

CLOSURE OF RHOMBOID SKIN DEFECTS : THE FLAPS OF LIMBERG AND DUFOURMENTEL

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IN excising the majority of skin lesions, surgeons create an elliptical defect which can be closed directly. As the lesions increase in size, however, there comes a stage when either the long axis of the ellipse becomes too long for the local anatomy or cosmetic result, or the short axis too wide to permit direct suture. In many such instances the excisional outline may be replanned and closure obtained with a local flap, until of course the defect becomes so large that cover can only be obtained with imported skin.

Designing such local flaps, particularly when the secondary defect is to be closed directly, can tax the skill of the most experienced plastic surgeon. Only after much trial and error does he learn intuitively to judge the maximum tension under which he can suture the partly devascularised flap and the absolute limits to which he may stretch the surrounding skin; the art of designing such flaps takes long to learn and is hard to teach.

There are, however, 2 exceptions to which we would like to draw renewed attention : the flaps designed by Limberg (1946, 1966, and 1967) and by Dufourmentel (1962, 1963) to close rhomboid defects. A rhombus is an equilateral parallelogram and may be regarded as an "ellipse with straight sides". Rhomboid excision has some advantages over elliptical excision particularly when the defect is to be closed with a local flap. For example, less normal skin needs to be excised in the long axis, the design and closure of a straight-sided flap is far simpler than that of the round flap and rhomboid excision lends itself to the technique recommended by Borghouts (1964) of histological examination of the specimen margins to check tumour clearance.

The Limberg flap and the Dufourmentel flap are different in design and application, and will be described and discussed separately.

THE LIMBERG FLAP

The flap which Limberg designed for a rhomboid defect is one extension of his classical studies on transposed triangular flaps. Thus in Figures 1 and 2 the defect is closed by interchanging the unequal flaps TUV and UVW. The design may also be regarded as a rhomboid flap XUVW of the same size and shape as the defect into which it is to be rotated.

The flap when used singly is suitable for closure only of rhomboid defects with angles of 60° and 120° ; in this paper such a defect is called a 60° rhomboid. The rhombus is thus composed of 2 equilateral triangles and the short axis is the same length as each side.

In constructing the flap (Fig. 1) the short diagonal is extended in one or other direction by its own length to the point V. A further incision VW parallel to UX and equal to each of the sides completes the design. It will be evident that the distance UW is also equal to the short diagonal of the defect and therefore to all other incisions in the plan. An attractive aspect of this Limberg flap is that, once the length of the short diagonal has been determined, the remainder of the design may be completed by using calipers set to that length.

For any given 60° rhomboid defect there are theoretically 4 Limberg flaps available as shown in Figure 3. Once the most appropriate flap has been chosen and raised it is rotated through 60° and placed in the defect (Fig. 2). It will be seen that U and W are approximated in closing the secondary defect. It follows that the ease with which these points can be apposed determines whether or not the design is appropriate; this in turn depends on the relative availability and extensibility of the skin. A major consideration in planning should therefore be to seek out the direction of maximum extensibility in the skin around the defect (Gibson *et al.*, 1969). This line is usually at right angles to Langer's lines (Gibson *et al.*, 1971) and on the face it may be regarded as at right angles to the crease lines. It may be readily determined clinically by picking

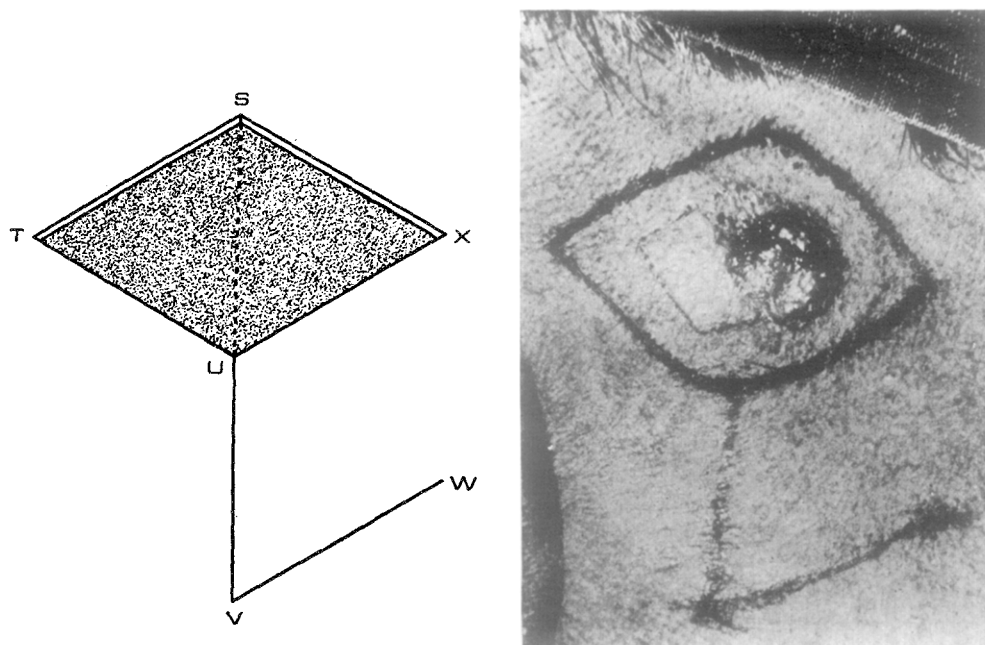
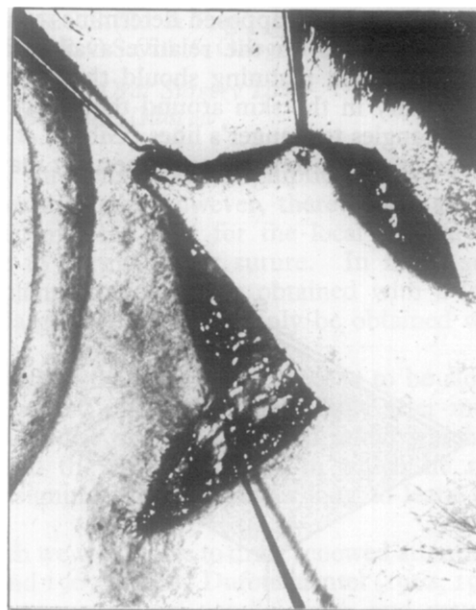
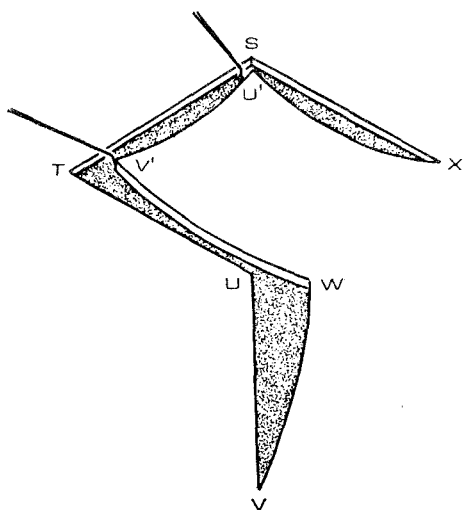


