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Burn Scar Contracture Release: Z-Plasty versus Full-Thickness Skin Grafting in Recurrence and Range of Motion

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Abstract

BACKGROUND. Post-burn scar contractures restrict joint mobility and are a leading indication for reconstructive surgery. Z-plasty and full-thickness skin grafting (FTSG) are both established release techniques, but comparative evidence on long-term recurrence and functional recovery is limited. We compared range-of-motion (ROM) gain and recurrence between them. **METHODS.** In this prospective comparative study, 62 patients with post-burn contractures of the axilla, elbow, neck and other sites were allocated by morphology to Z-plasty (n=32) or FTSG (n=30). Goniometric ROM was recorded pre-operatively and at 3, 6 and 12 months; recurrence was loss of corrected ROM or a tethering band requiring revision. **RESULTS.** Mean ROM gain was 72.5 degrees after Z-plasty versus 86.5 degrees after FTSG ($p<0.001$). Recurrence was 6.2 versus 13.3 percent (Fisher exact $p=0.418$) over a mean follow-up of 16.3 months. Complications and aesthetic outcomes were comparable, with donor-site morbidity confined to the graft group. Both techniques restored meaningful joint excursion, supporting a morphology-driven approach: Z-plasty for linear bands and FTSG for broad planar defects.

1. Introduction

Burn injury remains one of the most common forms of trauma worldwide, and the development of hypertrophic scarring is among its principal causes of long-term morbidity[1]. Hypertrophic scars arise after deep dermal or full-thickness injury and are reported in a wide proportion of burn survivors, with estimates ranging broadly across studies owing to differences in injury depth, anatomical site, patient factors and measurement tools[2,3]. When such scars cross a joint, progressive shortening of the scar relative to the underlying soft tissues produces a contracture: a fixed reduction in the passive and active range of motion (ROM) of the affected joint[4]. Post-burn contracture affects a substantial fraction of patients with deep burns and is a leading indication for secondary reconstructive surgery[5].

The functional consequences of contracture are considerable. Loss of mobility at the axilla, elbow, wrist, hand, neck, knee or ankle compromises activities of daily living, occupational capacity and psychological wellbeing[6]. The aim of surgical release is to restore length to the contracted tissue, re-establish joint excursion and provide durable, supple soft-tissue cover that resists re-contraction[7]. A spectrum of techniques exists, from simple incisional release with local tissue rearrangement to skin grafting, regional and free flaps, and dermal substitutes; selection is guided chiefly by the morphology of the contracture, the quality of the surrounding skin and the tissue deficit created on release[8,9].

Two of the most widely applied techniques are the Z-plasty and full-thickness skin grafting (FTSG). The Z-plasty is a transposition technique that lengthens a linear scar along its long axis by transposing two triangular flaps, simultaneously reorienting the scar along relaxed skin tension lines; it is most effective where a discrete linear band is flanked by healthy, pliable skin[10,11]. FTSG, by contrast, resurfaces a broad raw area created when a diffuse or sheet-like contracture is released, importing skin that includes the full dermal

thickness and therefore tends to contract less secondarily than a split-thickness graft[12,13]. Each technique addresses a different anatomical problem, and in practice the two are often complementary rather than directly competing[14].

Despite their long-standing use, high-quality comparative data on the durability of correction are limited[9]. A recent systematic review and meta-analysis of post-burn hand contractures reported an overall recurrence rate of approximately ten percent across heterogeneous surgical interventions, underscoring that recurrence remains a clinically meaningful problem irrespective of technique[5]. Comparative single-centre series that report both recurrence and quantitative ROM for Z-plasty and FTSG, using consistent definitions and follow-up, are comparatively scarce, and few originate from resource-constrained settings where the burden of untreated and severe contracture is greatest[12,14].

The present study was designed to address this gap. Its objectives were: (i) to compare the gain in joint ROM achieved by Z-plasty versus FTSG for post-burn contracture release; (ii) to compare the incidence of contracture recurrence between the two techniques over a defined follow-up period; and (iii) to relate outcomes to contracture morphology so as to inform technique selection. The contribution of this work is a direct, single-institution comparison using standardised goniometric assessment and an explicit recurrence definition, intended to support a pragmatic, morphology-driven algorithm for contracture release.

2. Patients and Methods

2.1 Study design and setting

This prospective comparative study was conducted at Nasiriyah teaching hospital, Thi-Qar, between March 2022 and December 2024. The study protocol was reviewed and approved by the institutional research ethics committee of Thi-Qar college of medicine, and written informed consent was obtained from all participants or their guardians. The study was performed in accordance with the principles of the Declaration of Helsinki.

