UNDERSTANDING DUFOURMENTEL FLAP DESIGN

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SUMMARY

Dufourmentel flap is a local transposition flap for rhombic defects. The details of its geometrical design have been discussed. Paper models and experimental study on canine skin have also been undertaken to study the biomechanics of this flap for better understanding.

Amongst the local flaps planned with geometric precision, the two flaps of Limberg and Dufourmentel deserve special attention. These are transposition flaps having advantages of a totally mathematical design. They leave no secondary defects. Moreover, the flap itself is stitched under minimal tension. The present paper is an outcome of our continuing study in evaluation of Dufourmentel flap designs.

As the name goes, this trapezoid flap, "le lambeau en L pour losange' dit 'LLL' " was designed in 1962 by a French Surgeon, Claude Dufourmentel. The first step in planning Dufourmentel flap is to tailor the defect in the shape of a rhombus (Fig. 1). The short diagonal of the rhombus (line BD) and one of the adjacent sides (line CD) are extended. The angle between these lines ($\angle$HDP) is bisected. This line DE equals the side of the defect. Line EF, the third side of the flap, is drawn parallel to the long axis of the defect (AC). Again EF equals all the sides of the defect. Markings are made with the help of calipers since the sides of the defect and the flaps are equal. Protractor is essential to accurately place the line DE. The flap CDEF is raised and transposed into the defect. Secondary defect is automatically closed.

Dufourmentel flap can be constructed for a rhombic defect of any angle, whereas the Limberg flap can only be constructed for 60° rhombus. Because these flaps can be designed from both ends of the short axis, hence four such flaps are available for closing the defect (Fig. 2). For square defects since both diagonals are equal, eight flaps can be designed (Fig. 3).

Experimental Study

Whenever a local flap is used, the surrounding skin undergoes certain stress and strain. In clinical situations extensibility (often loosely termed as elasticity) of skin tends to mask these deformations. They, however, can be appreciated in a better way when inelastic material like paper is used.

When Dufourmentel flap is planned on a piece of paper and is transposed, the paper undergoes a complex deformation (Fig. 4). However, a careful study at each point resolves the problem. The paper elevates from the surface at points C and E. These are known as standing cones and occur at points where angles close (in the skin they present as dog-ears). Folds parallel to surface (called lying cones) are found where angles open as would be seen at point F. Lying cones are converted to pits or depressions in the skin which are clinically insignificant.

In Vivo Study

Study of vector force was done on the abdomen of six Indian mongrel dogs. Dog was chosen for animal studies because of its easy avail-

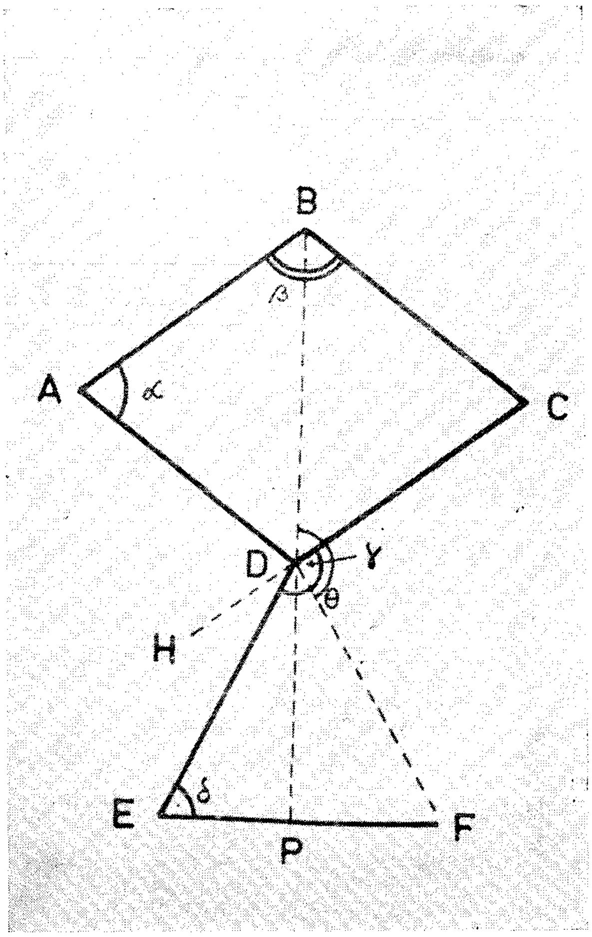

Fig. 1. Showing design of Dufourmentel flap and labelling used in text.