FIG. 1. Design of a Limberg flap. STUX represents a 60° rhomboid defect. SU is extended by its own length to V. VW is then drawn parallel and equal to UX. Note that the distance between any 2 adjacent points in the design is identical.

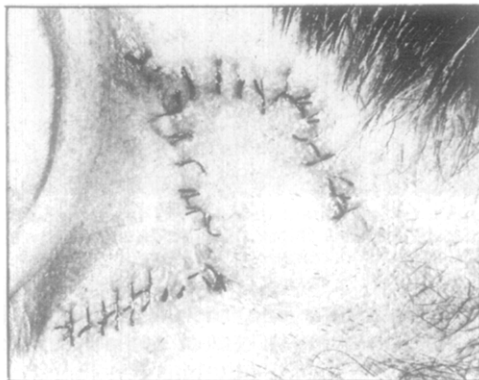
up the skin between finger and thumb. Having found that line, the points U and W should if possible be placed on it; they lie on the same line as one of the sides of the primary defect and 2 flaps can be designed in this fashion for any one 60° rhomboid (Fig. 4, A). If the lesion is circular, the rhomboid can be rotated giving 2 more flaps with the points U and W in the same line of maximum extensibility (Figs. 4, B and 4, C). However, when the shape of the lesion already determines the positioning of the rhomboid these remarks are not appropriate and one selects the most suitable flap available for the rhomboid so positioned.

Limberg pointed out that moving any flap involves but 2 processes, opening wound angles and closing wound angles. Closing a wound angle produces a dog-ear or, in Limberg's more precise term, a standing cone. Opening an angle in Limberg's paper models produces a lying cone. This cannot form in skin; what usually occurs is a taut, slightly depressed area around the angle. If for example one were to close the rhomboid defect shown in Figure 1 directly, dog-ears would form at points T and X

and depressed areas at S and U. By adding the rhomboid flap for closure Limberg avoids any movement of angles T and S. This can be of cosmetic value, particularly if the deformations around the other angles can be placed in less obtrusive positions.



A



B



C

FIG. 2. A, the flap designed in Figure 1 has been cut and transposed into the defect. B, 6 days post-operatively. C, 2 weeks post-operatively.

PRACTICAL APPLICATIONS

Excisional Surgery. In most cases it is possible to decide in advance whether a skin lesion will require elliptical excision and direct closure, excision with local flap closure or excision and distant skin cover.

Where doubt exists about the practicability of direct closure it is wise to excise only the lesion with appropriate clearance as the initial step. If apposition then shows that direct closure is feasible further excision to create an ellipse suitably long to avoid

FIG. 3. In theory a choice of 4 Limberg flaps is available for any 60° rhomboid defect.

