THE Z-PLASTY IN HAND SURGERY

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The Z-plasty has for many years been recognised as a most valuable technique in hand surgery but its use has tended to be restricted to the relief of linear contractures. The recent trend towards conservative in preference to radical fasciectomy in the treatment of Dupuytren's contracture, however, has given it a much wider currency. Used in the treatment of this condition it can make exposure of the affected fascia easier and excision both simpler and more effective; indeed, the planning and execution of a Z-plasty is often literally the beginning and end of a good fasciectomy.

The theory and practice of the Z-plasty in other parts of the body and in other circumstances has been well covered in the monographs of Limberg (1946, 1963), but it has not hitherto been discussed adequately in the specific context of the hand. In particular, the limiting factors imposed by the anatomical peculiarities of the hand and the modifications made necessary remain to be considered. Yet if it is true elsewhere in the body that full exploitation of the virtues of the Z-plasty calls for a corresponding recognition of its limitations it is doubly true in the hand where the limitations are if anything even more strictly imposed by the local conditions.

The purpose of this paper is to discuss the role of the Z-plasty in Dupuytren's contracture and skin contractures, and in particular to indicate the reasons for the modifications of basic technique which must so often be used. In the hand the Z-plasty has of course a role in the deepening of finger clefts and the correction of congenital ring constrictions. The mode of action of the procedure in these conditions has, however, already been discussed (McGregor 1966) and they will not be considered further.

In the hand as elsewhere the Z-plasty is capable of subserving not only its primary function of increasing length in a particular direction but also a secondary one of providing exposure of deeper structures. This secondary role is not invariably required but it is there in the background. It will be assumed throughout since it virtually goes without saying.

THE BASIC TECHNIQUE

When Z-plasty flaps are transposed there is lengthening in one axis and equal shortening in the other (Fig. 1). It has been shown that increasing the Z-plasty angle increases the amount of lengthening and shortening, and for reasons discussed by McGregor (1957) a compromise has been reached in practice with an angle of 60 degrees, producing a 75 per cent alteration in both directions.

Most writing on the Z-plasty discusses the lengthening which is achieved and less has been said about the shortening which inevitably accompanies it. This shortening is in the transverse axis, and in many areas of the body it does not give rise to difficulties because there is ample slack available to be taken up. This fact doubtless explains why the problems of shortening have received so little attention. Skin is never abundant in the hand, however, and shortening as a factor has to receive much more careful consideration if the Z-plasty is to be used successfully. In the hand indeed it is the problem of shortening which determines the fact that 60 degrees is the largest angle used, for shortening greater than 75 per cent could scarcely be tolerated even if for other reasons it were practicable. In the discussion to follow it will become apparent that it is shortening and the problems that it poses which determine most of the modifications of method described.

ANATOMICAL LIMITING FACTORS

The sites in the body where the Z-plasty has something to offer are those which concern concavities rather than convexities. It is in the popliteal fossa, not over the patella, that the Z-plasty is used. In the same way the Z-plasty is required in the palm of hand and finger, not on the dorsum.

Characteristically palmar skin shares with plantar skin a marked lack of elasticity and also a very firm attachment to the underlying fascia. These attributes, in the context of the Z-plasty, mean that palmar skin neither moves easily nor does it turn readily. When a Z-plasty is used in other parts of the body (if one excludes its rather special use in facial scars) a good

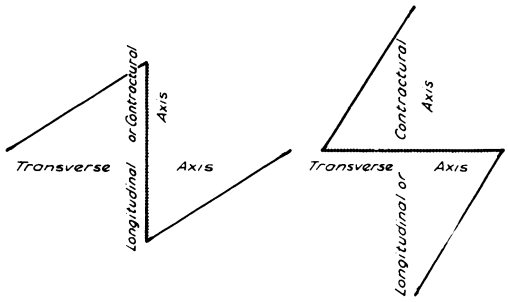

FIG. 1

The changes in length which accompany transposition of Z-plasty flaps; the longitudinal or contractural axis lengthens and the transverse axis shortens correspondingly. In this instance the Z-plasty angle is 60 degrees and the lengthening which takes place is consequently 75 per cent of the original length.

index of design and execution is that, once cut, the flaps should literally fall into their transposed position. It should be difficult or near-impossible to return them to their pre-operative position. In the hand, with its inelastic skin reluctant to move and turn, this is seldom true. And with this reluctance to move and turn is coupled the fact that there is little if any skin to spare in the palm and even less in the fingers.

