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Comparing Z-Plasty versus Z-Plasty and Skin Grafting for Surgical Tension-Free Treatment of Post-Burn Elbow Contractures: A Randomized Clinical Trial

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Abstract

Background: Elbow contracture is a common incidence. It has surgical treatments such as scar release and skin graft, Z or V-Y plasty, and lateral or medial arm flap. In this study, we compared Z-plasty versus Z-plasty and skin grafting in the surgical tension-free treatment of post-burn elbow contractures.

Methods: 30 patients with elbow joint extension restriction participated in this randomized clinical trial in two groups: experimental (Z-plasty with skin graft) and control (Z-plasty alone) groups. In both groups, Z-plasty was designed with a 60 angle. In the experimental group, the flaps were rotated without tension, and then the upper and lower parts of the flaps were grafted by a mid-split-thickness skin graft. The surgery area was examined regarding infections, wound healing time, necrosis, and scar. Significant differences were evaluated using unpaired student *t*-test.

Results: Only seven participants in the control group had complications. The statistical analysis of all variables in both groups showed that Z-plasty with skin graft treatment had a significantly better result than the Z-plasty alone (P = 0.006). However, the two groups showed no significant differences in terms of infection, flap tip necrosis, surgery site infection, and feeling of pressure in joint extension or scar recurrence (P = 0.273).

Conclusions: Tension-free flap must be used in patients with mild or moderate wide elbow scar contracture. Combining Z-plasty with skin graft is easy and has better results than Z-plasty alone. It is recommended using this technique in patients with intra-operative flap tension.

Keywords: Z-Plasty, Skin Graft, Elbow Contracture, Post-Burn Contracture

1. Background

Scar contracture after thermal burn injury is a challenge. Elbow contracture is a commonly affected joint with 21% to 40% incidence (1). Elbow burn contractures can significantly impair a patient's ability in daily activities because of flexor muscles and hypertrophic scar (2). An important issue in deep burns is restoration and recovery mechanisms. In addition, an understanding of skin restoration principles is important in burn injuries. It depends on proper grafting site selection and applying the skin flap restoration procedure in the correct position (3).

In severe burns, contractures are usually because of severely scarred surrounding skin. Contracture is released by surgery (4). Many burn surgeons have recommended splinting or serial casting as the initial treatment for most patients. Still, in spite of physical therapy, difficult scar contractures occur in the antecubital fossa (1). Depending on the function loss, tissue involvement depth, and scarring duration, the contracture can vary greatly. Therefore, surgical intervention should be tailored for each patient separately (5).

There are many surgical techniques for reconstructing antecubital fossa's burn scar including scar release and skin graft, Z and V-Y plasty, double rectangular flap (6), lateral and medial arm flaps (7). Some of them are complex and are accompanied by unhealthy donor site and occasional sacrifice of either the radial or the ulnar artery (1). Scar release and skin graft require prolonged splinting, the risk of graft failure, and scar contracture recurrence (8). In some patients, elbow scar contracture is relapsed after Z and V-Y plasty. Elbow joint auto-release results can tear

up in many patients. Recurrent tearing will lead to simple chronic contracture (9).

Many patients with elbow contracture experience recurrence after Z plasty. Some of them are not satisfied with the release and skin graft because of restrictions in the elbow joint hyperextension. A cause of scar formation and recurrence is the lack of skin elasticity around the elbow joint because of tension in the flaps' edge and tip. Although many surgeons are aware of this issue, they close the Z plasty with high tension, causing scar formation and recurrence.

Studies on scar contracture investigate the release by increasing scar length with Z plasty and repairing the wound without any tension with a split-thickness skin graft. Nevertheless, this depends on the thickening, severity, and width of the scar and contracture.

Figure 1. Z-plasty and mid split skin graft, free tension repair

2. Objectives

In this randomized clinical trial, we compared the combined treatment of Z-plasty and skin grafting versus Z-plasty alone in the surgical tension-free treatment of post-burn elbow contractures, considering the risk of recurrence, infection, and flap tip necrosis.

3. Methods

From March 2013 to September 2015, 30 patients with elbow joint extension restriction were investigated at a hospital in Zanjan city, Iran. This was a randomized clinical trial. The severity of their elbow burn contracture was first determined by evaluating extension loss, burned area percentage around the elbow, scar thickness, uncircumferential elbow scar, contracture wideness, and surgical history.

The inclusion criteria were having: 1) non-circumferential scar (circumferential up to 75%), 2) 15 to 30 degrees flexion and extension restriction in the elbow joint, and 3) no joint ossification. The exclusion criteria were: 1) being younger than 15 or older than 60 years, 2) taking non-steroidal anti-inflammatory drugs, high dosage of corticosteroids or chemotherapy agents, 3) having joint ossification, 4) having wound infection, and 5) having any comorbid diseases such as metabolic diseases or underlying medical illnesses such as diabetes, uremia, hypertension, cardiovascular diseases, chronic arterial obstruction, immunodeficiency conditions, and kidney failure. Many patients with elbow contracture were visited in our center during a two-and-a-half-year period, but only 30 patients were eligible to enter the study.

