

Angular Effects of Z-Plasty Technique on Extent of Relaxation of Contracted Scar, Cosmetic Appearance and Tip Necrosis in Dogs

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Abstract Z-plasty is a plastic surgery technique which is used to improve the functional and cosmetic appearance of a scar by redirecting it into better alignment and allowing the closure of a large wound by increasing circumference of its orifices. This experimental study was executed to evaluate the extent of relaxation of contracted scar, cosmetic appearance and tip necrosis in dogs by using Z-plasty technique at different angles, i.e. 45°, 60° and 75°, respectively. 18 mongrel dogs were randomly selected and divided in three groups (A, B and C) comprising six dogs each; after induction of scar tissue, Z-plasty was applied at 45° in Group A, 60° in Group B and 75° in Group C, respectively. % Gain in length was superior for the 60° group ($P < 0.05$), as compared with the 45° and 75° Z-plasty, respectively. Tip Necrosis Status and cosmetic appearance for the 60° group were also found superior ($P < 0.05$) than at 45° and 75°, respectively. The results of the experimental trial showed that the parameters of extent of relaxation of the contracted scar, cosmetic appearance and tip necrosis, were mainly governed by two factors, (1) length of contracted scar and (2) angle of Z-plasty technique. Conclusively, 60° Z-plasty serves a better option for correction of burn scar contractures since it provides average gain in length, good cosmetic appearance and causes no tip necrosis.

Keywords Burn Scar Contracture, Scar Revision, Z-Plasty, Tip Necrosis, Dogs

1. Introduction

Z-plasty is a plastic surgery technique which incorporates a Z-shaped skin incision, composed of one central and two

lateral limbs, with two triangular flaps of equal sizes and these flaps are raised on opposite sides of the two ends of the “Z”, and then transposed to each other [3, 14]. Z-plasty is mostly indicated for burn scar contractures which are one of the most pressing challenges to burn-patients [16, 19, 20] because they result in poor aesthetic appearance, functional impairment and musculoskeletal discomfort.

Initially, some non-surgical procedures like appropriate wound care, splinting and physiotherapy have been used to release the scar. Medical management serves transient relief, however, despite proper application of these treatments, contractures still occur [12, 21]. Hence, permanent relief from burn scar necessitates implication of some relaxing incision. For this purpose, many surgical procedures like skin grafting, flap technique, Z-plasty, Y-V advancement, W-plasty and combinations of the above-mentioned techniques have been used as relaxing incision [8, 18].

Regarding various techniques employed for correction of scars, although the primary aim of each is to lengthen the scar, yet Z-plasty and its modifications supervene over other techniques, since they provide superior lengthening-to-narrowing ratio (Vegetar and Hage, 1997). Z-plasty is a good choice for linear and narrow contracted scar [6, 22]. The major advantage is that Z-plasty can be performed in an area of high skin tension to allow skin relaxation and lengthening [14]; Z-plasty not only improves the functional and cosmetic appearance of scars, rather, it also prevents the contracture of linear scars [11]. Moreover, it also redirects a scar into better alignment with the line of least skin tension or a natural skin fold to allow the closure of large wounds by increasing the circumference of its orifices [1].

Although, a great wealth of literature is available on various issues of reconstructive surgery and the treatment of

post burn contractures [5]. However, condition of the problem, burn severity and choice of technique is still debatable [17, 13]. Considering these points in view, the present study was planned to evaluate the extent of relaxation of contracted scar, cosmetic appearance and tip necrosis at 45°, 60° and 75° by using Z-plasty technique.

2. Materials and Methods

After approval by the Animal Ethical Committee, this experimental study of 3 months' duration was executed at Surgery Section, (Dept. of Clinical Medicine & Surgery), University of Veterinary and Animal Sciences, Lahore-Pakistan. For this purpose, a total number of 18 adult healthy mongrel dogs were selected and randomly divided into three groups viz., Groups A, B and C, comprising six dogs each. A deep partial thickness burn wound was induced on the right thigh region of each dog using electrocautery into the reticular layer of dermis. The wound healed within 3 to 7 weeks with severe scarring, contraction and poor aesthetic appearance. After inducing scar, Group A dogs were allocated for Z-plasty at 45° and Group B and C dogs were allocated for Z-plasty at 60° and 75°, respectively.

3. Surgical Technique

Site Preparation and Anesthesia Induction

The surgical site was prepared aseptically by clipping, washing, and scrubbing of the surgical site; sterile surgical drapes were then placed around the surgical area and secured to patient skin using towel clamps [14]. The dogs were premedicated using an intramuscular injection of atropine sulphate @ 0.03 mg/kg (Atrostar®, Star Laboratories, Pakistan). Anesthesia was then induced using a combination of ketamine and xylazine HCl @ 0.5 mg/kg (Xylaz®, Farvet, Holland), intravenously.