Because the Z-plasty relies for its effectiveness on the presence of slack in the transverse axis, which is taken up to provide lengthening in the longitudinal axis, it follows that the hand is not a favourable site for the Z-plasty as usually employed elsewhere. As a corollary, modifications of standard technique must be sought which circumvent these difficulties.

MODIFICATIONS OF TECHNIQUE FOR THE HAND

As has been said, lengthening of the longitudinal axis equals shortening of the transverse axis and with the anatomical limiting factors already discussed it is obvious that if the Z-plasty is to be used successfully in the hand any modification of technique must have the effect of reducing transverse shortening to a minimum. To take a typical example (Fig. 2): if we consider a contracture which for complete relief requires two centimetres of lengthening we must accept the fact also that at no point in the palm are we likely to find skin loose enough in the transverse axis to permit shortening by the two centimetres necessary for the carrying out of a single Z-plasty. The solution lies in the division of the contracture into segments—say four—and in the construction in each segment of a Z-plasty one quarter the size of the large single Z-plasty. The effect of this is that each of the four small Z-plasties will produce a quarter of the desired lengthening and thus still give the desired total increase. It is the shortening which is drastically changed in character, for instead of the impossible two centimetres shortening of the single large Z-plasty we have the entirely possible half-centimetre shortening

at the transverse axis of each of the small Z-plasties. By using multiple small Z-plasties rather than a single large Z-plasty the difficulties of transverse shortening are readily overcome.

The multiple small Z-plasty, in addition to the fact that it reduces the amount of transverse shortening, also reduces the amount of tissue turning and of movement required, because the total movement of skin in each Z-plasty is similarly reduced by a factor equal to the number of Z-plasties—four in the hypothetical case considered above.

In designing a multiple Z-plasty (Fig. 3) it is possible to make it into individual independent, or discontinuous, Z-plasties or, alternatively, to make them into one continuous multiple Z-plasty extending as far proximally as may be needed into the palm. There are no

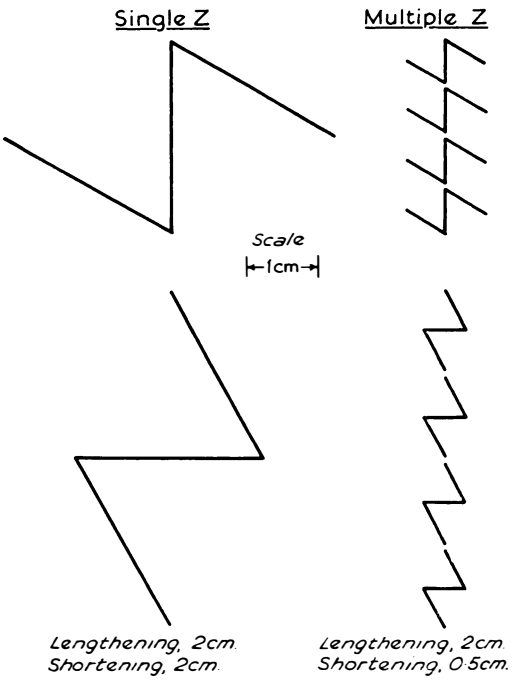

FIG. 2

The single and the multiple Z-plasty of similar lengths of contractural axis, compared from the point of view of lengthening and shortening. In both the lengthening is similar, but in the multiple Z-plasty shortening is reduced by a factor equal to the number of Z's, in the illustration four.

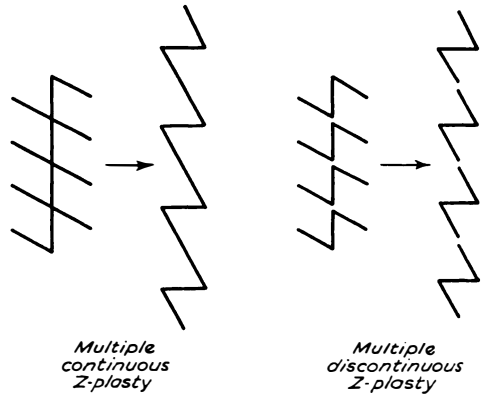

FIG. 3

The multiple continuous and the multiple discontinuous Z-plasty, showing how they produce essentially similar results.