Informed consent was obtained from all patients before their participation in the study. The study protocol was approved by the ethics committee of our university. All patients were included in the study following the flap elevation, without any tension for wound repair.

Considering these criteria, patients with antecubital fossa contracture were randomly divided into two groups. The first group was treated with Z-plasty and skin graft (experimental group) (Figure 1) and the second group with only Z-plasty (control group) (Figure 2). All surgeries were done under general anesthesia without tension at the beginning. In addition, all participants received 1 g cefazolin prophylaxis antibiotic.

In both groups, Z-plasty was designed with a 30 degrees angle (Figures 1 and 2). An incision was made on the scar. Then, the skin flap's soft tissue was released and elevated from the deep tissue while preserving the nerves, veins, and artery in the flap. Scarotomy and incision were done on the lateral and medial of the elbow extension according to the Z-plasty design and angle. After that, the flap was turned and the wounds without any tension were repaired with 5 - 0 Vicryl suture (Figure 2). However, in the experimental group, the flaps were turned and a skin graft was done without tension. Then, the upper and lower parts of the flaps were grafted by mid-split thickness skin graft (Figure 1). We placed a flap without any tension in the center of tissue defect and elbow joint, and covered their lower and upper areas (forearm and upper arm) with a mid-split thickness skin graft.

After the surgery, the dressing was done by Vaseline gauze and tied over. Using splint, the surgical area was immobilized for 10 days. The dressing was changed up to 5 - 7 days for both groups. All patients were visited on the 2nd, 4th, 8th, 12th, and 24th weeks after the surgery and the surgical area was examined regarding wound healing time (closing of the incision border without any secretion), scar formation (pigmentation, firmness, and el-

Figure 2. Z-plasty, ischemia, tip necrosis, and scar formation

evation of wound border), contracture details, infection (pus secretion and bacterial culture), necrosis (damage and cyanosis), and motion range of the joint. Significant differences were evaluated using unpaired student *t*-test and Fisher's test.

4. Results

In this randomized clinical trial, 30 patients with a burned elbow (forearm and upper arm) were equally divided into experimental (Z-plasty with skin graft) and control (Z-plasty alone) groups. Statistical analysis showed no significant difference between the two groups in terms of age, sex, and motion range of the elbow joint. The control group was discharged 48 hours after the surgery when the normal wound healing flow was ensured. The investigation group was discharged 24 hours later due to the time required for taking care of skin graft site and training patients on how to do it after discharge. The comparison of the two groups showed that seven patients developed complications in the control group, indicating that the experimental group had significantly better results (Table 1) (P = 0.006).

In general, the recovery duration was, on average, one to two weeks shorter in the experimental group and no infection and/or pressure was observed in joint extension; in addition, patients obtained near-normal motion range after six weeks (Table 2). The six-month post-surgery examinations showed similar results as those presented in Table 2. Despite longer recovery time in the experimental group, statistical analysis did not show any significant difference between the two groups (P = 0.273). The comparison of the two groups showed no significant difference in terms of infection, flap tip necrosis, surgery site infection, feeling of pressure in joint extension, and scar recurrence (reduced joint function and improvement). This indicated the relative similarity of the two groups in terms of recovery. The only problem in the experimental group was discomfort feeling in the donor site that lasted for two to three weeks; however, it was improved using emollient creams and taking protective measures.

Table 1. Distribution of the Study Participants Based on Their Sex

	Experimental Group, No. (%)	Control Group, No. (%)	P Value
Sex			0.66
Man	4 (26.6)	3 (20)	
Woman	11 (73.4)	12 (80)	

5. Discussion

The main result was that seven patients developed complications in the control group. Flap tip necrosis occurred in three cases, and surgical site infection and joint extension tightening (scar recurrence) occurred in two cases of the control group (Figure 2). Although the control group was repaired without tension, because of burned tissue and scarred skin without normal elasticity, this area's flap had a potential to become ischemic and necrotic. Such complications were not observed in the experimental group, which might be due to their tension free status, although their recovery time was about two weeks longer. Thus, the experimental group had significantly better results compared to the control group. Although skin graft was used only in one group, no significant difference was observed between the two groups after six weeks.

In our study, three cases were observed with flap tip necrosis in the control group, which was lower compared to the results of Chen and colleagues' study (9). This was because of the tension in the Z-plasty group, which did not exist in the other group. The incidence of this complication was lower in our study because of better blood circulation and tension-free repair. In our study, the reduction of joint function was observed in two patients of the control group, which was lower compared to the results of Wei and colleagues' study (10). High-tension wound disclosure and flap in tissues with old burn scars result in flap tip necrosis and consequent local infection, leading to scar, discom-

Table 2. Comparison of Recovery Condition and Surgical Results in the Study Groups

	Experimental Group, No. (%)	Control Group, No. (%)	P Value
Recovery duration			0.273
Less than 5 weeks	6 (40)	9 (60)	
More than 5 weeks	9 (60)	6 (40)	
Flap tip necrosis			0.224
Yes	0 (0)	3 (20)	
No	15 (100)	12 (80)	
Surgical site infection			0.483
Yes	0 (0)	2 (13.3)	
No	15 (100)	13 (86.7)	
Joint extension pressure			0.483
Yes	0 (0)	2 (13.3)	
No	15 (100)	13 (86.7)	

fort, and tightness in patients in long-term. Foyatier and colleagues used flaps combined with full-thickness graft for burn treatment (3).