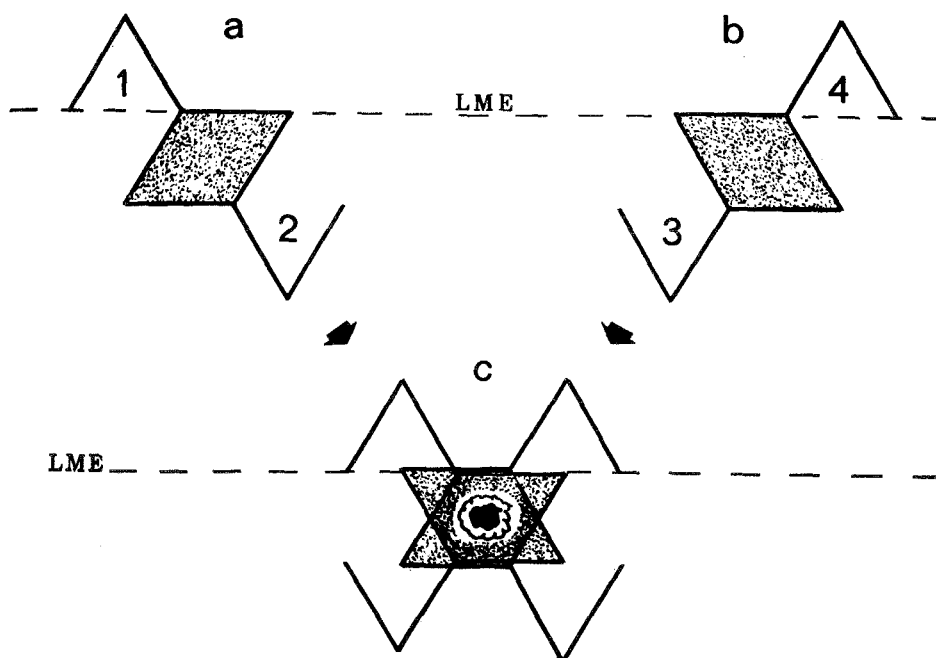
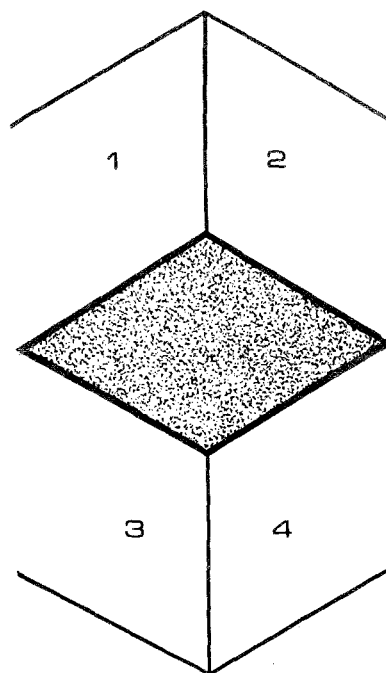
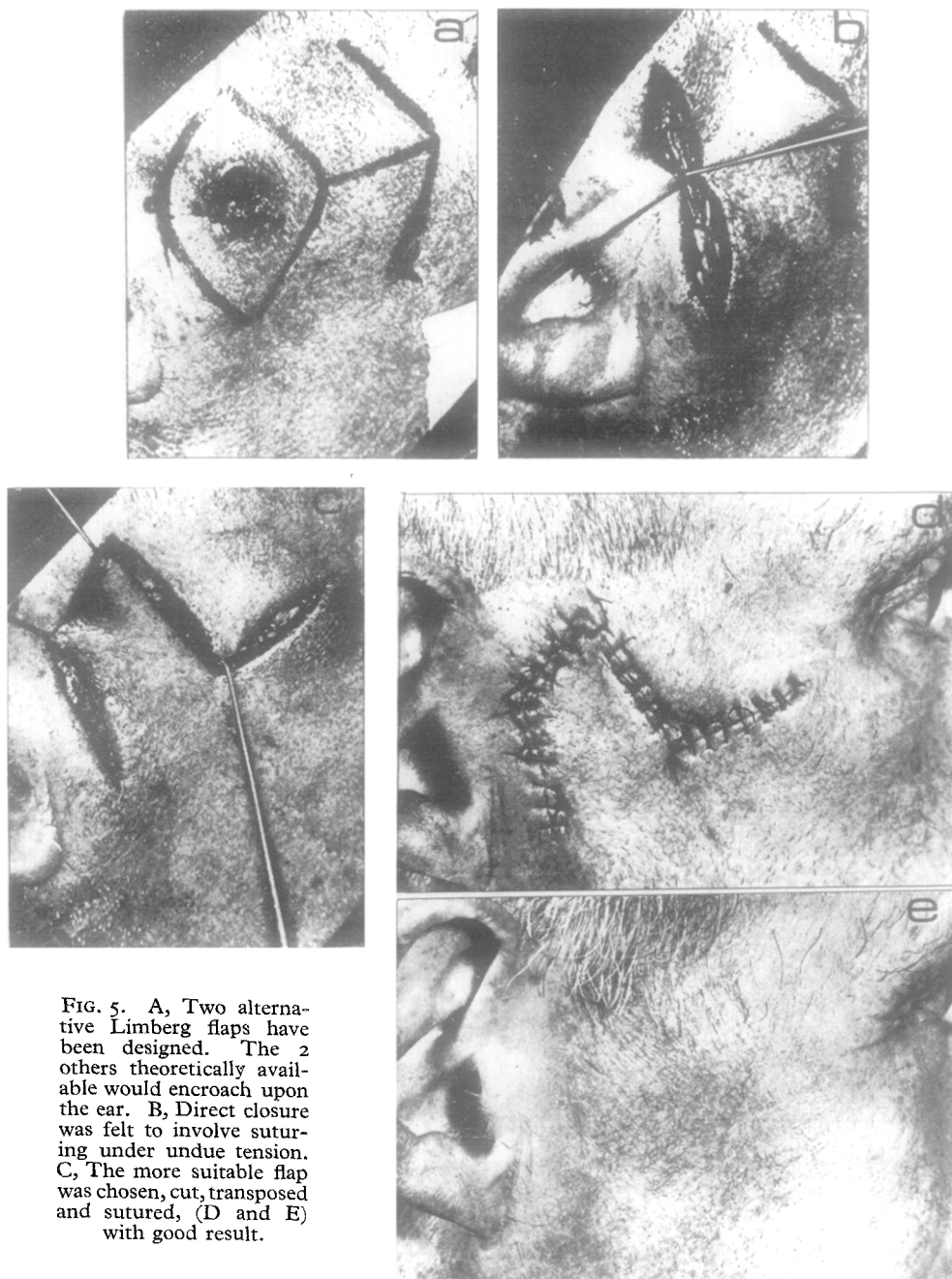


FIG. 4. With roughly circular lesions the rhombus should be so positioned that points U and W (Fig. 1) lie on the line of maximum extensibility. There are 2 possible ways in which the rhombus can be so sited (A and B) and thus 4 flaps of this kind are available (C). This of course is not applicable if the shape of the lesion dictates the position of the rhombus.



the formation of permanent dog-ears is performed. If direct closure is found to be inapplicable no normal tissue has been discarded needlessly and a flap previously designed can be cut and rotated into position (Fig. 5).