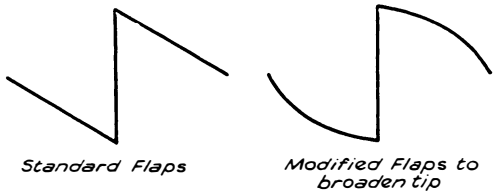

FIG. 4

The standard Z-plasty and the flaps modified to give maximum vascular capacity.

particular advantages in one design over the other and the factors determining which is used will be discussed later. But one can say that in the hand, for the reasons given, the multiple rather than the single Z-plasty is best. The problem then resolves into the design of the Z-plasty itself.

A further minor modification of design which can usefully be employed stems from the fact that the Z-plasty flaps all too often have to be dissected free of the palmar fascia and from the point of view of blood supply are thinner than one would like. A broader tip can be obtained by slightly modifying the cut of the Z (Fig. 4), adding a little to the safety factor.

PLANNING THE Z-PLASTY IN THE HAND

In keeping with the recognition that scars in the palm should parallel flexure lines, the Z-plasty should be so planned that its transverse limb after transposition lies in a flexure line.

Jones (1941) stressed that such lines mark the site of what he called a " skin joint " brought into action by the movement of an underlying bony joint, and he pointed out that they constitute lines of comparative skin rest. The advantages, when a joint has to be crossed by the Z-plasty, of having the transverse scar in the corresponding flexure line scarcely need to be emphasised.

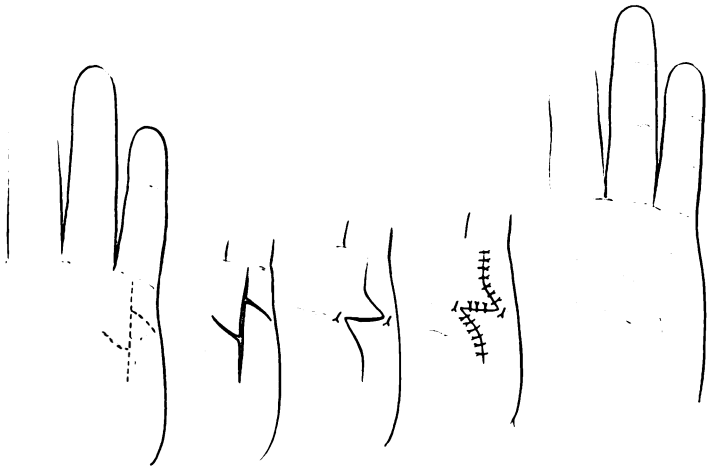

FIG. 5

Siting the single Z-plasty so that its transverse limb lies in a skin crease. With each oblique cut ending on the flexure line transposition of the flaps brings the transverse limb to lie in the crease.

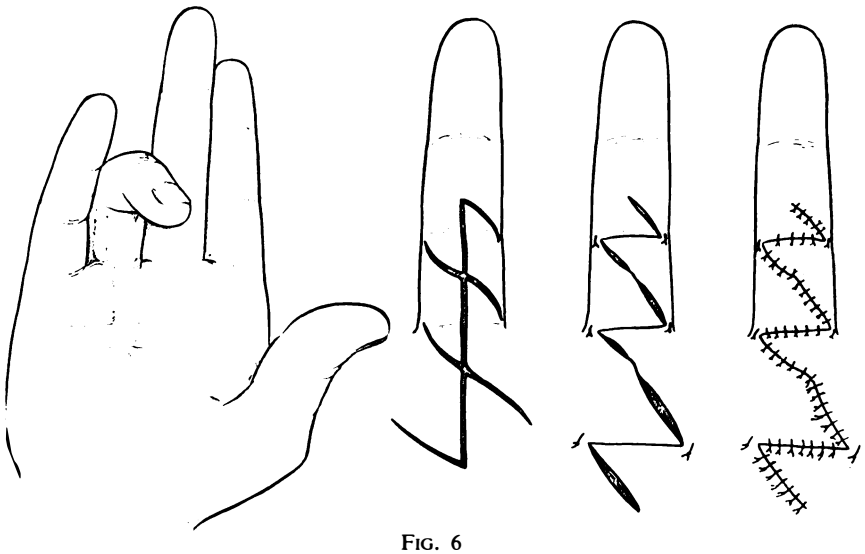

FIG. 6

Siting the multiple Z-plasty so that each transverse limb lies in the appropriate skin crease as applied in the type of Dupuytren's contracture shown where disease is confined to a single finger ray. The oblique cut of each Z of the series ends on the flexure line and transposition brings the transverse limb in each instance to lie in the crease.

