

# Contraction and Relaxation in Split Skin Autografts— A Human Study

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**N**UMEROUS publications in the last 40 years emphasise the problems raised by contraction of split skin grafts. Whereas skin grafting has been of great help in the repair of various defects following injuries and disease processes, the problem of contraction poses difficulties to the surgeon.

Behaviour of skin autografts has been studied from various aspects. In this paper a brief review of literature is given of the clinical behaviour of intermediate split skin grafts, along with observations in 30 patients.

## Material and Methods

This study was carried out on 30 patients of various ages ranging from 6 years to 50 years. Intermediate split skin grafts were applied after release of post burn contractures, excision of tumors or chronic ulcers. All the patients were in good nutritional status. All were operated under general anaesthesia. Scar tissue, if present was excised completely and bleeding controlled by hot saline packs. The split skin grafts were taken with the help of a skin dermatome of a fixed depth. Grafts were taken in the form of a longitudinal rectangle from the medial, lateral, anterior and posterior surfaces of the thigh and sutured in the wound. The wound

edges were prepared by giving tension releasing incisions and excisions of triangular areas of scar or normal skin to provide a zigzag line of sutures between the normal skin and skin graft. This was sometimes omitted on flat surfaces like the scalp, abdomen, back etc. The grafts were sutured at the edges and in the bed and firm pressure dressing applied. Plaster of Paris splints were used in the limbs for 4 weeks and then discarded. Moulded splints were used in the neck for 4 months. Area of the skin graft was measured by marking the edge of the grafted wound with Bonney's Blue skin marking ink. The impression was transferred on to a thin piece of sterile muslin. Permanent record of each graft was kept on an inch graph paper of adequate size. Subsequently the graft area was studied at 2 weeks, 4 weeks, 8 weeks, 12 weeks or longer periods where possible. There was some irregularity in post-operative follow-up of patients.

## Observations

For purpose of evaluation, these patients were divided into three groups.

*Table No. 1:* shows the grafts applied in loose areas of the body e.g. cheeks, eyelids, axilla and neck. There is a consistent shrinkage of skin grafts at 2 and 4 weeks. At

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8 weeks skin graft in patient No. 29 shows evidence of increase in size.

At 12 weeks, grafts in patients Nos. 32, 35, 38, 40 shows evidence of relaxation. During the period studied, none of these grafts have returned to original size.

*Fig. 1* (Case 38) : shows the patterns of intermediate split skin grafts in lower eye lid. The graft area has increased in size from 4 weeks to 12 weeks.

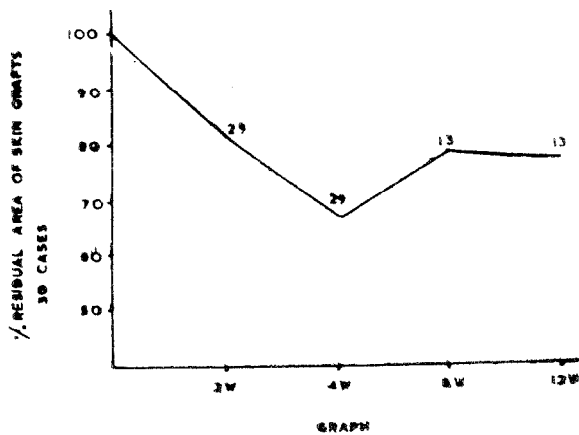


Fig. 1

*Table II* : shows intermediate split skin grafts applied on moderately firm areas of the body e.g. chest wall, elbow, wrist, popliteal regions, ankle etc. There is a general consistent contraction upto 4 weeks except in case No. 13. Evidence of relaxation is evident in case No. 9 at 14 weeks and 18 weeks; in case No. 13 at 12 weeks and 60 weeks; in case No. 14 at 28 weeks; case No. 20 at 52 weeks; and in case No. 41 at 10 weeks. Graft has become larger in case No. 13 at 60 weeks.

*Fig. 2* (Case 9) : shows the graft patterns in contracture elbow. After contraction, the graft has relaxed to almost its original size at 18 weeks.

