

Original Research Article

Comparative study of delayed primary closure by shoelace technique versus conventional secondary suturing method in closure of fasciotomy wounds, done for spreading cellulitis with compartment syndrome

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ABSTRACT

Background: Fasciotomy is a standard treatment for acute compartment syndrome. Historically, fasciotomy incisions were usually left open till oedema settles down. In literature, there is a wide range of wound closure techniques published, but none of them is deemed to be the best. In this study, focus is laid on whether delayed primary closure (DPC) by shoelace technique, is as effective as conventional secondary suturing, in closure of fasciotomy wounds, done for spreading cellulitis.

Methods: All those patients who met below mentioned inclusion criteria and underwent fasciotomy, were allocated into 2 groups (A and B) where Group A consists of 30 patients undergoing conventional secondary suturing, whereas Group B consists of 30 patients undergoing DPC by shoelace technique for closure of fasciotomy wounds. Parameters such as duration of hospital stay, time taken for complete wound closure, local wound complications, hospital expenses, anaesthesia related complications between the two groups were compared.

Results: Patients who underwent DPC for fasciotomy wound closure achieved wound closure ~7 days earlier with 5 days lesser hospital stay than that of those who underwent conventional secondary suturing. Average health care cost of Group B was significantly lower compared to Group A, but there was no statistically significant difference in incidence of wound infections between the two groups.

Conclusions: DPC by shoelace technique, takes less time for wound closure and hence the need for nursing care and hospital stay is significantly reduced in comparison to the conventional secondary suturing method.

Keywords: Delayed primary closure, Fasciotomy, Secondary suturing

INTRODUCTION

Fasciotomy is a standard treatment for acute compartment syndrome of limbs.¹ Fascia, which is present beneath the subcutaneous tissue, is a tough limiting inelastic fibrous membrane which encompasses muscles, nerves and blood vessels inside it and binds them into compartments. As the fascia is a tough layer, its non-compliant nature and increased interstitial tissue pressure secondary to various causes will lead to compartment syndrome.²

Certain conditions like fractures, injury to muscles, superficial skin infections leading to cellulitis can increase the pressure within the compartment resulting in compartmental syndrome. Compartment syndrome is a condition in which the pressure inside the muscle compartment increases which compromises blood supply to muscles leading to decreased perfusion resulting in pulselessness, pallor, paraesthesia, paralysis of limb.² Prolonged compromise of perfusion will lead to muscle necrosis which leads to acute kidney injury due to myoglobinuria. Persistent AKI will lead to systemic

complications ending up in multiple organ dysfunction syndrome (MODS).

Cellulitis is a spreading bacterial infection of the dermis and subcutaneous tissues.³ Cellulitis of limb in a setting of comorbidities like diabetes and immuno-compromised state, can spread extensively which can lead to increased compartmental pressure, warranting fasciotomy.

Fasciotomy is a surgical procedure which entails incision of the overlying skin and investing fascia of the compartment to relieve the compartmental pressure in patients with compartment syndrome of the limbs. Timely evaluation and clinical suspicion of compartment syndrome is of utmost importance, as functional impairment of limbs can be prevented, if fasciotomy is done within 6 hours of onset.⁴ Hence, timely fasciotomy will save the limb and prevents further complications associated with it.

Historically, fasciotomy incisions were usually left open till oedema settles down. Rarely, immediately closure of incision was attempted, however, rates of infections and recurrence were unacceptably high.⁵ Due to excessive tension across the wound, fasciotomy incisions, cannot be closed primarily. Once oedema subsides, attention is laid on wound closure.

In literature, there is a wide range of wound closure techniques published, which includes primary closure, secondary suturing, delayed primary closure, and ultimately utilizing a skin graft to fill the void.⁵ But, each method has its own advantages and disadvantages. Split-thickness skin grafting (STSG), was the conventional method of fasciotomy wound closure and was effective, but it results in aesthetically unappealing wound and is associated with donor site morbidity. Whereas, in secondary suturing of the wound, patient had to undergo repeated procedures which resulted in prolonged hospital stay. Hence, this kept surgeons in a constant quest of newer methods for fasciotomy wound closure.

