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Dr. Ram Avatar Saini
Associate Professor, Department
of Orthopedics Geetanjali
Medical College and Hospital
Udaipur; Rajasthan, India

Dr. Divyansh Sharma
Resident, Department of
Orthopedics Geetanjali Medical
College and Hospital
Udaipur; Rajasthan, India

Dr. Nihar Shah
Resident, Department of
Orthopedics Geetanjali Medical
College and Hospital
Udaipur; Rajasthan, India

Shoe lace technique, a simple and less expensive method for Fasciotomy wound closure following compartment syndrome

Dr. Ram Avatar Saini, Dr. Divyansh Sharma and Dr. Nihar Shah

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Abstract

Introduction: Compartment syndrome is a common and severe medical condition that can lead to ischemia and ultimately tissue loss. The treatment of choice is emergent fasciotomy to lower the compartment pressure. However, closing fasciotomy wound often presents a problem because of edema and skin retraction. As a result, numerous techniques have been devised to optimize wound closure.

AIM: To perform fasciotomy wound closure by shoe lace technique which is a type of dermal apposition technique for gradual primary closure of fasciotomy wound.

Materials and Methods: The study included 19 patients who presented with compartment syndrome involving either upper or lower extremities due to various causes. Decompression fasciotomy was performed in all the cases to relieve compartment pressure. Shoe lace technique was performed for closure of wound. Patients demographics, location of fasciotomy, time duration between injury and fasciotomy, number of tightening session, time to primary closure, length of hospital stay, need for skin grafts and any complication if occurred during procedure were recorded.

Results: Out of 19 patients 15 were males and 4 were females. Average age was 34.8 years. Lower extremity was involved in 14 cases. Fracture was the cause of compartment syndrome in 16 cases. Closure was obtained at an average of 3.5 tightening session. All the fasciotomy wounds were closed within an average of 8.3 days. Average duration of hospital stay was 12.3 days. No major complication was encountered in the study one case reported to have infection at wound site.

Conclusion: Shoe lace technique is a simple and economical method for fasciotomy wound closure. It takes less time to closure, does not need a second procedure for closure thus reduces need of nursing care, hospital stay resulting in lower morbidity, healthcare cost and better aesthetic result.

Keywords: compartment syndrome, fasciotomy

Introduction

Compartment syndrome, a situation where compartment pressure is higher than perfusion pressure occurs in both upper or lower extremities and can result from numerous injuries such as fracture, ischemia, reperfusion, crush injury, electrical injury, burns and over exertion^[1, 2]. If left untreated the sequel are devastating. It causes compression of vascular structures within these compartments, leading to muscle and nerve ischemia. If ischemia remains for 2 hours nerve damage and tissue necrosis occur which can cause permanent functional deficit of involved limb^[3] Therefore, early recognition and treatment via surgical decompression is of paramount importance.

To date fasciotomy is the most effective treatment for patients with compartment syndrome. Fasciotomy entails incision of the overlying skin and investing fascia of the compartment relieving pressure and enhancing tissue perfusion. Hence performing timely fasciotomy for compartment syndrome prevents ischemic injury to muscle and nerve and preserve future limb function. However, Fasciotomy wound often presents a problem for surgeons performing primary closure due to persistent tissue edema and skin contracture^[4].

Currently there are numerous techniques in literature that can be performed for closure of fasciotomy wound secondary to compartment syndrome. However each technique has its own advantages and disadvantages that must be taken into consideration. Of these closure via skin grafts and delayed gradual primary closure are the most commonly employed methods.

Correspondence

Dr. Ram Avatar Saini
Associate Professor, Department
of Orthopedics Geetanjali
Medical College and Hospital
Udaipur; Rajasthan, India

Previously classic management of fasciotomy wound closure was partial thickness skin graft. This however led to cosmetic and functional problems like requirement of an additional operative procedure, resulting in additional wound, complicates wound care at sides, donor site morbidity, sensory loss in grafted area, possibility of graft failure, prolonged hospital stay. And finally unappealing scar [4, 5, 6]. The impossibility of primary wound closure following fasciotomy due to tissue edema and complications arising due to skin grafting motivated surgeons to look for newer methods for fasciotomy wound closure with better functional and cosmetic outcome.