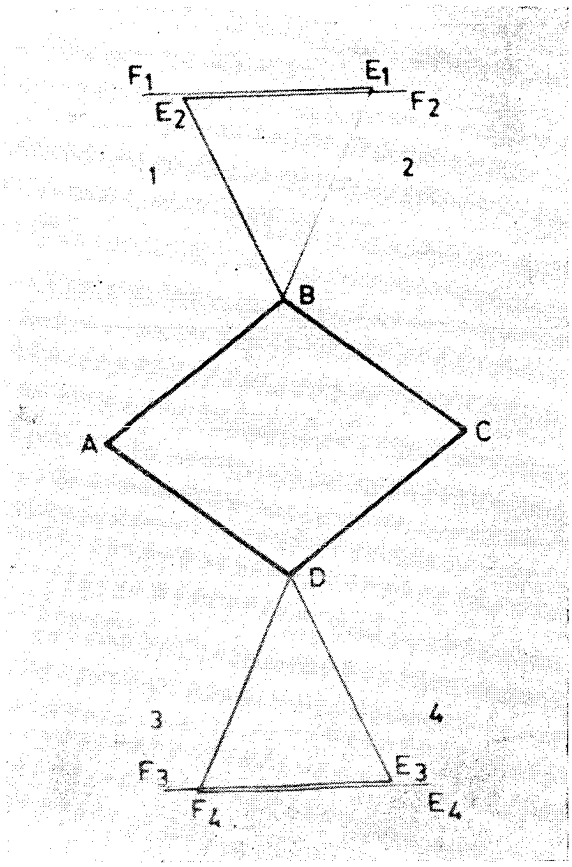

Fig. 2. Showing choice of 4 Dufourmentel flaps for a rhombic defect.

ability. A rhombic defect was created on either side of the abdominal wall 3 cms away from the midline. The size of the two raw areas created was kept equal by fixing the length of the shorter diagonal at 4 cms and the base of the defect was kept parallel to the midline. Thus the two defects, one on the right and the other on the left side were identical in position, area and direction. In this study, defect on the left side was closed by linear closure, while on the right side, a Dufourmentel flap was planned and used to cover the defect. Before suturing the defect, tension required for closing the defect was recorded. The method adopted for recording the force required to approximate points B and D for linear closure and D and F for Dufourmentel flap was the same as used in our previous study (Chandra and Singh, 1984). The findings of our observations are shown in Table 1.

Table 1. Showing the weights (in gms) needed for closure

	I	II	III	IV	V	VI
Dufourmentel flap	250	300	325	315	275	350
Linear closure						
Point B:	150	200	175	150	200	175
Point D:	175	200	200	150	175	125

