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Tie-overs under pressure☆

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Tie over dressings; Skin graft; Pressure dressing

Summary Dressings tied over skin grafts reduce the size of dead space, prevent haematoma formation, and immobilise the grafts [McCarthy, Plastic Surgery, 1990]. Their mechanism of action was thought to include the application of pressure to the bed and stabilisation of the graft and dressing. A quantitative analysis of the pressure exerted by these dressings has never been reported [Wolf at al., Ann Plast Surg 40 (1998) 149]. This study measures the pressure exerted by tie-over dressings at the graft-bed interface and finds that no significant pressure is exerted.

Since 1929, when Blair and Brown[3] stressed that one of the basic requirements for successful grafting was the application of even pressure to the graft by a carefully designed dressing, surgeons have been encouraged to use so-called pressure dressings on skin grafts.[2] This belief was perpetuated in 1957 by Gillies and Millard,[4] who stated that 'In the tie-over dressing…both stretch and pressure are applied to the graft'. McCarthy[1] uses tie-overs as his first example of a pressure dressing, and Grabb and Smith[5] state that tie-over dressings exert firm pressure onto the graft. Recent texts warn that tie-over dressings must be used with caution over bony prominences to avoid pressure necrosis.[6]

To our knowledge, no-one has previously measured the pressure produced by a tie-over dressing. This project measured the pressure at the graft-bed interface, before application of tie-over dressing, and then after application, and after tensioning of the tie-over sutures, to determine the change in pressure produced by these dressings.

Patients and methods

Twenty patients having full or partial thickness skin grafts dressed with tie-over dressings were prospectively enrolled in the study, and consent obtained. Defect sizes from 1 to 15 cm in diameter were examined. The graft bed surface was categorised as flat, concave or convex. An electronic pressure transducer of the type used for measuring intra-compartmental pressures was calibrated, and confirmed to be accurate to within 3 mmHg over a wide range of pressures (Table 1).

The graft bed and graft (full or partial thickness) were prepared in the normal manner. The graft was sutured in place with a minimum of eight sutures leaving the ends long for tying over. The catheter tip was introduced between two sutures and carefully placed at the graft-bed interface, and the final sutures inserted, leaving the catheter in situ. One millilitre of normal saline was instilled between the

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Table 1 Calibration of pressure transducer (Stryker model 295-1) against pneumatic transducer tester (Bio-Tech Instruments Inc. model DPM-18)

Pneumatic transducer tester, test pressure (mmHg)	Pressure monitor, pressure monitor reading (mmHg)
75	78
50	53
25	27
10	11
5	6
2	3

graft and its bed via the catheter, and allowed to equilibrate for 120 sec. It was ensured that the pressure monitor and the catheter tip were on the same horizontal level, to exclude minor variations in atmospheric pressure. The dressing comprised paraffin gauze, and proflavine soaked cotton wool packed to fill the contour defect and create a convex mound sufficiently high centrally to create an angle of approximately 45° from the surrounding skin surface. Sutures were tied with adequate tension just to create blanching at the suture site.

Pressures at the graft-bed interface were measured at three stages, allowing 120 sec for equilibration prior to each reading. Three measurements were recorded; before application of tie-over dressing; following application of tie-over dressing, but before tensioning with sutures and following tensioning of sutures.

The catheter was removed following the final measurement, and the patient given routine post-operative instructions. Percentage graft take was assessed one week post-operatively. Results were analysed by mean, standard deviation and paired *t*-test.

Results

The results of the study show that no significant pressure was generated by the tie-over dressings in any of the 20 cases. Table 2 shows the pressures recorded before application of tie-over dressing compared with pressure after tensioning with sutures. The change in pressure is not statistically significant at the 5% level. Greater than 80% graft take was achieved in all cases.

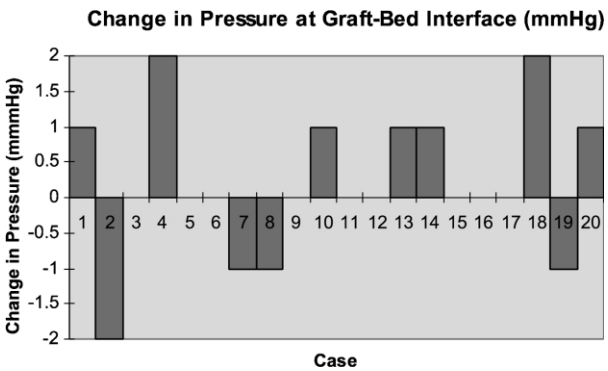
Graph 1 shows change in pressure at the graft-bed interface in millimeters of mercury. The maximum change in pressure produced by a tie-over dressing was only 2 mmHg. In four of the 20 cases, a negative change in pressure was produced, and in nearly half, there was no change in pressure at the graft-bed interface at all.