At the other extreme of applicability, it may be found that U and W cannot be

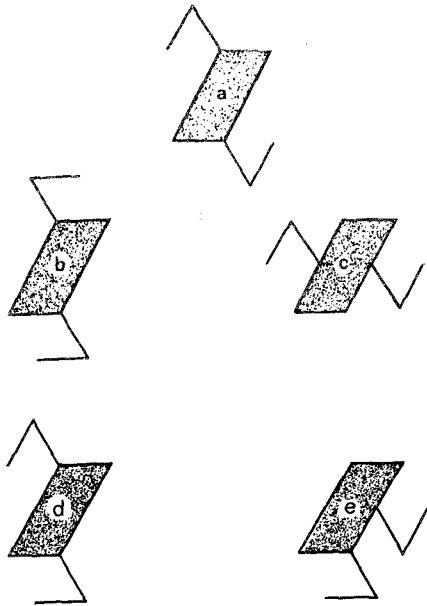
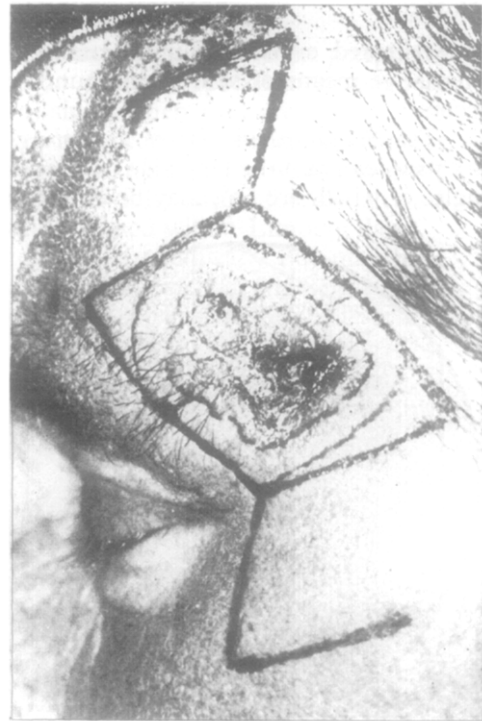


FIG. 6. A defect in the form of a parallelogram, having acute angles of 60° and long sides twice that of the short, can be closed with 2 Limberg flaps. The 5 possible designs are shown.



A



B



C

FIG. 7. A parallelogram defect created by excision of a rodent ulcer closed by 2 Limberg flaps. Any distortion of the eyebrow or irregularity of the hairline was avoided by the choice of flaps.

approximated even after undermining. The flap must then be replaced and some alternative means of skin cover found. With a little experience, however, this rarely occurs.

The Simultaneous Use of 2 Limberg Flaps. Any defect which can be considered as a parallelogram the long side of which is twice as long as the short side, and the acute angles of which are 60° , may be closed with 2 Limberg flaps.

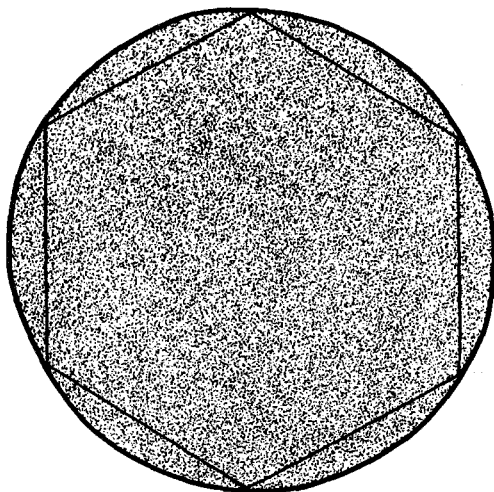


FIG. 8

FIG. 8. A circular defect may be considered as a hexagon. Each side equals the radius of the original circle in length.

FIG. 9. All equilateral hexagons are made up of three 60° rhomboids. Three Limberg flaps can be constructed to close a hexagonal defect. Preferably the peripheral limbs should point in the same direction.

FIG. 10. Construction where 2 of the flaps have peripheral limbs pointing towards one another. This may be necessary anatomically, but the angle closed at A is 120° and will produce a dog-ear.

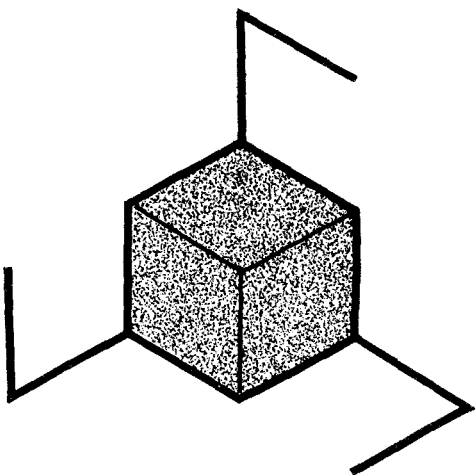


FIG. 9

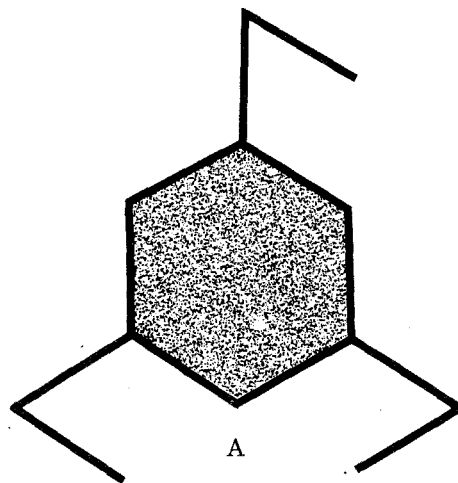


FIG. 10

There are 5 possible constructions (Fig. 6); the choice will depend on the local anatomy and the availability of skin. A clinical example is shown in Figure 7.

The Simultaneous Use of 3 Limberg Flaps. A circular defect closely approximates to the form of a hexagon, the length of the radius equalling the length of each of the 6 sides (Fig. 8). All such equilateral hexagons are made up of three 60° rhomboids and 3 Limberg flaps can therefore be designed to close the defect (Fig. 9). In this design the calipers are invaluable; set to the radius of the circular defect 18 distances are

measured and marked and the design completed. The flaps should have the peripheral borders pointing in the same direction as in Figure 9. Only in special circumstances would 2 share a common base (as at A in Figure 10) since, when they are rotated into position, an angle of 120° is closed and a pronounced and probably permanent dog-ear created. In the case illustrated in Figure 11, excision and grafting of a radionecrotic ulcer on the back had previously been performed, but the graft failed and further necrosis occurred. The ulcer was again excised and successfully closed with 3 Limberg flaps.