In the literature, there is plethora of innovative techniques and variations focusing on dermal apposition which take advantage of elastic property of skin for delayed primary closure of fasciotomy wound. These include the vessel loop shoe lace technique, sub cuticular suture, Ty –Raps, sure closure, Dynamic wound closure, STAR and Silver Bullet Wound Closure Device [7-11]. Fasciotomy wound closure using vessel loop or shoe lace technique has been described as a viable management [5, 7, 12-16]. In the present study we share our experience of employing shoe lace technique using silk suture no.1 as a method of fasciotomy wound closure and looked for any complications if occurred and the need for skin graft.

Materials and Methods

The study was carried out in the department of orthopedics of a tertiary care teaching hospital of Southern Rajasthan from March 2016 to March 2017. The study was commenced after obtaining approval from institutional research ethics committee. A total of 19 patients with compartment syndrome who gave consent to participate were enrolled in the study.

Inclusion criteria were fracture related compartment syndrome, closed fracture, no concomitant skin loss, fasciotomy done within 36 hours of injury. Exclusion criteria were open fracture, skin loss, compartment syndrome due to burns or electrical injury and delay of presentation beyond 36 hours. Patient’s demographic characteristics such as age, gender, affected extremity; cause of compartment syndrome, duration of presentation at hospital was noted.

Compartment syndrome was diagnosed based on clinical examination and findings done by a senior surgeon. Decompression fasciotomy was performed in all cases. Fasciotomy wound was managed by gradual closure with progressive tension using shoe lace technique. We used a modified protocol for fasciotomy wound management. Silk suture no.1 was used as tensioning material. Early version of this technique used materials such as heavy prolene sutures and were claimed to lead to gradual closure of fasciotomy. Simple sutures were anchored to alternate sides of wound approximately 2 cm apart keeping about 1 cm distance from edge in a zigzag /shoe lace pattern using silk as a suture material intra operatively during compartment release. The loops were tightened progressively during routine dressing change or whenever required as assessed by attending surgeon. Tightening was done by pulling suture one at a time with tension adjusting manually until maximum approximation of the edge without undue tension was obtained. Progressive tightening of shoe lace permitted gradual reapproximation of the skin while compartment edema resolves. In order to minimize pain during tightening session intravenous analgesia was given to all cases before tightening. The tightening procedure was continued until final closure was achieved. [As shown in photographs below]



Preoperative Fasciotomy Day-1



1st Tightening Day-3rd Final Tightening Day 6th

During tightening session wound was inspected for hematoma, increase in swelling and tension, secretion from wound, skin necrosis, damage to muscle and deep structures that might compromise the cleanliness of wound and prevents its closure. Patients were indicated for debridement or for skin grafting if attending surgeon determined or judged that there

is infection at wound site and the fasciotomy wound cannot be closed primarily. The patients were discharged from hospital after wound closure was achieved and fixation of fractures or other procedures required were done and advised to come for stitch removal after 15 days.

Result

Out of a total 19 patients who met the inclusion criteria 15 were males and 4 were females. The average age was 34.89 years (range 16-72 years). Lower extremity was involved in 14 cases where as in 5 cases upper extremity was involved. 16 cases were due to fracture and blunt trauma was the cause in 3 cases. The fasciotomy was performed at an average of 15.2

hrs (range 8-24 hrs) following the injury. All fasciotomy wound healed eventually. The skin closure was obtained at an overall average of 3.5 tightening sessions (range3-6). The mean duration between the day of suturing on the fasciotomy line and the day of complete primary closure was 8.31 days (range 6-15 days).