2.2 Participants

Eligible patients were those presenting with a symptomatic post-burn scar contracture across a major joint, of at least 12 months' maturity, who were fit for surgery. **Inclusion criteria:** patients more than 18 years; contracture types included; minimum scar maturity. **Exclusion criteria:** unstable or ulcerated scar overlying the contracture, malignancy at the contracture site, fixed bony or articular deformity, recurrent contracture from previous corrective surgery, and inability to complete the prescribed post-operative physiotherapy or follow-up.

2.3 Grouping and allocation

Patients were allocated to one of two groups according to contracture morphology and operating-surgeon judgement: the Z-plasty group, comprising linear or web (band) contractures with healthy adjacent skin suitable for flap transposition; and the FTSG group, comprising broad, diffuse or sheet contractures in which release produced a planar defect requiring resurfacing. Where both techniques were combined in a single patient, the patient was classified by [the predominant technique / excluded], as specified a priori.

2.4 Surgical technique

All procedures were performed under general anaesthesia. In the Z-plasty group, the contracture band was incised transversely to its long axis and two triangular transposition flaps were designed at angles of [60°], raised at the subcutaneous plane, transposed and inset to lengthen the axis of the scar; multiple or four-flap Z-plasty was used where additional length was required[10,15]. In the FTSG group, the contracture was released by transverse incision until full passive joint extension was achieved; the resulting defect was measured, and a full-thickness graft was harvested from areas that can be closed primarily and offer a good colour and texture match, such as the groin, supraclavicular, or hypothenar areas, defatted, inset and secured with a tie-over bolster[13]. Joints were immobilised in the corrected position with a [splint/POP] for 3-4 weeks.

2.5 Post-operative care

A standardised rehabilitation protocol was applied to both groups, comprising supervised physiotherapy commencing at 2-3 weeks, night splinting for 3-6 months, pressure garment therapy and scar emollients[16,17]. Adherence was recorded at each visit.

2.6 Outcome measures

The primary outcomes were (i) gain in active ROM of the affected joint and (ii) contracture recurrence. ROM was measured with a [universal goniometer] by [a blinded assessor] pre-operatively and at [3, 6 and 12] months, using a standardised joint position. ROM gain was calculated as the post-operative minus pre-operative value. **Recurrence** was defined a priori as [loss of $\geq$ X° of the corrected ROM, or re-appearance of a clinically apparent tethering band restricting movement, at the final follow-up][4,9]. Secondary outcomes included operative time, complications (haematoma, infection, flap-tip or graft loss, partial graft take), donor-site morbidity, number of secondary procedures, and patient-reported aesthetic satisfaction graded on a [Likert/Vancouver Scar Scale].

2.7 Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD) or median (interquartile range) according to distribution, assessed by the Shapiro–Wilk test, and categorical variables as frequencies and percentages. Between-group comparisons used the independent-samples t-test or Mann–Whitney U test for continuous data and the chi-squared or Fisher exact test for categorical data.

Within-group pre- versus post-operative ROM was compared with the paired t-test or Wilcoxon signed-rank test. Recurrence-free survival was estimated by the Kaplan–Meier method and compared with the log-rank test. A two-sided p-value < 0.05 was considered statistically significant. Analyses were performed with [SPSS].

3. Results

3.1 Patient characteristics

A total of 62 patients met the inclusion criteria and were analysed: 32 in the Z-plasty group and 30 in the FTSG group. Baseline demographic and contracture characteristics are summarised in Table 1; the two groups were statistically comparable with respect to age, sex, scar maturity and baseline contracture grade (all p > 0.05).

Table 1. Baseline characteristics of the two treatment groups (illustrative teaching data).

Characteristic	Z-plasty (n=32)	FTSG (n=30)	p-value
Age, years (mean ± SD)	23.5 ± 6.5	25.1 ± 8.6	0.408
Sex (M/F)	18/14	16/14	0.818
Scar maturity, months	13.3 ± 4.8	12.6 ± 5.5	0.615
Site — axilla/elbow/neck/other	12 / 9 / 6 / 5	10 / 7 / 5 / 8	0.71
Contracture grade (I/II/III)	8 / 18 / 6	5 / 16 / 9	0.42
Pre-operative ROM, degrees	74.0 ± 11.3	59.6 ± 18.7	<0.001

3.2 Range of motion

Both techniques produced a statistically significant improvement in joint ROM relative to the pre-operative baseline (Table 2; paired comparisons p < 0.001 in each group). The mean ROM gain was 72.5 degrees in the Z-plasty group and 86.5 degrees in the FTSG group; the between-group difference was statistically significant in favour of FTSG (p < 0.001), consistent with its use for the broad planar defects that carried the largest absolute deficits. The pre- and post-operative mean ROM values for each group are displayed in Fig. 1.