*Table 3* : shows grafts applied in firm areas of the body e.g. flat surfaces of the limbs,

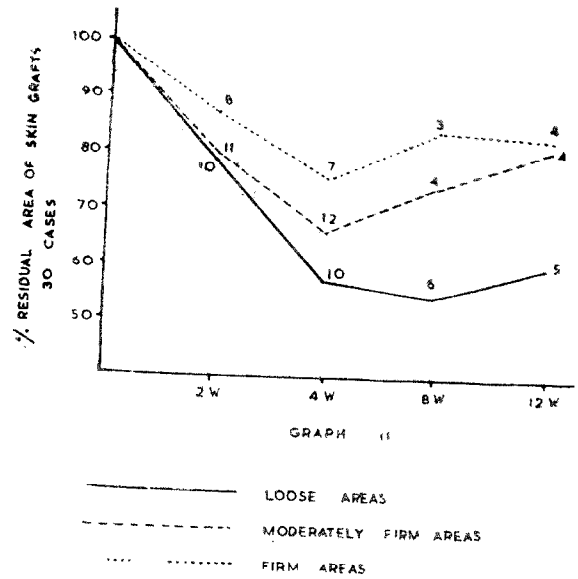
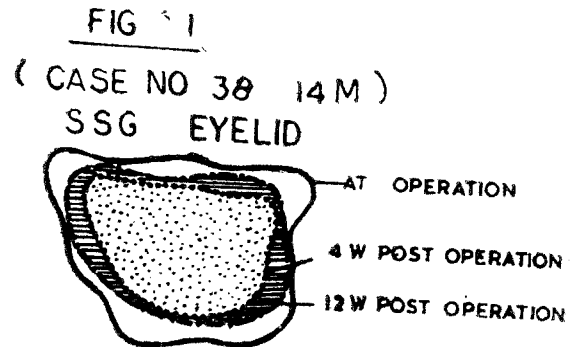


Fig. 2

scalp, back. Cases Nos. 24 and 34 shows evidence of graft relaxation at 12 weeks, and cases nos. 31 and 37 at 8 weeks. Grafts have become larger in cases nos. 24 and 37.

*Fig. 3* (Case 34) : shows graft patterns after excision of tumour on the back. There is



4 WEEKS = 51.0%  
12 WEEKS = 73.0%

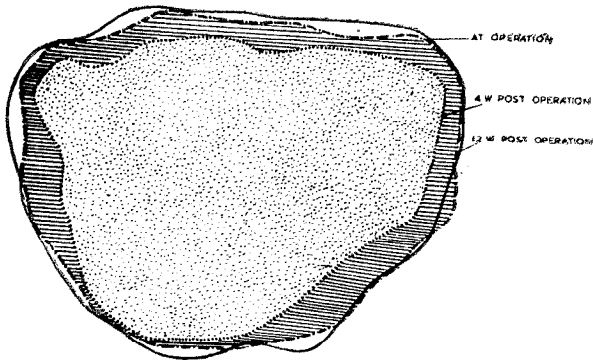
Fig. 3

evidence of relaxation from 4 weeks to 12 weeks.

Graph 1 represents the changes in skin grafts (mean residual areas in 30 patients) over a

practice for wound cover, to promote early healing and prevent wound contracture. But

FIG. 3  
CASE (34) 40M  
SSG BACK



4 WEEKS = 73.0%  
12 WEEKS = 94.0%

Fig. 4

period of 12 weeks. Figures at each point of study (e.g. 29 at 2 weeks) represent the number of cases studied at these points. It is seen that there is a gradual but consistent contraction of skin graft from the time of application to 4 weeks post-operative ( $P < 0.02$ ) and relaxation from 4 weeks to 12 weeks post-operative ( $P < 0.001$ .)

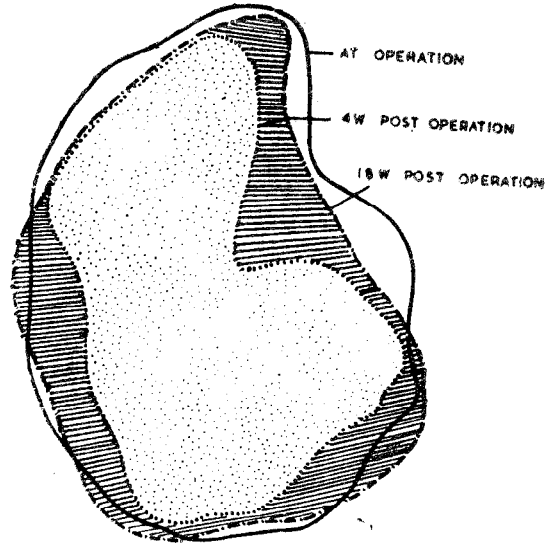
Graph 2 represents the break up of data of these 30 patients according to Tables, 1, 2, 3. Initial contraction is maximal in loose areas, then in moderately firm areas and minimal in firm areas. Loose areas show relaxation after 8 weeks, moderately firm and firm areas after 4 weeks.