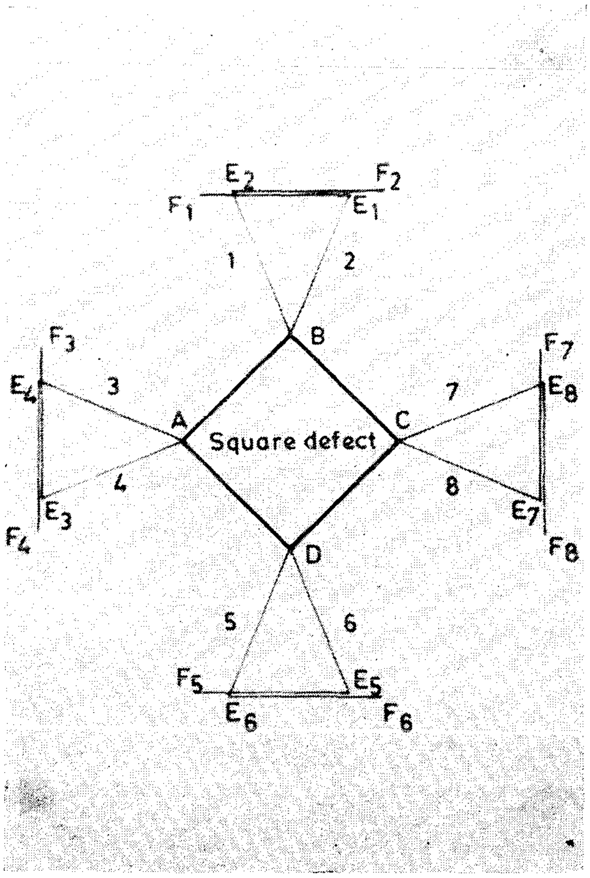

Fig. 3.
Showing eight flaps are available for a square rhombus.

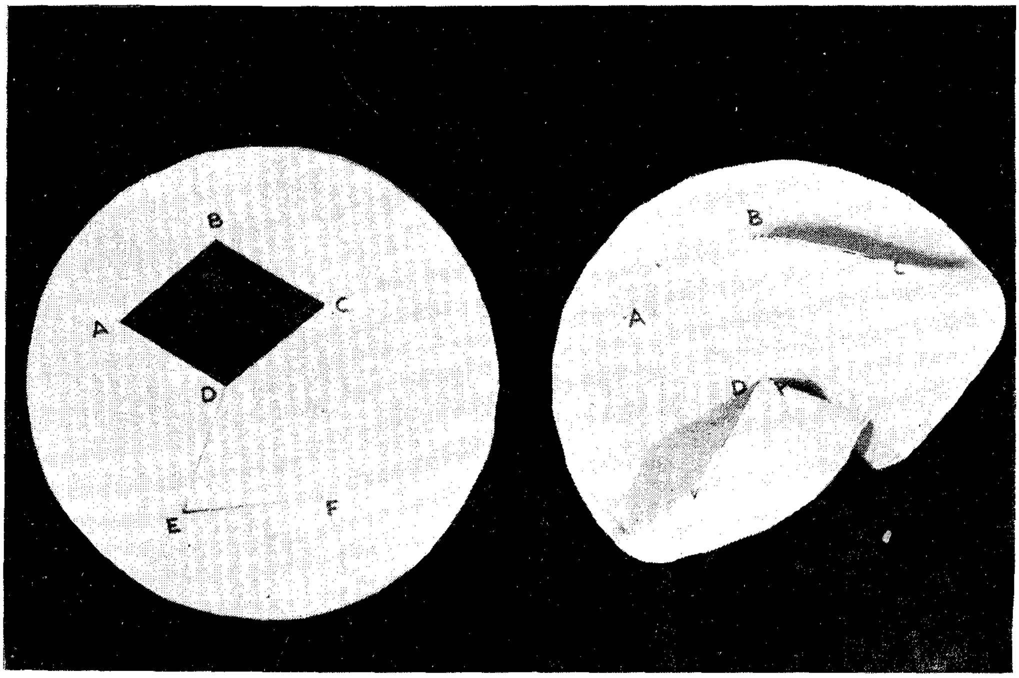

Fig. 4. Paper model showing deformation before and after transposition of the flap.

Average force required for closure of defect by Dufourmentel flap was 302.5 gms and by linear closure 358 gms. The difference between the two methods of closure is apparent.

Mathematical Analysis

Dufourmentel's trapezoid flap design (Fig. 1) is more complex. It is applicable to rhombus of any degree (acute angle). With changes in acute angle of the defect, the apex angle of flap also alters.

