRS for temporary abdominal closure[16].

The TRS was a novel method for large wound closure. Topaz *et al*[5] first introduced the use of TRS in 20 patients for preoperative skin stretching or intraoperative wound closure. Their study presented many cases who underwent TRS for larger defect closure after malignancy resection[17,18]. Dan *et al*[19] reported two cases of using TRS for wound closure of high-tension flap donor site following the harvest of deep inferior epigastric perforator flap and ALT flap. Choke *et al*[20] described their successful experience of using TSR and vacuum-assisted closure techniques for the treatment of extensive soft tissue defects in four patients. Similarly, Li *et al*[21] used a combined treatment with vacuum sealing drainage, TRS, and Ilizarov technique for traumatic hemipelvectomy in one case. The patient was able to ambulate and perform activities of daily life at the follow-up visit. Zhu *et al*[22] reported a 61-year-old man with bladder exstrophy who received primary closure of a large abdominal defect using TRS. In addition, a simulation study using finite element modeling by Katzengold *et al*[23] showed that the tensile stress generated by the TRS was only 4% of that generated by conventional sutures, suggesting that TRS significantly reduced local tissue deformations and stress concentrations during large wound closure. These studies have demonstrated that TRS reduced operative time, length of hospital stay, and

Table 1 Details of cases treated with Tension Relief System

Ref.	Case no.	Age (yr)	Gender (male/female)	Cause of defect	Region of defect	Size of defect	Application time (prior to, during, and/or after surgery)	Closure (immediate/delayed closure)	Time to closure (min/d)
Topaz *et al*[5], 2012	1	62	Male	SCC	Left distal leg	3 cm × 2 cm	Prior to surgery	Delayed	16 d
	2	52	Female	Scar	Lower abdominal	7 cm × 8 cm	Prior to surgery	Delayed	11 d
	3	26	Male	High-voltage electric burn	Left lower limb	NA	During surgery	Immediate	NA
	4	12	Female	Congenital nevus	Right thigh	Φ = 2 cm	Prior to surgery	Delayed	14 d
	5	29	Female	Infected surgical wound	Abdominal	NA	NA	Delayed	NA
	6	88	Female	SCC	Left distal leg	Φ = 2.5 cm	Prior to surgery	Delayed	12 d
Topaz *et al*[17], 2014	7	64	Male	BCC	Parietal scalp	Φ = 3.5 cm	After surgery	Delayed	5 d
	8	64	Male	BCC	Parietal scalp	Φ = 3 cm	After surgery	Delayed	1 d
	9	74	NA	SCC	Frontal scalp	Φ = 3 cm	During surgery	Immediate	NA
	10	78	NA	Ulcerated BCC	Occipital scalp	Φ = 3.2 cm	After surgery	Delayed	5 d
	11	17	NA	Scar tissue neoplasia	Parietal scalp	Φ = 2.5 cm	After surgery	Delayed	2 d
	12	95	Male	SCC	Occipital scalp	Φ = 4.5 cm	After surgery	Delayed	17 d
	13	82	NA	SCC	Parietal scalp	Φ = 3.5 cm	After surgery	Delayed	21 d
	14	82	NA	SCC	Occipital scalp	Φ = 3 cm	After surgery	Delayed	2 d
	15	65	NA	SCC	Occipital scalp	Φ = 4 cm	After surgery	Delayed	5 d
Topaz *et al*[18], 2014	16	60	Male	Basal cell carcinoma	Flank	15 cm × 25 cm	During surgery	Immediate	26 min
	17	35	Male	Malignant melanoma	Scapular	7 cm × 11.5 cm	During surgery	Immediate	60 min
	18	41	Male	Spindle cell sarcoma	Supraclavicular	26 cm × 25 cm	During surgery	Immediate	135 min
Dan *et al* [19], 2015	19	20	Female	Tumor	Left groin	10 cm × 8 cm	After surgery	Delayed	28 d
	20	53	Male	Traffic accident	Foot and ankle	10 cm × 9 cm	After surgery	Delayed	15 d
Zhu *et al* [22], 2020	21	3	Female	Infantile hemangiomas	Scalp	6.5 cm × 5.2 cm	During surgery	Immediate	20 min
Choke *et al*[20], 2017	22	42	Male	Bacterial infection	Limb	91 cm × 17 cm	After surgery	Delayed	60 d
	23	55	Male	Sternal osteomyelitis	Chest	28 cm × 8 cm	After surgery	Delayed	42 d
	24	29	Male	Hernia	Abdomen	9 cm × 10 cm	After surgery	Delayed	28 d
Li *et al* [21],	25	4	Female	Traffic accident trauma	Pubic symphysis	14 cm × 9 cm	After surgery	Delayed	NA

SCC: Squamous cell carcinoma; BCC: Basal cell carcinoma; NA: Not available.

costs, improved wound aesthetics, and minimized complications and obviated donor site morbidity caused by conventional skin grafting or flap reconstruction (Table 1).

There are several advantages of using TRS. First, TRS narrowed the width of the abdominal wall defect, thus reducing the flap area in the final abdominal reconstruction from 26 cm × 28 cm to 15 cm × 25 cm. Second, the operation time and associated risks were significantly reduced. The abdomen was successfully closed within 40 min using TRC, compared to hours of operation time for conventional reconstruction[24]. At the last follow-up, the patient reported satisfaction with his treatment owing to significant improvement in quality of life without signs of hernial recurrence.

CONCLUSION

The large full-thickness abdominal defect caused by a gunshot wound is often associated with infection, multiorgan injuries, and poor patient conditions. TRC is a useful method for the temporary closure of LAWD, particularly in cases in which one-stage abdominal wall reconstruction is unfeasible.

FOOTNOTES

Author contributions: Li Y and Xing JH contributed equally to this work and as co-first author; Han Y and Chen YB as co-corresponding author of this study; Li Y, Xing JH, and Yang Z wrote the main manuscript text and prepared all the figures; Xu YC, Chen YB, Han YD, and Han Y suggested ideas and steps for the article; Xu YJ, Yin XY, and Chi Y participated in the revision of part of the article; and all authors read and approved the final manuscript.

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