Primary closure of wound is defined as suturing the wound within 6 hours of wound formation.⁶ This method is followed for clean cut, incised/lacerated wounds. Secondary closure is defined as suturing the wound, once the infection/oedema completely settles.⁶ Whereas, delayed primary closure is a technique which is intentionally applied to wounds which are not clean enough for immediate primary closure. In this method, the wound is left open for a few days, after which gradual closure of wound is attempted using various techniques.

Skin has several unique and useful properties that allow for delayed primary closure of wounds despite large tissue defects or significant retraction.⁷ The inherent extensibility, a unique property of skin have been exploited by a variety of techniques for delayed primary closure of fasciotomy wounds. Delayed primary closure (DPC) by shoelace technique, demonstration using

various commercial skin stretching devices are few of them. In this study, focus is laid on whether DPC by shoelace technique is as effective as conventional secondary suturing, in closure of lower limb fasciotomy wounds done for spreading cellulitis.

METHODS

Description of study

This study is a non-randomised control trial conducted at JSS Hospital, Mysuru during the period December 2017 to May 2019 (18 months) with sample size estimated as 30 in each group (n=60), considering standard deviation in each group of hospital stay as 6 days and mean difference of hospital stay as 5 days, alpha error of 5%, power of 90%.

Using the formula below,

$$n = \frac{2S_p^2 [Z_{[1-\alpha/2]} + Z_{[1-\beta]}]^2}{\mu_d^2}$$

$$S_p = \frac{[S_1^2 + S_2^2]}{2}$$

Where,

S₁: Standard deviation in first group, S₂: Standard deviation in second group, μ_d: Mean difference between the samples, α: Significance level, [1- β]: Power.

Study population

All patients who met the below mentioned inclusion criteria, admitted in the department of general surgery in JSS hospital during the period of December 2017 to May 2019 (18 months).

Inclusion criteria

All non-suppurative, spreading cellulitis cases who have undergone fasciotomy.

Exclusion criteria

Spreading cellulitis with associated necrotizing-fasciitis, extensive soft tissue loss during fasciotomy and extensively debrided limbs and more than 2 fasciotomy wounds were excluded from the study.

Study setting and method of collection of data

All those patients who met the above criteria were considered for the study. Study were conducted by allocating the patients into 2 groups (A and B) where Group A consists of 30 patients undergoing conventional secondary suturing whereas Group B consists of 30 patients undergoing DPC by shoelace technique for closure of fasciotomy wounds. Every alternate patient undergoing fasciotomy was allocated into either of the groups and parameters such as duration of hospital stay, time taken for complete wound closure, local wound

complications, hospital expenses, anesthesia related complications between the two groups were compared.

Procedure

All patients who met the inclusion criteria, admitted in General Surgery Department of JSS hospitals, during the period November 2017 to June 2019 were considered for this study. Informed consent was taken from all those included in the study.

Girth of the both lower limbs was measured (reference point taken as 10cms below the knee joint) pre-operatively and noted.

For Group-A subjects, after performing fasciotomy under regional anesthesia, wound was left open and compression dressing was applied over it, which was regularly changed. Once, when the oedema and inflammation reduced, under regional anesthesia, fasciotomy wound was sutured using Ethion 2.0 suture material and regular dressings were done. When the suture line was found to be healthy, patients were discharged and followed up for the total duration of 25 days.

For Group-B subjects, after performing fasciotomy under regional anesthesia, in the same sitting, loose, continuous, shoelace like, subcuticular suturing of fasciotomy incision was done using proline 2.0 suture material and free ends were brought out at the ends, tied and fixed to skin using adhesive material.