McGregor (1965) indicated how a Z-plasty in the face can be sited at will to place the transverse limb as desired, and the same technique is entirely applicable in the hand whether the Z-plasty be single (Fig. 5) or multiple (Fig. 6). All that need be done in planning is to ensure that the oblique cut of each Z-plasty ends on the flexure line. Flap transposition will inevitably bring the transverse limb into the flexure line as planned—a fact more readily seen from illustration than description.

It is possible then to design the Z-plasty so that the resulting transverse limb will lie along the flexure line, but the question remains of how big can the Z-plasty safely be made. The problem is most acute in the fingers, because it is here that transverse shortening is least possible. In practice a good working rule is that a Z-plasty of a size to fit into the adjoining phalangeal segment will give rise to shortening in the transverse axis which is acceptable by the local tissues. This is probably the largest size of Z-plasty which should be used and on occasion a smaller one may be preferable.

The actual size of the possible Z-plasty diminishes from the proximal to the distal phalangeal segments. There are three separate factors which can be responsible for this, one or more of which may be operative at a time in each of the fingers. Firstly, the finger narrows from the proximal to the distal end, and in consequence the tissue available for transverse

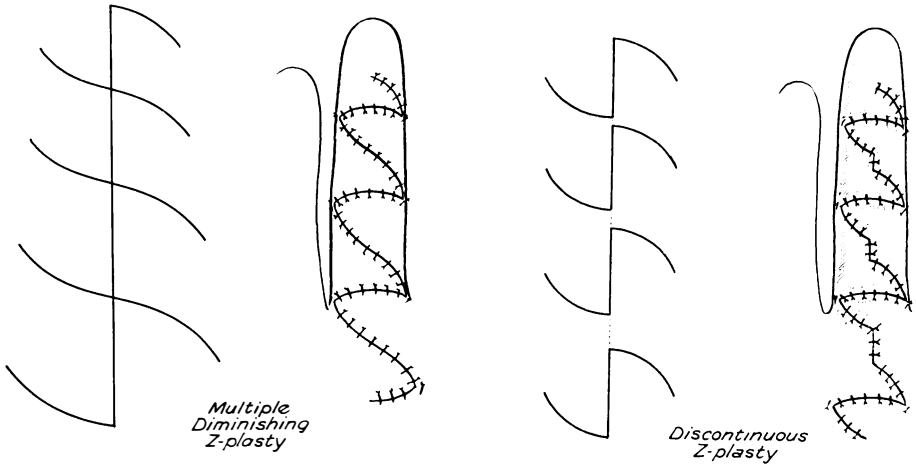

FIG. 7

The continuous multiple diminishing Z-plasty and the multiple discontinuous Z-plasty; *left*—before transposition; *right*—after transposition, showing how they have virtually similar effects.

shortening becomes less. Secondly, the distance between flexure creases tends to diminish from the proximal to the distal end, and the Z-plasty which can be constructed consequently becomes smaller. Thirdly, the mobility of the dorsal tissues becomes less from the proximal to the distal end, reducing the slack available for transverse shortening.

The experienced surgeon is usually able to take these factors into account and design a continuous multiple diminishing Z-plasty (Fig. 7), but this is rather a refinement and by no means obligatory. An equally good result will be obtained by making a series of discontinuous Z-plasties linked by the single line running proximo-distally along the fingers and palm.

A point worth making at this stage is the finding, when the flaps are transposed, that there is almost always a redundancy of skin where one Z-plasty passes to the next, usually in the middle of the phalangeal segment. The natural temptation to trim the skin to a more elegant fit should be resisted. Skin is normally most bulky in the middle of a phalangeal segment, the redundancy settles rapidly to a normal and natural bulkiness and, in any case, palmar skin has never enough spare to warrant its wanton excision.