Table 1

| Case | Age In Yrs | SEX | Extremity With Fasciotomy | Cause of Compartment Syndrome | Deley IN HRS Before Fasciotomy | NO. of Tighteni-NG Session | Time to Primary Closure in Days | Duration of hospital Stay in days | Complications |
|------|------------|-----|---------------------------|-------------------------------|--------------------------------|----------------------------|---------------------------------|-----------------------------------|---------------|
| 1 | 45 | M | LE | # Tibia | 12 | 3 | 6 | 8 | |
| 2 | 72 | F | LE | # Tibia | 11 | 4 | 10 | 12 | |
| 3 | 20 | M | UE | # BBFA | 20 | 4 | 11 | 22 | |
| 4 | 22 | F | LE | # BBL | 12 | 3 | 6 | 9 | |
| 5 | 18 | M | LE | # BBL | 22 | 6 | 15 | 22 | Infection |
| 6 | 50 | M | LE | # Tibia | 21 | 3 | 6 | 9 | |
| 7 | 46 | M | LE | Blunt Tr. | 9 | 3 | 6 | 8 | |
| 8 | 25 | M | LE | # BBL | 23 | 4 | 12 | 15 | |
| 9 | 21 | F | UE | # BBFA | 10 | 3 | 6 | 13 | |
| 10 | 18 | M | UE | # BBFA | 12 | 4 | 8 | 14 | |
| 11 | 48 | M | LE | Blunt Tr. | 11 | 3 | 8 | 10 | |
| 12 | 65 | M | LE | # Femur | 13 | 3 | 6 | 9 | |
| 13 | 21 | M | UE | Blunt Tr. | 23 | 4 | 9 | 15 | |
| 14 | 24 | M | UE | # BBFA | 12 | 3 | 6 | 8 | |
| 15 | 16 | F | LE | # Tibia | 12 | 3 | 8 | 12 | |
| 16 | 20 | M | LE | # Tibia | 22 | 4 | 10 | 16 | |
| 17 | 30 | M | LE | # Tibia | 24 | 5 | 13 | 16 | |
| 18 | 65 | M | LE | # Tibia | 12 | 3 | 6 | 8 | |
| 19 | 34 | M | LE | # Tibia | 8 | 3 | 6 | 8 | |
| AVG | 34.8 | | | | 15.2 Hrs | 3.5 | 8.3 | 12.3 | |

F: Female; M: Male; LE: Lower extremity; UE: Upper Extremity; #: Fracture; BBFA: Both bones fore arm; BBL: Both bones leg; Tr.: Trauma; Hrs: Hours.

The mean duration of hospital stay was 12.31 days (range 8-22 days). In one case persistent wound discharge was observed indicating infection at fasciotomy site. In this case patient was taken to Operation Theater for removal of shoe lace apparatus and further debridement of necrotic tissue was done. When local wound condition improved shoe lace apparatus was reapplied in the operating room and tightening sessions were carried out again. And the wound was allowed to heal by secondary intention. No major complications (eg. vascular compromise, amputation) were encountered in this study. No suture related complications (eg. rupture of tissue by suture, suture rupture etc.) were observed in any of the patients. Skin grafting was not performed in any case. All fractures were fixed according to treatment guidelines preferred by surgeon's choice. (Table-1)

Discussion

Various reconstructive strategies may be performed for the closure of fasciotomy wounds that are secondary to compartment syndrome. Of these gradual primary closure of fasciotomy wound by dermal apposition takes advantage of elastic properties of skin. In the literature, there are number of techniques and variations that take advantage of dermal apposition, shoe lace technique is one of them.

In our study, all fasciotomy wounds closed at an overall average of 3.5 tightening sessions. (Range3-6). Eid *et al.* [17] carried out similar study and obtained skin closure at an overall average of 4.2 tightening sessions (range 3-7). Ji yong park *et al.* [18] reported 2-6 operations when shoe lace was used as a method of fasciotomy wound closure. Marek *et al.* [19] and chiverton and redder *et al.* [8] suggested obtaining

complete wound closure by dermal apposition in a single session. In our study, we did not attempt to obtain complete wound closure in a single session in any patients. Skin closure was obtained at an overall average of 3.5 tightening sessions. (range3-6), which allows us to reexamine wounds in OR and redo debridement when necessary. Thus minimizing the chances of complications like failure of wound closure due to excessive amount of traction required to close large wounds, late presentation of infection, reelevation of compartment pressure etc. which otherwise could have happened if closure was attempted in single fashion