Relationship of the flap apex angle with the acute angle of the defect

Variation of apex angle of flap (δ) is being discussed in relation to acute angle of defect (α). DPE is a right angled triangle. Apex angle DEP$(\delta) = 90 - \angle$EDP. Since $\angle$EDP $= \angle$HDP/2 and $\angle$HDP $= \angle$ADC/2 and $\angle$ADC $= \angle$ABC; hence $\angle$EDP $= \angle$ABC $(\beta)/4$. Therefore $\angle\delta = 90 - \angle\beta/4$. But $\angle\beta = 180 - \angle\alpha$. Now substituting β for α: $\angle\delta = 90 - \left(\frac{180-\alpha}{4}\right) = 45 + \angle\alpha/4$. The relation of $\angle\alpha$ to $\angle\delta$ has been shown in figure 5. When acute angle of defect (α) is 60 degrees, apex angle of flap (δ) is also 60 degrees. When the acute angle of the defect is 40 degrees, the flap apex angle (δ) will be 55 degrees and when the acute angle of the defect is 30 degrees, the flap apex angle (δ) will be 52.5 degrees. It can therefore be concluded that $\angle\delta$ changes by quarter degree for one degree change of $\angle\alpha$.

Relationship of the obtuse angle of the flap with the obtuse angle of the defect

Obtuse angle of the flap $\angle$CDE $(\angle\gamma) = 180 - \angle$EDH (or $\angle$EDP) $= 180 - \angle\beta$ ($\angle$ABC)/4, since $\angle$EDP $= \angle\ \beta/4$ (vide supra). So the obtuse angle of flap ($\angle\gamma$) changes by quarter degree for each degree change in obtuse angle of defect ($\angle\beta$) like the change in the acute angles. In other words when the obtuse angle of the defect is 120 degrees the obtuse angle of the flap will be 150 degrees and when the obtuse angle of the defect is 140 degrees then the obtuse angle of the flap will be 145 degrees.

The obtuse angles of defect and flap will be equal at 144 degrees (Fig. 5). Therefore, corresponding angles of defect and flap cannot be equal in one construction. Ratio of the defect Vs. flap is never one (Fig. 6). When acute angle of the defect is 50 degrees and obtuse angle is 130 degrees, then, the area of the flap is closest to that of the defect. Respective angles of flap will be 58 degrees approx. (since $\angle\delta = 45 + \angle\alpha/4 = 45 + 50/4 = 45 + 12.5 = 57.5$) and 148 degrees approx (since $\angle\gamma = 180 - \angle\beta/4 = 180 - 130/4 = 180 - 32.5 = 147.5$).

Relationship between the short diagonals of the defect and the short diagonal of the flap

Angle formed between the short diagonal of defect (BD) and short diagonal of flap (DF) has been labelled (θ). The line of pull in Dufourmentel design is along DF. With change in value of $\angle\alpha$, $\angle\delta$ also alters. Lister and Gibson (1972) have calculated $\angle\theta$ and found it equal to $157\frac{1}{2} - \alpha/8$. For example, for a defect with the acute angle (α) of 64°, θ will be $149\frac{1}{2}°$ ($157\frac{1}{2} - 64/8 = 157\frac{1}{2} - 8 = 149\frac{1}{2}$), and for a defect with the acute angle of 72°, θ will be $148\frac{1}{2}°$ ($157 - 72/8 = 157\frac{1}{2}° - 9 = 148\frac{1}{2}°$). That is for 8 degrees change of $\angle\alpha$, $\angle\theta$ changes by one degree. For all practical purposes it can be assumed that angle of pull at point D is at 157 degrees to the shorter diagonal of the defect.

Analysis of flap design is entirely theoretical. The situation however is even more complex in practice. After transposition, acute angle of flap tends to increase and obtuse angle decreases while reverse changes take place in the defect. Flap and defect tend to accommodate each other. Closure of secondary defect further complicates the issue. It has opposite effect on the angles. Furthermore, practical analysis is handicapped by absence of simple and reliable methods to measure the extensibility of the skin.