Skin Incision

A vertical incision was made through the skin along the lines of contraction using a number-15 scalpel blade. The skin flaps resulting from incision were undermined at the level of subcutaneous tissue to produce two triangular flaps of equal size and shapes. These triangular flaps were then transposed with each other. During transposition, the upper flap was placed at the position of the lower flap and vice versa. This transposition of triangular flaps not only caused redirection of the central limb at appropriate angle and a disruption of straight scar into a non-linear Z configuration, but also resulted in gain in the length of the original scar limb.

Skin Closure

After transposition, the skin was closed by using non

absorbable suture material (Mersilk 3/0) with simple interrupted suture pattern (Bouladaas et al., 2004). Topical antibiotics were used to minimize the risk and complications as the Z-plasty technique may be complicated by wound infection, hematoma formation and tip necrosis [11].

In group A dogs, Z incision was made by taking scar area as middle part of Z and arms of Z were connected at angle of 45°. Similarly in groups B and C, the Z incision was made and arms of Z were connected at angle of 60° and 75° respectively. The triangular area was undermined to make a triangular flap. Both triangular flaps were transposed to each other and skin was sutured with non-absorbable suture material (Mersilk 3/0) with simple interrupted suture pattern.

Post-Operative Care

Post-operatively, the dogs were monitored for behavior changes, vitals (TPR), feeding, defecation, urination and wound healing/ complications.

Parameters of Evaluation

The operative technique was evaluated on the basis of

1. Physical findings
2. Wound healing
3. Extent of relaxation of contracted scar at 45°, 60° and 75°
4. Cosmetic appearance at 45°, 60° and 75°
5. Tip Necrosis at 45°, 60° and 75°

4. Data Analysis

Data regarding % gain in length was calculated by using the formula:

$$\text{Percentage Gain} = \frac{\text{Original scar length} - \text{obtained length}}{\text{Original scar length}} \times 100.$$

The data thus obtained was analyzed according to Completely Randomized Design (CRD) under factorial arrangements using Analysis of Variance (ANOVA) technique [15].

5. Results

1) Physical findings

The vitals, viz. TPR (Temperature, Pulse and Respiration) were recorded twice daily in all experimental dogs. On an average, the TPR values in Group A dogs were within normal range, i.e. 39.5°C (temperature), 103 beats/min (pulse), and 25 /min (respiration), except dogs #3 and # 6 which suffered slight hypothermia (37°C) during the first 24 hours post-surgery. Average TPR values recorded in dogs of

Group B and C were also within normal range, i.e. 40°C, 102 beats/minute, and 24 /minute (respiration). However, dog # 4 in Group B and dog # 2 in Group C suffered transient hypothermia. Yet, with proper treatment, both dogs recovered well and the temperature in these dogs rebounded towards the normal range as for all other dogs.

2) Wound healing

The wound healed satisfactorily in all dogs however, wound healing took slightly longer than the anticipated normal time. The wound healing was delayed in Group A dogs due to tip necrosis and wound healed in 4-7 weeks. While in Groups B and C, where Z- plasty was applied at 60° and 75°, respectively [7], the wound healed in 3-4 weeks and 3-7 weeks, respectively.

3) Extent of relaxation of contracted scar at 45°, 60° and 75°

The % Gain in length at 45° Z-plasty was found to be highest (47.50%) in Dog # 1 and lowest (35.00%) in Dog # 6. $P=0.001^{**}$ (Table 1) . Similarly, % Gain in length at 60° Z-plasty was found to be highest (72.50%) in Dog # 1 and lowest(45.00%) in Dog # 6 $P=0.002^{*}$ (Table 1) while % Gain in length at 75° Z-plasty was found to be highest (120%) in Dog # 1 and lowest (95.00%) in Dog # 6 $P=0.001^{**}$ (Table 1) . Among the Groups, highest % Gain in length(120%) was found in dog #1 of group C and lowest (35%) in dog #6 of group A $P=0.000004$ (Table 1)

Table 1. Measurements of percent gain in length of contracted scar at 45°, 60° and 75° in experimental dogs

Dog No.	Group A	Group B	Group C	P-Value
1	47.50	72.50	120.00	0.000004
2	44.73	71.00	118.42	
3	42.85	65.70	111.42	
4	43.33	63.33	110.00	
5	36.00	56.00	104.00	
6	35.00	45.00	095.00	
P-Value	0.001**	0.002*	0.001**	