On occasion closure of a defect may be quite feasible technically but may have undesirable results. In the case shown in Figure 12 the patient had previously had a buccal fan flap rotated at the left angle of his mouth and now presented with active

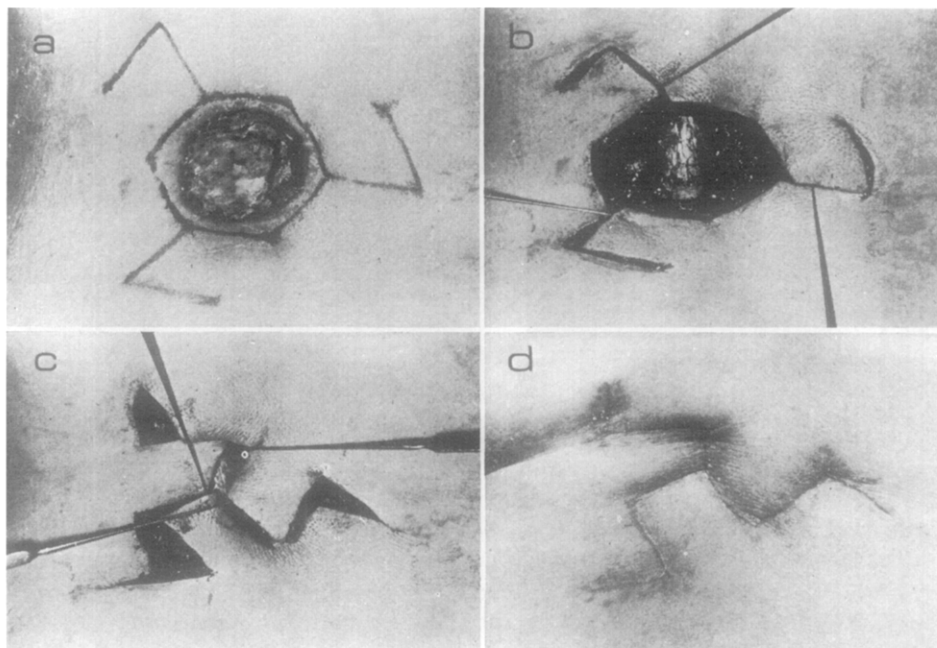


FIG. 11. A, A circular radionecrotic ulcer of the back was excised as an equilateral hexagon and 3 Limberg flaps designed as in Figure 10. B, The defect excised and the flaps cut. C, Flaps transposed and sutured with, later, (D) sound healing.

eukoplakia of the opposite commissure. While excision was indicated, it was important that no further narrowing of the mouth should result. Three Limberg flaps, one of which was mucosal, gave an acceptable solution. The 2 skin flaps were designed with a common base, however, and this resulted in the creation of a dog-ear as predicted. Although it cannot be easily appreciated in black and white photographs, the use of the flap of buccal mucosa served to reconstitute the vermillion in a manner which would have been difficult to achieve by other means.

Finger Webs. Moderate degrees of finger webbing are usually treated by release and free skin graft or by Z-plasty. However, a free graft has certain inherent drawbacks while a Z-plasty may not introduce sufficient tissue into the line of the web because of the limitation in length of the central limb. It was noted that, when a web is divided in the midline (Fig. 13) and the fingers separated, the defect is rhomboid and further that there is frequently sufficient skin on the sides of the fingers adjacent

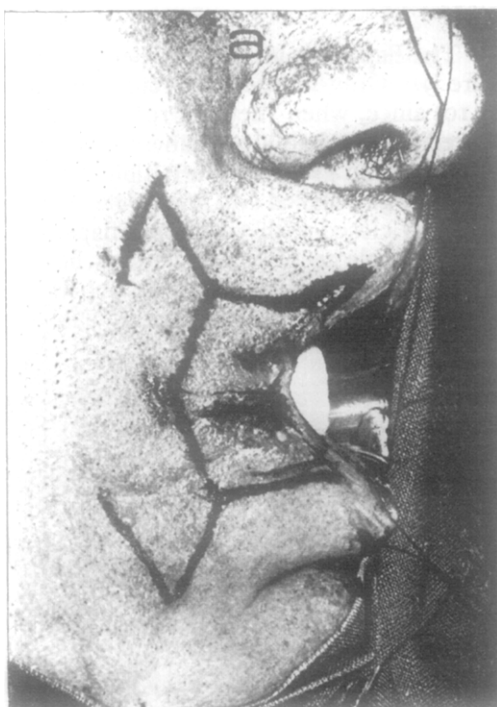


FIG. 12. A, Excision of leukoplakia of the commissure is planned. Two skin flaps and (B) one buccal mucosal flap designed. C, The 2 skin flaps with a common base as in Figure 11 has resulted in a noticeable dog-ear. D, Further narrowing of the stoma has been avoided by reconstructing the vermilion of the commissure with the buccal mucosal flap.

o the web to supply a Limberg flap large enough to give good correction. The limiting factor is again the amount of skin available, but this is easily assessed in advance.