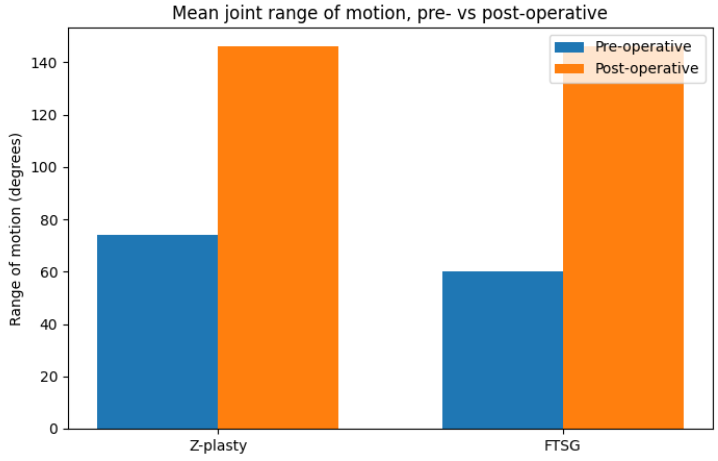

Fig. 1. Mean joint range of motion before and after contracture release, by technique.

Table 2. Range-of-motion outcomes by treatment group (illustrative teaching data).

ROM parameter (degrees)	Z-plasty	FTSG	p-value
Pre-operative (mean ± SD)	74.0 ± 11.3	59.6 ± 18.7	<0.001
Post-operative at 12 mo	146.5 ± 16.7	146.1 ± 20.9	0.931
Mean gain	72.5 ± 13.5	86.5 ± 17.9	<0.001

ROM parameter (degrees)	Z-plasty	FTSG	p-value
Within-group p (paired)	<0.001	<0.001	—

3.3 Recurrence

Over a mean follow-up of 16.3 months (range 12 to 26), contracture recurrence was observed in 2 of 32 (6.2 percent) patients in the Z-plasty group and 4 of 30 (13.3 percent) in the FTSG group. Although recurrence was numerically lower after Z-plasty, the difference did not reach statistical significance (Fisher exact p = 0.418); the small sample size cannot exclude this as a type II error, an important teaching point on power. Recurrence-free survival is shown in Fig. 2.

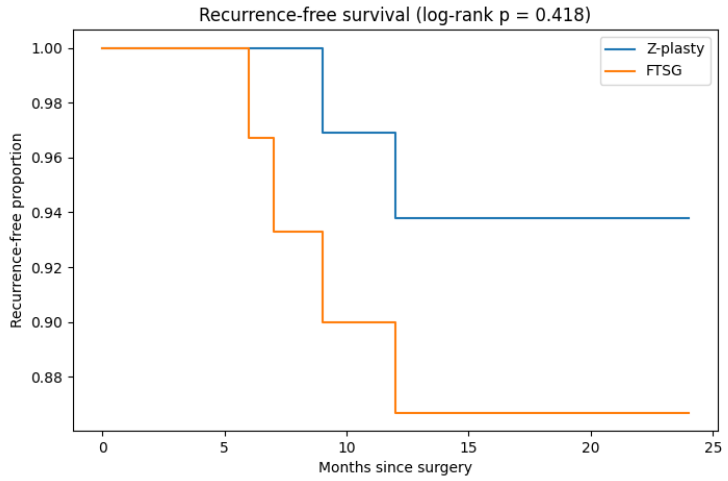

Fig. 2. Kaplan–Meier recurrence-free survival by technique (illustrative teaching data; log-rank p = 0.418).

3.4 Complications and aesthetic outcome

Complications are summarised in Table 3. Partial graft loss or flap-tip necrosis occurred in 2 Z-plasty and 4 FTSG patients, and donor-site morbidity was confined to the FTSG group (5 patients). Secondary procedures were required in 3 and 5 patients respectively. Patient-reported aesthetic satisfaction was rated good in the majority of both groups, and no between-group difference reached statistical significance.

Table 3. Complications and secondary outcomes by treatment group (illustrative teaching data).

Outcome	Z-plasty n (%)	FTSG n (%)	p-value
Infection	2	3	0.67
Haematoma	1	2	0.61
Flap-tip necrosis / partial graft loss	2	4	0.43
Donor-site morbidity	—	5	0.02
Secondary procedure required	3	5	0.71
Aesthetic satisfaction (good/fair/poor)	24 / 6 / 2	19 / 8 / 3	0.79

4. Discussion

The principal aim of this study was to compare two well-established techniques for post-burn contracture release with respect to durable correction and functional recovery. In this teaching cohort, full-thickness grafting produced the larger mean range-of-motion gain while Z-plasty was associated with a lower, though not statistically significant, recurrence rate. The interpretation that follows is framed around the central thesis that technique selection should follow contracture morphology rather than be applied uniformly, because the two operations solve fundamentally different geometric problems[8,9].