USE IN DUPUYTREN'S CONTRACTURE

The most important use of the Z-plasty technique is in the single ray contracture, and here the multiple diminishing Z-plasty is often ideal, when the contracture forms a continuous band from finger to palm (Fig. 8). It allows use of the obvious surgical approach—abhorred in the past by so many surgeons—namely the longitudinal incision along the length of the

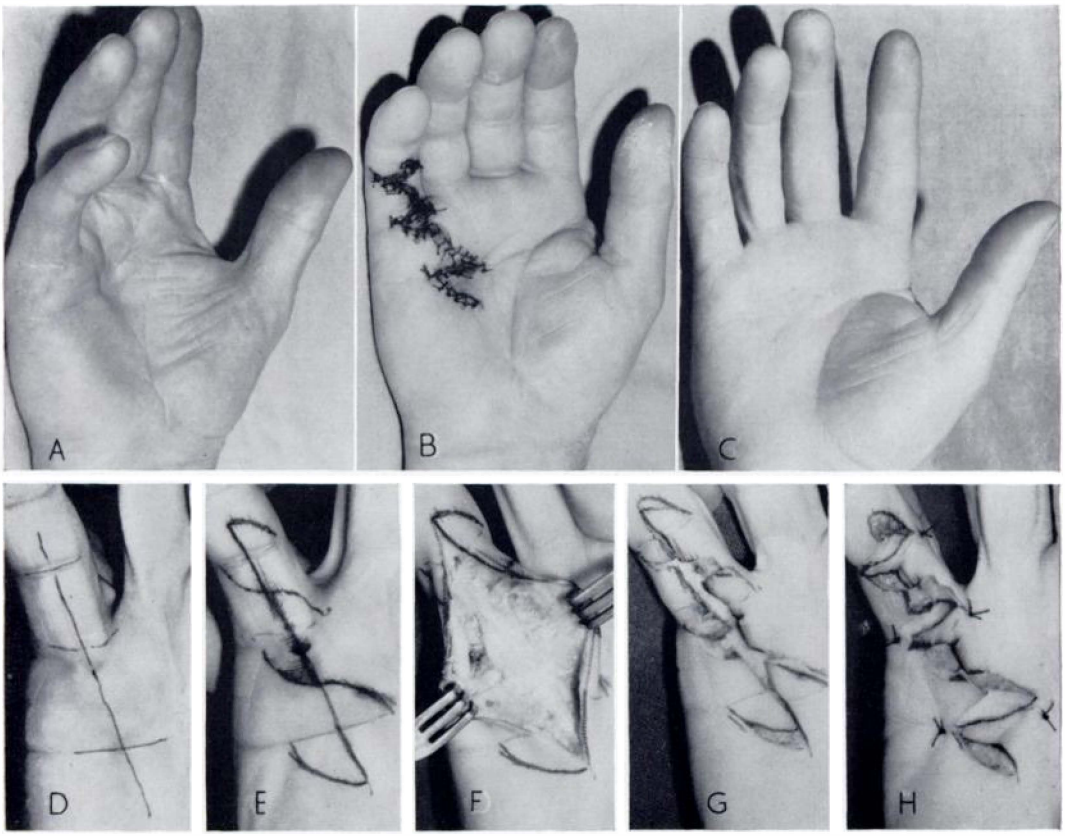

FIG. 8

The continuous multiple diminishing Z-plasty used in the treatment of Dupuytren's contracture of the little finger ray. A shows the condition before operation, B is seven days after operation and C the final result with each transverse scar in a skin crease. The stages of the operation are shown first in D, where the contracted fascia and transverse creases are delineated, and in E the Z-plasty flaps are marked. F shows the exposure of the fascia, G the cut flaps and H the flaps transposed. Note how the fascia was removed before the flaps were actually cut.

involved finger and into the palm as far as needed. Such a linear incision gives excellent exposure, there is no blind area in the difficult segment just proximal to the web, and the neurovascular bundle can be visualised throughout its length. Contracture of a single ray confined to the palm may of course only require a single Z-plasty (Fig. 9).

The experienced operator can design his Z-plasties before incising but, if severe skin puckering is present, or if relative inexperience makes the surgeon chary, it is just as satisfactory to make the long linear incision for exposure first. With the fascia excised and skin puckering gone the oblique cuts to make the Z-plasties can be made. As already stressed continuity of the Z-plasties is not essential, though it adds an undoubted technical elegance.

Dingman (1955) and Hueston (1961) showed that a multiple skew Z-plasty is possible but the symmetrical multiple Z-plasty with all flaps turning the same way and no tendency to narrow bases and broad tips is generally safer.