Compression dressing was done to drain out oedematous fluid. Once the relative difference between the girth of diseased and normal limb became less than 1cm, we objectively concluded that oedema, inflammation has reduced and then started tightening the suture every day, by giving traction to the suture material from both ends, in order to achieve the wound approximation, in a graded manner. Once the distance between the two edges of the wound became less than 0.5cm, suture material was removed, and pressure dressing applied, and patients were discharged and followed up for a duration of 25 days.

Data pertaining to duration of hospital stay, time taken for complete wound closure, local wound complications, hospital expenses, anaesthesia related complications was entered in a tabulated column and all the parameters were compared between the two groups.

Statistical analysis

Data analysis of summary statistics was done using mean, median, SD, proportion. Whereas, inferential statistics using t-test/Mann Whitney test, Chi-square test. All the above measurements are done using SPSS software [Version-21.0]. P-value <0.05 considered as significant.

RESULTS

All those patients who came with spreading cellulitis, leading to compartment syndrome warranting fasciotomy, to OPD of department of general surgery/casualty, JSS Hospital, during the period of November 2017 to June 2019, and met the above mentioned inclusion criteria were considered for the study. As per previously decided sample size, 30 cases were included in both Group A (Secondary suturing) and Group B (DPC). An attempt was made to include all sex and age group people equally in both groups.

Table 1: Age distribution in the study.

Age category (in years)	Group			
	A		B	
	Count	Column N (%)	Count	Column N (%)
<30	1	3.3	3	10.0
31-40	4	13.3	7	23.3
41-50	4	13.3	6	20.0
51-60	9	30.0	4	13.3

In this study, the highest percentage of study participants in Group A were in the age group of >50years, whereas in Group B, participants were distributed among all age groups but none of them were above 70 years. Statistically significant with p-value 0.025 by Chi square test.

Mean age of all the participants in Group A was found to be 57.3 yrs with SD of 14.0, whereas in Group B mean age was 49.0 yrs with SD of 15.2 which was statistically significant (p=0.03 by independent t-test).

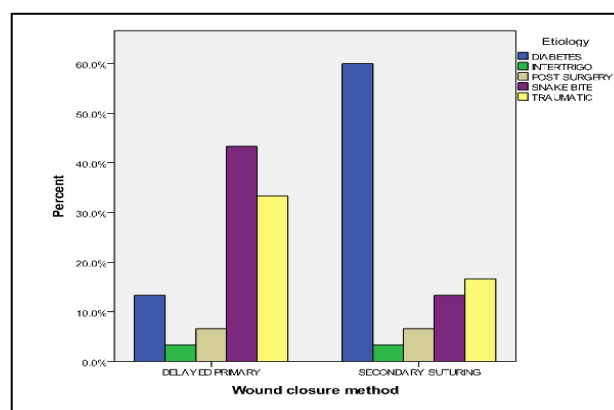


Figure 1: Graphical representation of etiology.

Table 2: Sex distribution.

Sex	Group			
	Control		Intervention	
	Count	Column N (%)	Count	Column N (%)
Female	8	26.7	8	26.7
Male	22	73.3	22	73.3

Table 3: Duration of hospital stay (in days).

Duration of hospital stay in days	Group			
	A		B	
	Mean	SD	Mean	SD
	13.1	2.4	8.0	2.1

One of the main aims to conduct this study was to know whether incorporating DPC method will help in reducing the length of hospital stay. Final study results showed that the mean duration of hospital stay in Group B was 5days less than that of Group A, which was statistically significant (p=0.0001).

Table 4: Mean time taken for complete wound healing (in days).

Time taken for complete wound healing in days	Group			
	A		B	
	Mean	SD	Mean	SD
	25.2	3.9	17.9	2.8

In Group B, complete wound healing was achieved ~7 days (mean) earlier than that of Group A which was statistically significant (p<0.001).

Table 5: Hospital expenses.