**Review of Literature :**

1. *Contraction of Skin Grafts :*

Skin grafting has been used in clinical

FIG-2  
CASE NO. (9) 50F  
SSG ELBOW



4 WEEKS = 67.0%  
18 WEEKS = 96.0%

Fig. 5

the second object has not been achieved in its entirety. The skin grafts over the wound, do contract, thin grafts contract more than thick ones. This has been studied in human subjects by Blair (1929), Padget (1939), Brown (1941), Gillman (1953), Keswani (1966, '70), Sawhney (1971). Controlled studies have been done in experimental animals to study this problem; in rabbits (Ragnell '52, Billingham '56 and Sawhney '70), in hooded rats (Corps et al '69) and Pigs (Hinshaw, 1965; Kurata, 1971 and Baran et al, 1972). Montagna (1964) pointed out that skin of pig resembles human skin histologically. Weinstein (quoted by Bustad 1965) by radioisotope labelling techniques, demonstrated that pig

**Table 1**

Case No.	Age and Sex.	Recipient area	2 weeks	4 week	8 weeks	12 weeks	and above.
7	8F	Axilla	90.5	50.4	—	—	22.9 (36W)
12	6M	Neck	86.2	77.6	65.6	46.0	—
16	12F	Axilla	66.9	58.6	35.5	—	—
19	10M	Axilla	81.9	66.4	—	—	—
28	40 F	Axilla	95.2	68.6	76.8	—	57.6 (32W)
29	9F	Axilla	76.8	68.3	80.0	—	—
32	6M	Axilla	79.4	59.8	41.1	62.9	—
35	23F	Neck	72.1	54.6	—	80.1	—
38	14M	Lower eyelid	68.3	51.0	—	73.0	—
40	14M	Cheek	75.3	48.1	37.6	46.5	—

Figures represent percentage residual area of skin graft applied at time of operation.

**Table 2**

Case No.	Age and sex	Recipient area.	2 weeks	4 weeks	8 weeks	12 weeks	and above.
9	50F	Elbow	86.8	67.0	71.4	60.0 89.2	96.0 (10W) (14W) (18W)
13	14F	Elbow	—	103.7	94.1	100.7	117.0 (60W)
14	3F	Wrist	39.5	23.1	—	—	46.0 (28W)
15	6F	Lt. Groin	105.6	73.4	—	—	—
18	10M	Elbow	87.2	62.4	—	—	—
20	12M	Elbow	56.6	32.3	—	—	43.1 (52W)
23	22F	Elbow	73.3	64.0	—	65.7 (10W) 69.6 (12W)	—
30	6M	Hip. Knee	55.7	53.7	—	—	—
36	4M	Popliteal region	91.3	75.2	74.7	—	62.3 (16W)
41	40M	Foot	99.8	85.5	—	98.18 (10W)	—
43	45M	Chest	99.1	86.9	—	—	—
44	7M	Foot	83.1	74.1	61.8	—	—

Figures represent percentage residual area of skin graft applied at time of operation.

Table 3

Case No.	Age and sex.	Recipient area	2 weeks	4 weeks	8 weeks	12 weeks and above.
22	12F	Thigh	101.1	68.7	—	—
24	23M	Thigh popliteal region	87.2	78.0	—	112.1
31	45F	Scalp	88.3	68.5	73.4	—
33	60M	Thigh	82.3	78.3	78.1 (6 weeks)	—
34	40M	Back	80.8	73.0	—	94.0
37	16F	Thigh	96.3	97.3	105.5	—
39	10M	Thigh	91.2	—	—	75.3
42	27M	Leg	74.3	72.5	—	55.1

Figures represent percentage residual area of skin graft applied at time of operation.

epidermis was similar to human epidermis. Pig dermis is however poorly vascularised, has large elastic tissue content and contains much alkaline phosphatase. Keeping above facts in view, skin of the pigs has been found to be the nearest to human skin, for extrapolation of its experimental results.

## 2. Site of Contraction :

Padgett (1939) wrote 'the underlying base on which a skin graft is placed, tends to contract in direct proportion to the thinness of the graft, aside from certain anatomical factors which may be such that a base is formed which prevents contraction'. He thus emphasised the fact that it is the base of the wound that contracts and not the overlying skin graft.

Blair (1929) believed this to be due to a thin layer of scar between the wound and the skin graft. Gillman (1953) felt that the

contraction was due to the production of connective tissue fibrils and then subsequent shortening. Billingham (1956) postulated that the granulation tissue provides an 'ephemeral organ of contracture'. As a corollary of this, it would mean that if the formation of granulation tissue was prevented or inhibited the contraction of the graft could also be prevented or inhibited.