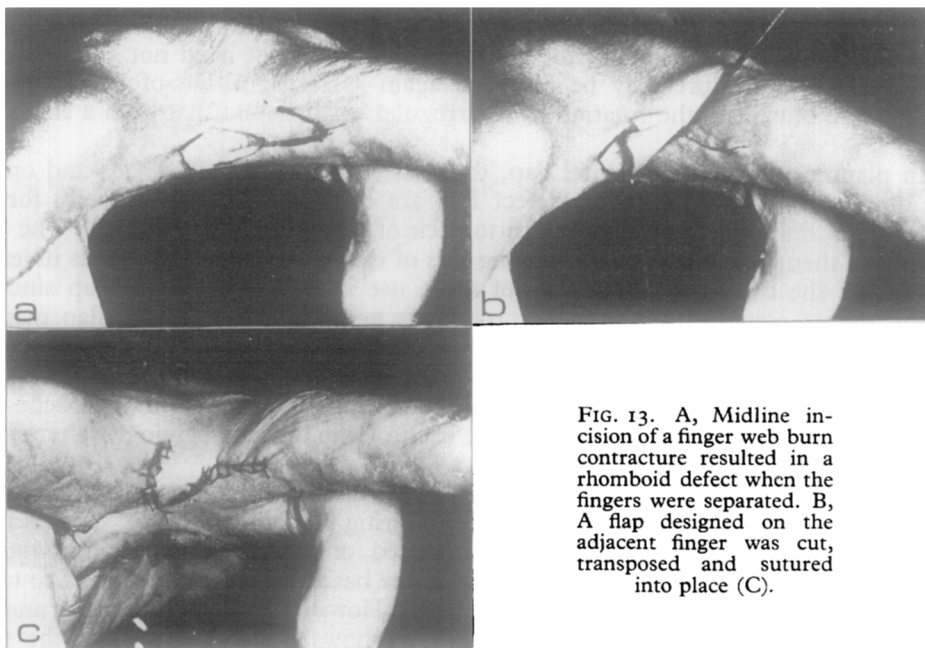


FIG. 13. A, Midline incision of a finger web burn contracture resulted in a rhomboid defect when the fingers were separated. B, A flap designed on the adjacent finger was cut, transposed and sutured into place (C).

DISCUSSION

In our experience of over 50 cases in which the Limberg flap has been used, we have found it safe, reliable and versatile. One great merit of its geometrically precise design and the fact that only one measurement is needed to construct both the defect and the flap, is that it is so easily taught. The trainee has the assurance that the blood supply is adequate and that the edges to be apposed will fit together precisely without any of the adjustment so often required in placing other flaps; in other words, the flap will "work".

The major limitation of the Limberg flap is that the secondary defect must be closed directly and flap placement cannot be eased by the use of free grafts on the secondary defect; the size depends directly on the availability of skin in the area. A further limitation, common to all local flaps, is that the correct quality of skin may not be readily available, for example after excision of lesions of or near the eyelids and close to hair margins. At the same time because the Limberg flap can be designed in so many different directions, it is more often possible to construct a flap of the right skin than with less versatile designs.

The final scar follows a slightly bizarre line which cannot all be lost in crease lines, but in most cases the quality of the scar has been good without spreading or hypertrophy and the result has certainly been better than that obtainable by the simplest alternative, a full thickness graft. Theoretically the shape of the Limberg flap should encourage the formation of a raised "trap-door" scar. Whether the increased tension imposed on the flap prevents this is not known, but we have only seen it on one occasion, where a rather small flap was used.

If correctly executed and if good primary healing occurs, the Limberg flap produces results which, for colour and texture match and overall appearance, are excellent.

THE DUFOURMENTEL FLAP

Whereas the Limberg flap can only be constructed for a 60° rhomboid defect, the Dufourmentel flap, "le lambeau en L pour losange" dit 'LLL', can, in theory, be used for any rhomboid. The rhombus is thus composed of two isosceles triangles and, unlike the Limberg construction, the short axis of the defect need not equal each of its sides. The procedure may be regarded again as transposition of two triangular flaps or more obviously the rotation of an irregular quadrilateral flap into a rhomboid defect.

In planning the Dufourmentel flap, the short diagonal LN (Fig. 14) and one or other of the adjacent sides of the defect KN are extended and the angle so formed bisected by a line (NQ) equal in length to each of the sides of the defect. The final line (QR) is then drawn parallel to the long axis of the defect and again equals in length each side of the defect. Calipers are of some use in constructing the flap since all incisions are of equal length, but a protractor is necessary to place the flap margins accurately. Once raised, the flap KNQR is transposed into the defect. As shown in Figure 15, 4 Dufourmentel flaps can be planned for any rhomboid defect. As the 4 angles of the defect come to equal one another, as the rhomboid approaches the shape of a square, flaps may be designed at each of the 4 angles giving 8 alternatives (Fig. 16).

The merit of placing the equivalent points N and R in the line of maximum skin extensibility has already been discussed in considering the Limberg flap. This is more complicated with the Dufourmentel design; indeed, on initial consideration, it appears to be quite impractical, since the relationship of the baseline of the triangular flap to the defect varies as the shape of the rhomboid varies. However, as the geometrical analysis of the design given as an appendix to this paper shows, the angle between the short axis of the flap (NR) and the short axis of the defect (LN) changes by less than four degrees from 150° as the acute angle of the defect varies from 60° to 90° . This change may be ignored and, in practice, having determined the line of maximum skin extensibility, points N and R may be placed upon it and the short axis of the defect at an angle of 150° to that line. This applies only to those cases in which the position of the rhombus is not dictated by the shape of the lesion.

As the acute angle of the defect falls below 60° , the Dufourmentel flap becomes progressively wider than the primary defect. Little is to be gained therefore from the use of the flap in these circumstances and direct closure is to be preferred.

As the acute angle of the defect increases from 60° , the defect becomes progressively wider than the flap and when it reaches a square the short axis of the flap is only three-quarters the length of the short axis of the defect. It is in this range that the flap is of clinical value.

PRACTICAL APPLICATIONS

As shown above, the Dufourmentel flap has no practical value where the acute angle is less than 60° . In closing a 60° rhomboid defect, it has no advantage over the Limberg flap, although it has been argued in its favour that it has a safer blood supply than the Limberg flap because its base is wider. Embarrassment of the blood supply of a Limberg flap, however, is rarely seen anywhere on the body and never on the face.

It is in closing defects the acute angle of which lies between 60° and 90° , therefore, that the Dufourmentel flap is of use. Such defects are not often created as additional excision is usually possible to convert the defect to a 60° rhomboid which can be closed with the simpler Limberg flap. Where, however, such additional excision is contra-indicated, for example by the proximity of vital structures, then a Dufourmentel flap

ay provide a satisfactory solution. Such a procedure for a defect which could not be used directly without undue tension is shown in Figure 17.