Category	Group			
	A		B	
	Count	Column N (%)	Count	Column N (%)
1.0	0	0.0	12	40.0
2.0	0	0.0	16	53.3
3.0	16	53.3	0	0.0
4.0	9	30.0	2	6.7
5.0	5	16.7	0	0.0

In order to calculate the hospital related expenses, 5 categories were designed as Category 1 - Rs.<15000; Category 2 - Rs. 15001-20000; Category 3 - Rs. 20001-25000; Category 4 - Rs. 25001-30000; Category 5 - Rs. >30000.

Then, study participants were assigned into these categories based on their final hospital bill. It was found that, in Group A, most number of participants came under Category-3 (53.3%), followed by Category-4 (30.0%). Whereas, in Group B, maximum number of study participants came under Category-2 (53%), followed by Category-1 (40%). This was found to be statistically significant (p<0.001), which means that hospital related expenses in Group B was significantly lower than that of Group A (Table 5).

The observations in Table 6 are statistically insignificant and hence it was found that there was no significant difference in local wound related complications between the two groups.

Table 6: Incidence of local wound related complications.

Complications	Group			
	A		B	
	Count	Column N (%)	Count	Column N (%)
Nil	26	86.7	27	90.0
Skin necrosis	1	3.3	1	3.3
Wound infection	3	10.0	2	6.7

Exposure to anaesthesia

In this study, all 30 participants in Group A were subjected to anaesthesia/drugs more than once, as everyone underwent second/third procedure. Whereas, in Group B only 4 participants received anaesthesia/drugs more than once which is statistically significant (p <0.0001).

Incidence of anaesthesia related complications

Incidence of anaesthesia related complications in Group A (23.3%) was higher than in group B (10%) but was found to be statistically insignificant (p=0.6).

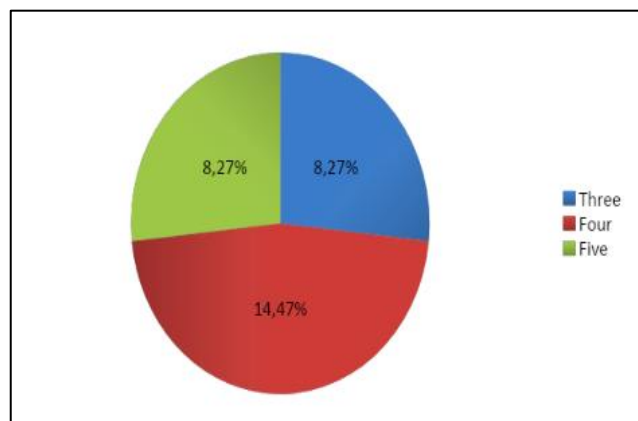


Figure 2: Number of sutures tightening sessions.

DISCUSSION

Cellulitis is an inflammation of the skin and subcutaneous tissues.⁸ It occurs almost equally among both men and women.⁹ The incidence of lower limb cellulitis was as high as 199 cases per 100,000 person-years in a population based study.¹⁰ The most common causative organisms are *Streptococcus pyogenes* and *Staphylococcus aureus*.¹¹ The common risk factors for recurrent cellulitis are venous insufficiency, diabetes, lymphedema and previous episodes of cellulitis.¹² The common symptoms at presentations are pain, swelling and redness of the limb. Systemic symptoms like fever and raised white cell counts were present in 42% of the individuals at the time of admission.¹³ Surgical intervention is required in patients developing local

complications such as spreading of cellulitis which spreads to involve the entire limb followed by perineum and abdomen, leading to compartment syndrome which requires prolonged hospital stay, increasing the cost burden for hospital services.¹⁴

Fasciotomy, a limb saving surgery, often poses problem to a surgeon with regards to its wound closure. Early decompressive fasciotomy is essential in the prevention of the complications of compartment syndrome.¹⁵ Various wound closure strategies may be followed for the closure of fasciotomy wounds. Well, to name a few, conventional secondary suturing, split skin grafting, delayed primary closure, healing by secondary intention, use of modern dermal closure devices etc., Among these, DPC method by dermal apposition makes use of the inherent elastic property of skin. By doing so, proliferation phase of wound healing is hastened/partially bypassed. Proliferation phase of wound healing comprises of proliferation of new blood vessels, formation of granulation tissue, myofibroblasts assisted wound contracture by gripping the wound edges and pulling them together.¹⁶