## 3) Factors related to Contraction :

Among the known factors which inhibit contraction of the wound are :

a) Skin grafts of various types applied on fresh, granulating or surgically created wounds, thicker grafts causing lesser contraction than thinner grafts (Blair '29; Padgett '39; Brown '40).

b) Recipient site : A firm recipient site allows much less wound contraction (Blair, 1929; Padgett, 1939; Sawhney, 1970; Keswani,

1970) than a loose recipient site.

c) Supportive splints : when skin grafted wounds are supported by close fitting splints, the skin graft remains stretched and the contracture does not recur (Cronin, 1955).

d) Firm surrounding skin as in lateral most areas of the neck (Keswani, '66, 1970).

Davis (1931) and Padgett (1939) showed that once the skin graft has been cut, it contracts. Contraction is unquestionably due to the presence of elastic fibres in the corium (Gillman, '53). Thus a full thickness graft shrinks approximately 43%, a half thickness 25%, a thick Ollier-Thiersch graft 12% and a true Ollier Thiersch graft, containing only tips of papillae (with no dermal elastic tissue) shrinks only 2%.

Billingham (1956) observed that wounds covered with full thickness graft did not contract, while those covered with epidermal grafts (which bring about rapid epithelial coverage), are almost *in-effective* in retarding contracture. It would thus mean that dermis (with its collagenous and elastic tissue content) in some way retards or prevents contracture.

#### 4. Rate of Contraction

Billingham (1956) introduced a concept of rate of contracture. This can be computed for any wound, from a series of measurements. The specific rate of contracture can be employed as a quantitative measure of the influence of a variety of factors on healing of wounds. This rate of contracture was considerably reduced in open wounds by full thickness skin

grafts (Billingham '56, Sawhney, '70).

#### 5. Skin Tension Lines and Contraction

Concept of skin tension lines started with Langer (1861). It has been shown that dermal fibres (Collagen and elastic tissue) run parallel to these tension lines (Duputryn, 1834 ; Davis, 1931).

Ragnell (1952) did not see any difference in contraction or growth of wounds under full thickness grafts along lines of tension. Rotation of grafts also did not produce any difference in the various dimensions of contraction. Sawhney (1971) reported that contraction was less under split skin grafts along lines of tension. Similar finding has been reported by Baran (1972) in growing mini pigs in open wounds and those covered by split skin graft.

#### 6. Growth/Relaxation of Skin Grafts

Brown (1941), observing the behaviour of free skin grafts over long periods of time felt that both thick split and full thickness grafts seem to grow or at least stretch out with growth of the body area.

Keswani ('66, 1970) while reporting detailed linear measurements of skin grafts in the neck, felt that contraction is inhibited by moulded splints in the neck. In one patient there was an increase in vertical dimension of the graft by 20%. Sawhney ('74) has reported relaxation of skin grafts in the neck.

Ragnell (1952) showed that full thickness grafts in rabbits, after initial contraction reaching their maximum in 4 weeks, expanded to their original size and finally

grew larger in conformity with animals' growth in general.

Corps et. al. (1969) saw similar phenomenon in hooded rats while using ear skin grafts.

While it is easy to conceive of fibrous tissue formation, as the cause of contraction, it is more difficult to envisage the physiology of expansion.

### Discussion

Clinical and experimental studies have shown beyond doubt that intermediate skin grafts contract. Site of contraction is not the graft itself but probably the wound and in the wound, it is probably the granulation tissue (Billingham, 1956). The grafts containing more of dermal tissue contracted less and relaxed better (Brown '41; Ragnell '52; Corps '69). A number of other factors have been found to influence contraction of skin grafts i.e. recipient site and supportive splints. In this paper, the time factor of contraction and relaxation of intermediate split skin grafts has been presented, contraction occurring upto 8 weeks

post-operatively and relaxation of skin grafts occurring after 8 weeks post-operatively. If the factors causing the relaxation could be understood and controlled, it would be a big step forward in the clinical application of skin autografts.

### Summary

1. Intermediate skin grafts were applied in 30 patients after obtaining a clean surgical wound.
2. Detailed measurement studies have revealed that such grafts contract during the first four weeks post-operatively.
3. Relaxation begins after 4 to 8 weeks so that the ultimate area of skin graft is larger than during its period of maximum contraction.
4. Some skin grafts relax/grow to a larger size than the original area of the skin graft applied at time of operation.
5. Most skin grafts, however, do not regain the original area.

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