Grishkevich applied the skin flap technique to thoracic and axilla areas in patients with scars, tightly surrounding the joints, with large flexion contracture, and reported acceptable results (4). However, our study showed different results after applying the same technique to the elbow region (forearm and upper arm) (4). More importantly, non-damaged skins have normal elasticity and thus are more resistant to ischaemic contracture. In severe burn injuries with joint capsule involvement, island flap (10), pedicled flap (4), and free flap (11) can be used. Although these complicated skin flap techniques were associated with more complications and difficulties, they were suitable for the selected patients. Chen and colleagues studied partial necrosis caused by a retrograde pedicled flap in upper limbs and found necrosis only in two cases (less than 1%) in patients undergoing the traditional procedure (12).

Gachie and Casoli used orthopedic treatment to correct joint contracture while only skin flap and graft were used in this study (13). Moreover, Haslik and colleagues conducted a two-stage procedure to treat contractures using Matriderm dermal matrix (14).

Ezoe and colleagues reported venous congestion as the main cause of graft failure (15). In this study, there existed two cases of flap necrosis (caused by tension on the wound), but none with graft necrosis (15). However, in cases with more than 50% burned surface area in and around the elbow (forearm and upper arm) and in large contractures, these methods have been useless (15). Uygur and colleagues used V-Y flap and rhomboid flap while we used rotational flap for contracture treatment (7).

Antecubital contracture is divided into three categories: mild, moderate, and sever. In mild antecubital contracture, the release or excision of more advanced contractures will frequently result in soft-tissue deficits that are too large for primary closure, in which skin grafts can be used to resurface the wound whereas the latter are generally repaired using a simple or modified Z-plasty or a transpositional flap technique (2). Some have used burned skin as part of the reconstruction, exemplified by the bipedicled flap and the propeller flap, to decrease autografting burden (16). These studies are in line with our results. Doing Z-plasty with graft prevents secondary surgeries in most patients.

In moderate antecubital scar contracture, after releasing the scar, large soft-tissue defects that cross the joint or expose vital structures are treated with a variety of local, adipofascial flaps and regional flaps that recruit uninjured tissues from the upper arm, forearm (1, 17, 18). Local fasciocutaneous flaps have become the mainstay for elbow reconstruction and provide supple skin, but they can also result in an unhealthy donor site and occasional sacrifice of either the radial or the ulnar artery (1, 7).

Linear post-burn scar contractures are usually released by Z-plasty or Y-V plasty (19, 20). However, these techniques may not be effective or easy to use when the linear contracture is wide. Double opposing rectangular advancement is a new technique consisted of two adjacent rectangular flaps' opposition by advancement. Postoperative measurements indicate the lengthening provided with the technique ranging from 72% to 100% (21).

Perhaps the most common surgery is the Z-plasty, although in burn cases, it has a high risk of tip necrosis. This can be avoided by using partial Z-plasty with a 90 degrees angle (5). We used a combined technique (Z-plasty and skin graft) for covering antecubital contracture because of large flap donor site morbidity, the occasional sacrifice of the radial or ulnar artery, scar contracture recurrence, and mild to moderate wide scar contracture. Our findings showed that it has better results compared to when graft or flap surgeries are used alone. The surgeons can change the treatment from Z-plasty to Z-plasty plus skin graft in pa-

tients with flap tension intra-operatively.

There are two confusing groups of patients. The first group is patients with large burned areas but milder contracture, due to low normal elasticity around the joint. Using only skin flap technique for such patients is associated with some problems which constrain joint extension in long-term. The second group is patients with severe contracture in which small tissue area and reduced skin elasticity pose a two-fold problem. In our study, this problem was solved by combining skin flap and graft techniques. In our experimental group, the flaps were turned without any tension. Then, the upper and lower parts of the flaps were grafted by mid-split-thickness skin graft (Figure 1). We placed a flap without any tension in the center of tissue defect and elbow joint and covered their lower and upper areas (forearm and upper arm) with a mid-split thickness skin graft. (Figure 1) Late postoperative results were excellent in the upper extremities since re-contracture was not seen in any participant of the experimental group.

There are several techniques to release burn contractures, but selecting the proper technique for each patient is important. Although many surgeons know that the flap has tension, they do Z-plasty and repair the wound with 2 - 0 Vicryl suture with some tension. Nevertheless, a burned tissue does not have the normal elasticity. Therefore, the flaps of this area have the potential to develop ischemia and necrosis. We recommend using the flap without any tension in patients with mild or moderate wide elbow scar contracture. Combining Z-plasty and skin graft is easy and has better results compared to Z-plasty alone.

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Footnotes

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