Discussion

Tie-overs have been proposed to increase graft take by decreasing haematoma and seroma formation, decreasing sheer, and stabilising the graft. The proposed mechanism for decreasing haematoma and seroma formation is production of pressure, hence these have been called pressure dressings.[1] The required amount of pressure to decrease haematoma and seroma formation has been postulated to be capillary closing pressure of 25 mmHg. Hence, the expectation was that tie-over dressing would produce pressure in that range.

This study shows no significant production of pressure by these dressings. The pressure measurement system has been calibrated and validated both in this study and previously to be capable of measuring clinically significant pressure.[7] Conformation and attachment of the skin graft to the bed effectively seals the system and pressures greater than 30 mmHg could easily be achieved by applying digital pressure over the tie-over dressing, whilst avoiding occlusion of the catheter tip. We do not believe failure to record significant pressure change arose from system failure.

Analysis of the results reveals that in some cases there was a decrease in the pressure at the graft-bed interface after tensioning of the tie-over. A possible mechanism for this fall in pressure could be that as the sutures are tensioned, they lift up the surrounding skin edges and tent the graft across the



Graph 1

Table 2 Pressure recorded at Graft–Bed interface

Case	Pressure before application of tie-over dressing (mmHg)	Pressure after tensioning sutures (mmHg)	Change in pressure (mmHg)
1	0	1	1
2	2	0	−2
3	1	1	0
4	2	4	2
5	1	1	0
6	1	1	0
7	2	1	−1
8	1	0	−1
9	2	2	0
10	0	1	1
11	0	0	0
12	0	0	0
13	0	1	1
14	0	1	1
15	1	1	0
16	0	0	0
17	0	0	0
18	1	3	2
19	1	0	−1
20	1	2	1
Mean	0.8	1.0	−0.2
Standard deviation	±0.8	±1.1	

Paired t-test, obtained t value = 0.89, tabled t value = 2.09, no significance at $p < 0.05$.

defect. The graft bed will also tend to deform and deepen. These effects act together to create a relative negative pressure at the graft-bed interface. It might be expected that this effect would be greatest in cases where the graft bed was concave. Given the small size of the study, this can be neither confirmed nor refuted.

In the majority of cases proflavine soaked cotton wool was chosen for the dressing. This was felt to be the least deformable of the bolster materials available, and, therefore, the most likely to transmit pressure to the graft. Foam was used in one case but still no change in pressure was produced. Bandages were used over the tie-over dressing in four cases. This produced only a transient rise in pressure, which decayed rapidly over a few minutes. The highest pressure recorded under the tie-over dressing was only 4 mmHg, in a case where the bandage was applied around a backslab plaster cast.

The laws of physics dictate that it is extremely difficult to generate pressure in tie-over dressing mechanics. The vector of force of each suture is mainly parallel to the graft-bed interface unless the height of the bolster dressing creates an angle of greater than 45 degrees from the skin surface. To increase the vector of force perpendicular to the interface would require a bolster dressing higher then the radius of the defect, which is frequently impractical. As pressure is force by area the effect of tension in each suture is easily dissipated once the area of the bed is accounted for. To create sufficient tension in each suture to generate pressure would lead to tissue necrosis at the suture anchorage point. Furthermore as the bolster dressing conforms to the bed or vice versa, the suture tension diminishes.

Given that tie over dressings do not produce pressure, one hypothesis for the mechanism of action of tie-over dressings is the prevention of shear and stabilisation of the graft along with fixation of the dressing. The reduction of haematoma and seroma should occur rapidly by the action of fibrin adhesion. Our findings are supported by a study, which found that quilting was equally as effective as tie-over dressings in the take of full thickness skin grafts.[8]

There is no doubt that tie-overs are valuable dressings, particularly in areas which are not amenable to bandaging. Changing our perception of the mechanism by which tie-over dressings have their beneficial effects could lead to the refinement of this dressing as a stabilisation mechanism. For example, if the dressing is not required to exert pressure on the underlying graft, then fewer sutures and a smaller volume of cotton wool may be as effective.

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