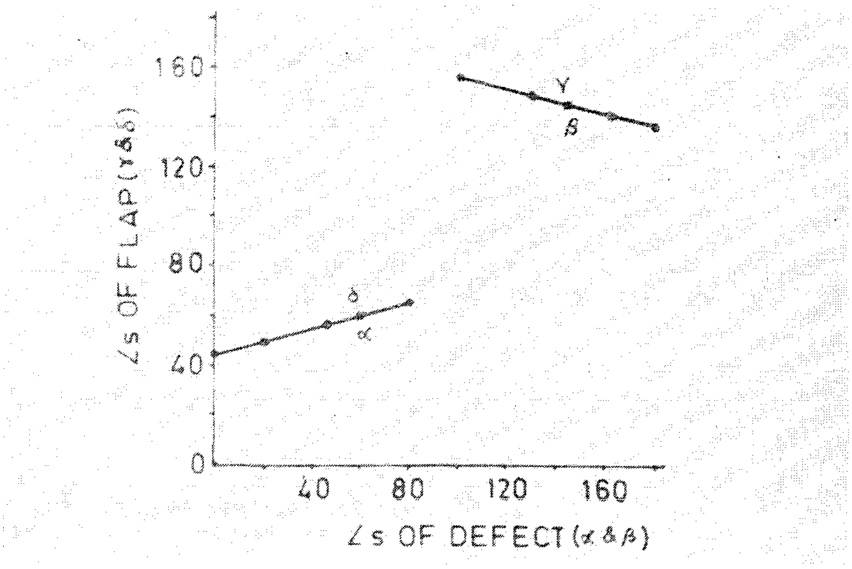

Fig. 5. Showing relationship between corresponding angles of defect and flap.

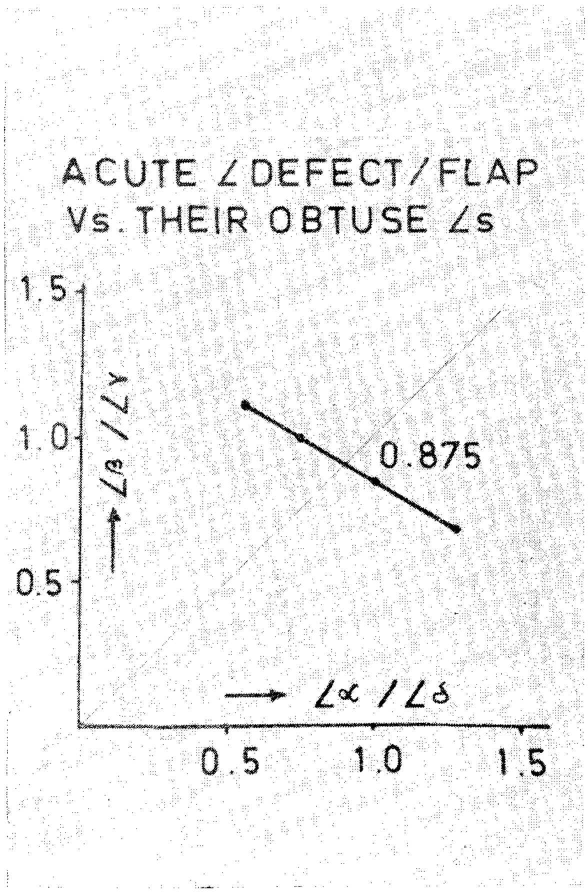

Fig. 6. Showing relationship of ratio between corresponding acute angles and obtuse angles of defect.

Conclusion

Dufourmentel flap is a local transposition flap for rhombic defects, with the advantage that no secondary defect persists. The design though appears formidable in the first instance is easy to execute. The Dufourmentel flap is of clinical value for closing rhombic defects whose acute angle is between 60° and 90°.

If the acute angle of the defect is less than 60° the flap becomes progressively wider than the primary defect, and therefore little can be gained from the use of this flap in these situations. Under such circumstances direct closure should be preferred. At 60° acute angle, it has no advantage over a Limberg flap.

The size of the flap most closely approximates the defect, when the acute angle of the rhombus is 50 degrees. The line of pull is at 157 degrees variance to the short diagonal of the defect. This fact should be taken into consideration while planning the flap, so that the pull is along the line of maximum extensibility of the skin. Tendency for formation of dog-ear is present at points C and E (Fig. 1) but its occurrence in clinical situations would depend on the angle closed and the extensibility of the skin.

As the acute angle of the defect increases from 60°, the defect becomes progressively wider than the flap. At 90° the short axis of the flap is only three quarters the length of the short axis of the defect. Hence it is in this range that the flap is of value. Area of the flap and defects are never equal, hence the flap has to be stitched under some tension.

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