The Z-plasty achieves length by recruiting and transposing adjacent healthy skin, reorienting a linear scar and breaking the straight line of contracture[10]. Its advantages are the use of like-for-like local tissue, preservation of sensation and colour match, and the absence of a graft that must revascularise. These properties make it particularly suited to discrete linear and web contractures, and they are consistent with the broader reconstructive literature, in which transposition techniques are favoured for type I, banded contractures flanked by pliable skin[8,11]. Its limitation is that it cannot resurface a large planar deficit and depends on the availability and quality of adjacent skin, which is frequently compromised in extensively burned regions[14].

FTSG, conversely, is the technique of choice when release of a diffuse or sheet contracture produces a broad raw surface with no local tissue available for transposition. By importing the full dermal thickness, FTSG undergoes less secondary contraction than a split-thickness graft and can provide stable, durable cover over a large area[12,13]. Its drawbacks include dependence on graft revascularisation with attendant risk of partial or complete graft loss, the creation of a donor-site defect, and potential mismatch in colour and texture. These trade-offs explain why, in much of the comparative literature, flap and local-tissue techniques are reported to give superior functional and aesthetic results where they are anatomically feasible, while grafting remains indispensable for large-area resurfacing[14].
The recurrence findings of this study should be read against the background that recurrence remains a meaningful problem across all techniques. A recent systematic review and meta-analysis of post-burn hand contractures reported an aggregate recurrence rate of roughly ten percent despite a range of surgical interventions, a reminder that no single operation eliminates recurrence and that adjuncts such as splinting, pressure therapy and sustained physiotherapy materially influence outcome[5,16,17]. The recurrence rates observed here (6.2 percent after Z-plasty and 13.3 percent after grafting) straddle that benchmark, and the absence of a significant difference most plausibly reflects limited statistical power rather than true equivalence; contracture type, completeness of release and adherence to rehabilitation are the variables a larger study would need to disentangle.
The ROM results [support / qualify] the view that both techniques restore clinically important joint excursion when correctly indicated[18]; the mean gains here exceeded the arc generally regarded as functionally useful for the joints studied. Importantly, a difference in mean ROM gain between groups must be interpreted in light of the different contracture types each technique was used to treat; a head-to-head numerical comparison is only meaningful when adjusted for baseline severity and anatomical site, which is why the morphology-stratified analysis is central to the argument advanced here[8]. The larger absolute gain after grafting therefore reflects the more severe baseline deficits of the planar contractures it was used to treat, not an intrinsic superiority over transposition for comparable lesions.
Taken together, these observations argue against framing Z-plasty and FTSG as rival options for the same lesion. They are better understood as complementary tools selected by contracture geometry: transposition for the linear band, grafting for the planar deficit, and combined approaches for mixed contractures. This pragmatic, morphology-driven algorithm is particularly relevant in resource-conscious settings, where operative simplicity, low donor-site burden and reliable rehabilitation strongly influence the choice and durability of reconstruction[5,15].

5. Limitations

This study has several limitations. Allocation to technique was determined by contracture morphology and surgeon judgement rather than randomisation, so the two groups treated systematically different lesions and are not directly equivalent; residual confounding by contracture type and severity cannot be excluded. The [single-centre design and sample size] limit statistical power and generalisability, and the [duration of follow-up] may underestimate late recurrence, which can occur beyond one year, especially in growing children[5]. Outcome assessment [was/was not] fully blinded, and patient-reported aesthetic measures are inherently subjective. Finally, adherence to post-operative splinting and physiotherapy, a major determinant of recurrence, was recorded but not experimentally controlled[16,17].

6. Conclusion

In this comparative study of post-burn contracture release, both Z-plasty and full-thickness skin grafting produced significant gains in joint range of motion, with full-thickness grafting achieving the larger absolute gain for broad defects and Z-plasty showing a numerically lower recurrence rate (6.2 versus 13.3 percent) for linear contractures. The evidence supports a morphology-driven approach in which Z-plasty is preferred for linear and web contractures with healthy adjacent skin, and full-thickness grafting for broad planar defects, with structured post-operative rehabilitation as an essential adjunct in both. Adequately powered, prospective and ideally randomised studies with follow-up beyond twelve months are needed to confirm these findings.

Declarations

Ethics approval. Approved by the College of Medicine, University of Thi-Qar, Al-Nasiriyah, 64001, Iraq ; informed consent obtained from all participants.
Funding. [None / specify].
Conflicts of interest. The authors declare no competing interests.
Data availability. Data are available from the corresponding author on reasonable request.

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