Previous studies in the literature compared various new methods for closure of fasciotomy wounds.^{1,12,17-20} In this study, all study subjects in Group A, underwent conventional secondary suturing for fasciotomy wound closure. In this group, the average duration of hospital stay was 13.1 days (range 10-19) and time taken for complete wound healing was 25.2 days (range 20-37). Hospital stay and wound healing time was affected by the presence of comorbidities. These patients had multiple episodes of exposure to anesthesia, increased incidence of anesthesia related complications.

All study subjects in Group B, who underwent DPC method, achieved wound approximation in an average of 4 suture tightening sessions. In a similar study by Eid et al, closure was obtained at an overall average of 4.2 tightening sessions (range 3-7) whereas, Park et al and Cheng et al reported 2-6 sessions for wound approximation.²¹⁻²³

Marek et al and Chiverton et al suggested obtaining closure in single sitting.^{20,24} We achieved wound approximation in 4 tightening sessions which was on par with other studies in literature. This method of gradual coaptation of wound edges helped us to assess the oedema, redo debridement's whenever necessary which helped us to overcome problems of single sitting closure as in secondary suturing method, such as recurrence of increased compartment pressures, late onset infection due to fluid accumulation, need of excessive traction to close large wounds resulting in local wound complications.²

In this study, we compared total duration for complete wound healing, unlike other studies wherein duration for wound approximation was accounted for Group B subjects achieved complete wound healing on an average

of 17.9 days (range 13-24) which was ~7 days earlier than that of Group A study subjects (25.2 days).^{25,26} In literature, wound approximation was achieved in 8.3 days by Saini et al. Zorilla et al reported approximation time of 8.8 days (range 6-19) days using shoelace technique.^{15,19} Using dermal apposition devices, Taylor et al, Medina et al and Geertruida et al reported 11.5 days (range 6-11 days), 7.4 days, and 6.3 days of average closure time, respectively.^{7,27,28} Commercial devices such as sure closure, dynamic wound closure, STAR, silver bullet wound closure device may result wound closure in only 4 days.²⁹ As time to closure varies according to the technique used, surgeon plays a key role in decision making regarding the best method to be used for closure considering the financial status and medical condition of the patient.

With regards to duration of hospital stay, in Group B, on an average it was 8 days which is on par with studies till date, and it is 5 days less than that of Group A subjects. In Saini et al study it was 12.3 days, whereas in Zorilla et al, study it was 10 days. Hospital duration differed according to the presence of additional comorbidities, age factors.^{15,19}

Disease related financial burden was one of the main factors in a developing country like ours. One of the important objectives of this study was to compare the hospital related expenses between the two groups. In delayed primary closure method, we used 1-2 prolene suture material, in a single anaesthesia sitting, whereas in secondary suturing method, 1-2 ethilon suture material was used along with 2-3 times anaesthesia exposure. In this hospital setting, average expenditure of Group A subjects was ~Rs. 26700 (range 18700-42300) which was found to be ~Rs. 7300 higher than that of Group B subjects (~Rs. 19400). Hence, this study found that DPC method is more economical than conventional secondary suturing method.

In this study, there was no statistically significant difference in the rate of wound infection between the two groups.

CONCLUSION

This study concludes that DPC by shoelace technique using proline suture material, for fasciotomy wound closure following spreading cellulitis with compartment syndrome of lower limbs takes lesser time for wound closure, hence the need for nursing care and hospital stay is significantly reduced in comparison to the conventional secondary suturing method. But, as the sample size was small and spreading cellulitis was the only cause for fasciotomy, which we considered in this study, further controlled study with larger sample size including various causes that results in fasciotomy, is needed in order to demonstrate the efficacy of DPC method by shoelace technique.

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