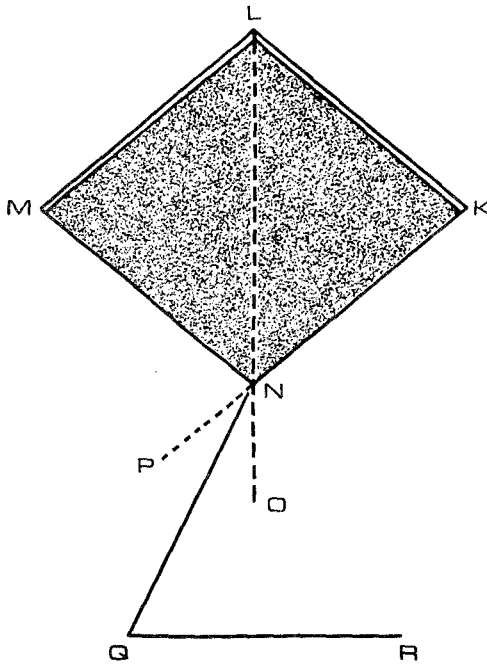


FIG. 14

FIG. 14. Design of a Dufourmental flap. LMNK represents a rhomboid defect. LN and KN are extended and the angle thus formed bisected by a line NQ equal to each of the sides of the rhomboid. QR is then drawn of equal length and parallel to the long axis of the defect MK.

FIG. 15. In theory a choice of 4 Dufourmental flaps is available for any defect approximating to a 60° rhomboid.

FIG. 16. If the defect is square in shape a choice of 8 flaps is available.

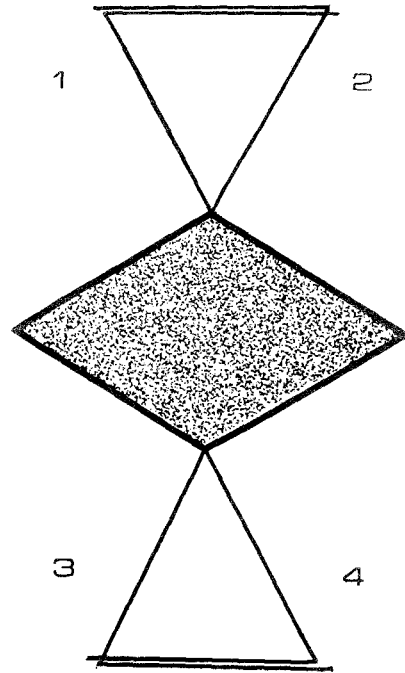


FIG. 15

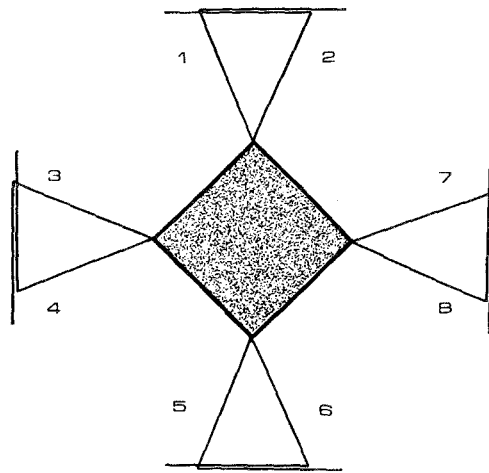
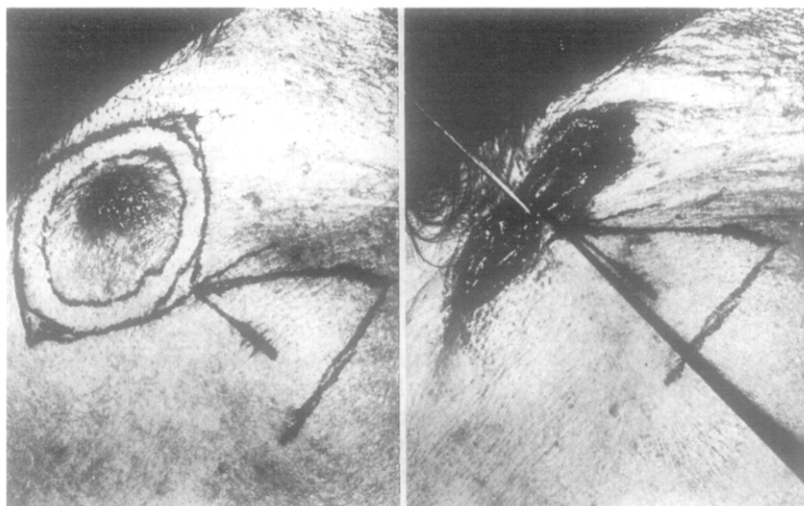


FIG. 16

DISCUSSION

One major merit of the Limberg flap is the simplicity of the design, all angles being 60° or 120° , all sides being equal. This makes it easy to learn and apply. The Dufourmental flap is by no means complicated but it is certainly more difficult to learn and to plan than the Limberg design. Indeed, at first sight it seems that the Dufourmental flap with its angles rarely matching those of the defect is inferior to the Limberg design, but this is too superficial a view. In both instances a defect is



A

B



C



D

FIG. 17. A, A Dufourmental flap has been designed for a planned rhomboid excision having an acute angle of 75° . B, Direct closure would have involved suturing under considerable tension.

FIG. 17. C, The flap was cut, transposed and sutured (D) with good result (E).



E

closed and in closing it the surrounding skin is stretched and put under increased tension; the angles carefully planned and measured may have changed considerably by the end of the procedure.

In its range of usefulness between 60° and 90° , the acute angle of the Dufourmental flap is always more acute than that of the defect, while the obtuse angle of the flap is more obtuse than that of the defect. But imagine point L being pulled to point N as the defect is closed; the acute angle of the flap would tend to become less acute, the obtuse angle less obtuse, while the acute angle of the defect becomes more acute and the obtuse angle more obtuse. In other words the angles of the flap and the defect become much more congruous. Unfortunately this variation in angle size is complicated by the closure of the secondary defect; approximating point N to point R would seem to have the opposite effects on the angles than bringing L to N.