In our study fasciotomy was performed at an average of 15.2 hrs (range 8-24 hrs) following injury. In a study carried out by Eld *et al.* [17] fasciotomy was performed at an average of 21.1 hrs (range 12-36 hrs) following injury. Kakagia *et al.* [20] reported closure time was more if fasciotomy was performed 8hrs after injury.(Vacuum assisted closure 29 days V/s shoe lace technique closure 18.2 days).we also observed in our study that when fasciotomy was performed after 12 hrs following injury time to closure for such cases was more (ranging 10-15 days). This could be explained by the fact that the delay in performing fasciotomy following injury resulted in excessive soft tissue swelling and edema which interfered in closure thus increasing the closure time in such cases.

With regards to the duration of gradual primary closure of fasciotomy wound our result were found to be similar to other studies which were conducted using various dermal apposition devices [7, 10, 11]. In our study, the mean duration of closure was found to be 8.31 days (range 6-15 days). Zorilla *et al.* [7] achieved closure in a mean of 8.8 days (range 6-19) days using shoe lace technique. Taylor *et al.* [10] Medina *et al.*

[11] Geertruida *et al.* [9] reported 11.5 days (range 6-11 days), 7.4 days, and 6.3 days of average closure time respectively when closure was done with dermal apposition devices. Commercial devices such as sure closure, Dynamic wound closure, STAR, Silver bullet wound closure device (SBWCD) may result wound closure in only 4 days [21]. As time to closure vary according to the technique used, a clinician can decide which technique to use to optimize fasciotomy wound closure for a particular patient considering financial investment and patients current medical condition.

In our study the shoe lace apparatus used for closure consisted of two silk sutures, which in our setting cost rupees 200 only seems very economical. The material is readily available in any standard operating theatre, making this procedure useful for hospitals with limited resources. Numerous commercial devices have been utilized to obtain skin closure following fasciotomy, Hirshowitz *et al.* [22] used the sure closure device, Taylor *et al.* [10] uses skin anchors, Govaert *et al.* [9] used Ty – Raps medina *et al.* [11] used silver bullet wound closure device (SBWCD). However, the use is limited by availability and expenses. This is particularly important in a developing country with limited resources of the health care system.

In our study the total duration of stay was 12.3 days (range 8-22 days) Zorilla *et al.* [7] reported an average hospital stay of 10 days. The duration of hospital stay on other hand differed according to the presence of additional trauma and the time required to manage the fractures or other causes of compartment syndrome for which fasciotomy was performed. Similar to study carried out by Zorilla *et al.* [7] we also found low rate of complications, only 1 case had infection and not performed skin grafting in any case.

An important limitation of the present study is the absence of monitoring system or other safety mechanisms to monitor compartment pressure or skin tension. This was left to rely totally on the surgeons experience and judgment. So it is suggested that the technique should be performed under close direct supervision of an experienced surgeon. As the sample size was small and fracture was the cause in most cases of compartment syndrome, further controlled study with large sample size including various causes of compartment syndrome is needed in order to demonstrate its efficacy.

Conclusion

Our study conclude that shoe lace technique for fasciotomy wound closure following compartment syndrome does not require additional equipments or training so can be easily performed with material found in any operating room taking aseptic precautions, takes less time for closure thus reduces need for nursing care and hospital stay, does not require second procedure for closure i.e. decreases the need for skin grafts and its associated morbidity and achieve skin closure with acceptable esthetic result, less expensive so resulting in lower health care cost. At the same time allows easy access to the wound for inspection and toilet with maximum patient comfort and tolerance. This close monitoring of the limb during closure is helpful in early detection of complications like recurrence of compartment syndrome, skin necrosis due to constant tension, deep muscle damage and necrosis which could have occurred.

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