Group A: % gain in length at 45°

Group B: % gain in length at 60°

Group C: % gain in length at 75°

$P < 0.005$ shows significant association

Tip necrosis status at 45°, 60° and 75°

Group A dogs treated with Z-plasty at 45° showed tip necrosis while group B and C dogs treated with Z-plasty at 60° and 75° showed no tip necrosis. Tip necrosis Status at 45°, 60° and 75° showed statistical significance $P=0.0001234^{*}$ (Table 2)



Figure 1. Induction of deep partial-thickness wound through epidermis and into papillary dermis



Figure 2. Z-plasty technique applied at 45° angle.



Figure 3. Z-plasty technique applied at 60° angle.



Figure 5. Z-plasty technique applied at 75° angle.



Figure 6. Suturing of Z-plasty incision given at 60° angle.



Figure 7. Post-operative measurements of Z-plasty technique done at 60° angle.

Cosmetic appearance status at 45°, 60° and 75°

The cosmetic appearance status at 45°, 60° and 75° showed statistical high significance. $P=0.000^{***}$ (Table 2).

Table 2. Measurements of Tip necrosis and cosmetic appearance of contracted scar at 45°, 60° and 75° in experimental dogs

Parameter	Status	Angles			P value
		45°	60°	75°	
Tip Necrosis	Positive	6**	0	0	0.0001234**
	Negative	0	6	6	
Cosmetic Appearance	Bad	6	0	0	0.000**
	Good	0	6*	0	
	Fair	0	0	0	

$P < 0.005$ shows significant association

6. Discussion

The Z-plasty technique was evaluated on the basis of physical findings, wound healing, extent of relaxation of contracted scar, cosmetic appearance and tip Necrosis at 45°, 60° and 75°, respectively. Among vital signs, the temperature, pulse and respiration in all three groups A and B and C were recorded to increase slightly, but became normal after a few days. The wound healed satisfactorily in all dogs. However, wound healing took slightly longer than the anticipated normal time, which could be attributed to temperatures. Delay in wound healing due to temperature fluctuations has also been documented upon by Fossum, [4]; Jain and Shakya, (2009).

In Group A dogs treated with z-plasty at 45°, the percentage gain in length was found to increase from 35% - 47.5% ($P < 0.05$). This was in agreement with similar findings reported by Cochran et al. [2] that Z-plasty at 45° yields 50 % increase in length. The difference may be attributed due to difference in skin elasticity. Pomaranski et al. [9] described that actual gain in length depends on skin elasticity and tissue mechanics. Similarly, the percentage gain in length in Group B dogs treated with Z-plasty at 60° was found to increase from 45% - 72.5% ($P < 0.05$). This was also in close agreement of the findings of Cochran et al. [2], who reported a 75 % increase in length with 60° Z-plasty, and Rohrich and Zbar [10], who reported a total increase in length of 41% to 63 % with 60° Z-plasty procedure. The slight difference in reported values may however, be attributed to differences in skin elasticity, since Pomaranski et al. [9] described that actual gain in length depends on skin elasticity and tissue mechanics. Similarly, the percentage gain in length in Group C dogs treated with Z-plasty at 75° was found to increase from 95 % to 120% ($P < 0.05$). This was in complete agreement with the findings of Cochran et al. [2] who documented upon a 120% increase in length with 75° Z-plasty.

On the whole, it was concluded that, the percentage gain in length depends on the length of contracted scar and angle of the Z-plasty. The greater the initial length of contracted scar the higher is the percentage gain in length and vice versa. Similarly, the wider the angle, the higher is the percentage gain in length.

Tip necrosis is a common sequela of plastic reconstructive surgery techniques. In our study, Group A dogs treated with Z-plasty at 45° showed tip necrosis, while Group B and C dogs treated with Z-plasty, respectively at 60° and 75°, showed no tip necrosis ($P < 0.05$). Hence, the cosmetic appearance of dogs that underwent Z-plasty at 45° was scored bad whereas for dogs that underwent Z-plasty at 60° and 75°, were scored good and fair respectively ($P < 0.05$).

7. Conclusions

Conclusively, it was inferred that Z plasty at 60° proved better in terms of average gain in length, good cosmetic appearance and no tip necrosis. The 60° Z-plasty supervenes over the other two techniques, since Z plasty at 45° caused tip necrosis, and Z plasty at 75° offered greater difficulty for transposition of triangular flaps, thus resulting in some degree of tip necrosis.

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