The matter is obviously very complex; even if we had simple reliable methods of measuring extensibility of skin at any one site and the effect of varying tensions on it, the analysis and prediction of the exact behaviour of either flap would require a computer rather than a plastic surgeon.

The Dufourmental flap is probably the better design in so far as it takes into consideration the effects of increased tension on the skin, but until we have more precise knowledge of the latter both designs are still to some extent empirical. It is perhaps fortunate that the majority of cases in which the flaps have been used are in the older age group and old skin absorbs unequal angles, unequal sides, too-far-opened and too-far-closed angles in a way which makes such flaps, with their various shortcomings, cosmetically so successful.

APPENDIX

MATHEMATICAL CONSIDERATIONS IN THE DUFOURMENTEL FLAP

As the angles of the defect vary so do the measurements of the flap. The general trend has been given in the text, but the mathematical variations are readily derived from Figure 18, A.

Variation of the Acute Angle of the Flap (β) with that of the Defect (α). β is one angle of a right-angled triangle the other angle of which is equal to $\gamma/4$. Since

$$\gamma = 180 - \alpha \quad \therefore \quad \beta = 45 + \alpha/4$$

This has been plotted on Figure 18, B. For each degree of change in α , β changes by one quarter of a degree. They are only equal when both are 60° .

Variation of the Obtuse Angle of the Flap (δ) with that of the Defect (γ). It can be readily seen that $\delta = 180 - \gamma/4$ and this relationship is also plotted on Figure 18, B. With each degree change of γ , δ varies by one quarter of a degree and the angles are equal when both are 144° .

Since β fits α precisely only when both are 60° and δ fits γ only when both are 144° , the angles of the flap cannot both equal their respective angles in one construction. By plotting α/β against γ/δ in Figure 18, c it is possible to determine that the angle sizes which give the closest approximation to perfect fit are $\alpha 50^\circ$, $\gamma 130^\circ$; $\beta 58^\circ$, $\delta 148^\circ$.

Variation of the Angle (θ) between the Short Axis of the Defect (a) and that of the Flap (b).

θ can be readily shown to be equal to $180^\circ - \beta/2$.

Substituting $\beta = 45^\circ + \alpha/4$ and simplifying

$$\theta = 157\frac{1}{2}^\circ - \alpha/8.$$

In other words θ changes at a rate 8 times slower than α and in the clinical range this is negligible.

Variation in Lengths of Short Axes of Flaps and Defect. Since the construction is made up of isosceles triangles the same relationship exists between a and b and α and β . In other words a and b are equal when α is 60° . As α increases towards 90° the short axis of the defect (a) increases at a rate 4 times as rapid as (b).

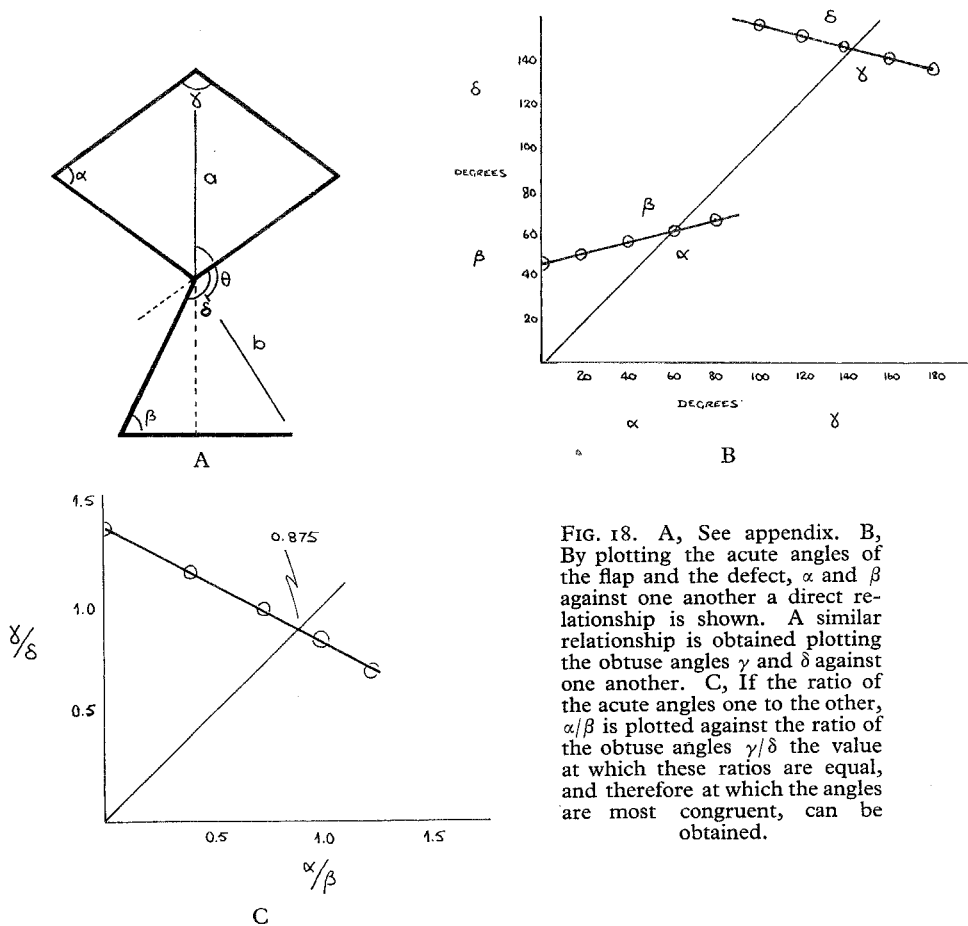


FIG. 18. A, See appendix. B, By plotting the acute angles of the flap and the defect, α and β against one another a direct relationship is shown. A similar relationship is obtained plotting the obtuse angles γ and δ against one another. C, If the ratio of the acute angles one to the other, α/β is plotted against the ratio of the obtuse angles γ/δ the value at which these ratios are equal, and therefore at which the angles are most congruent, can be obtained.

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