An added benefit which results from the use of the Z-plasty in Dupuytren's contracture is lengthening in the long axis of the finger. In theory there should be no shortening of the skin in Dupuytren's contracture and thus in theory no skin should need to be added even if it does seem to be short—a fact which McCash's (1964) demonstration of the effectiveness of the " open palm " method of fasciectomy incidentally highlights. However, lengthening with the Z-plasty positively relieves any tendency to contracture on the part of the skin and any

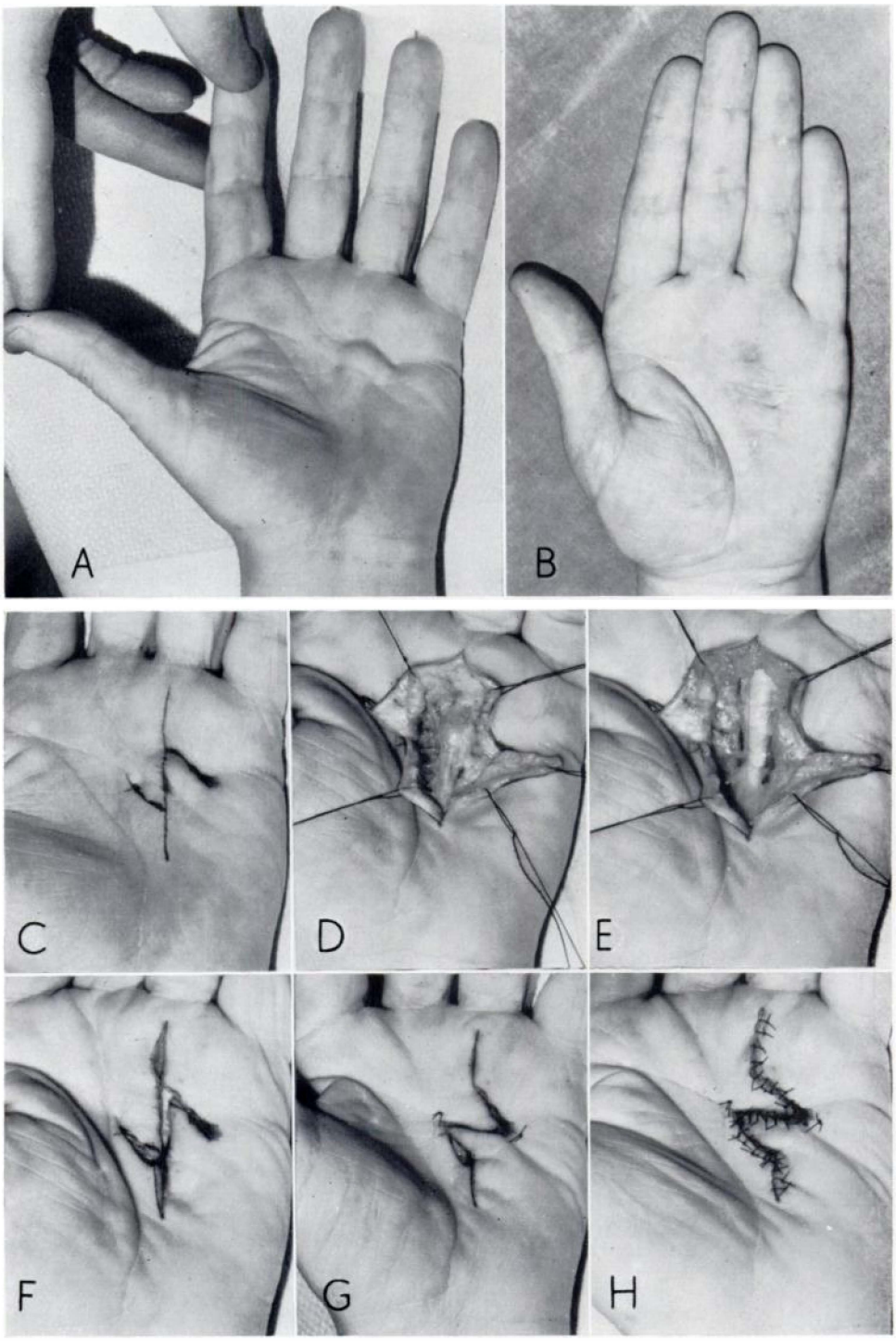

FIG. 9

The single Z-plasty used in Dupuytren's contracture confined to the palm and involving only one ray. The appearance before operation is shown in A with final result in B with the transverse scar lying in the transverse palmar crease. The incisions are outlined in C and the surgical exposure of the contracted fascia is shown in D and after removal in E. The flaps (F) are transposed in G and have beensutured in H.

tendency to subsequent scar contraction. It is entirely feasible of course to combine Z-plasties in the fingers, single or multiple, continuous or discontinuous, with " open palm " handling of the palmar component of the contracted fascia (Fig. 10).

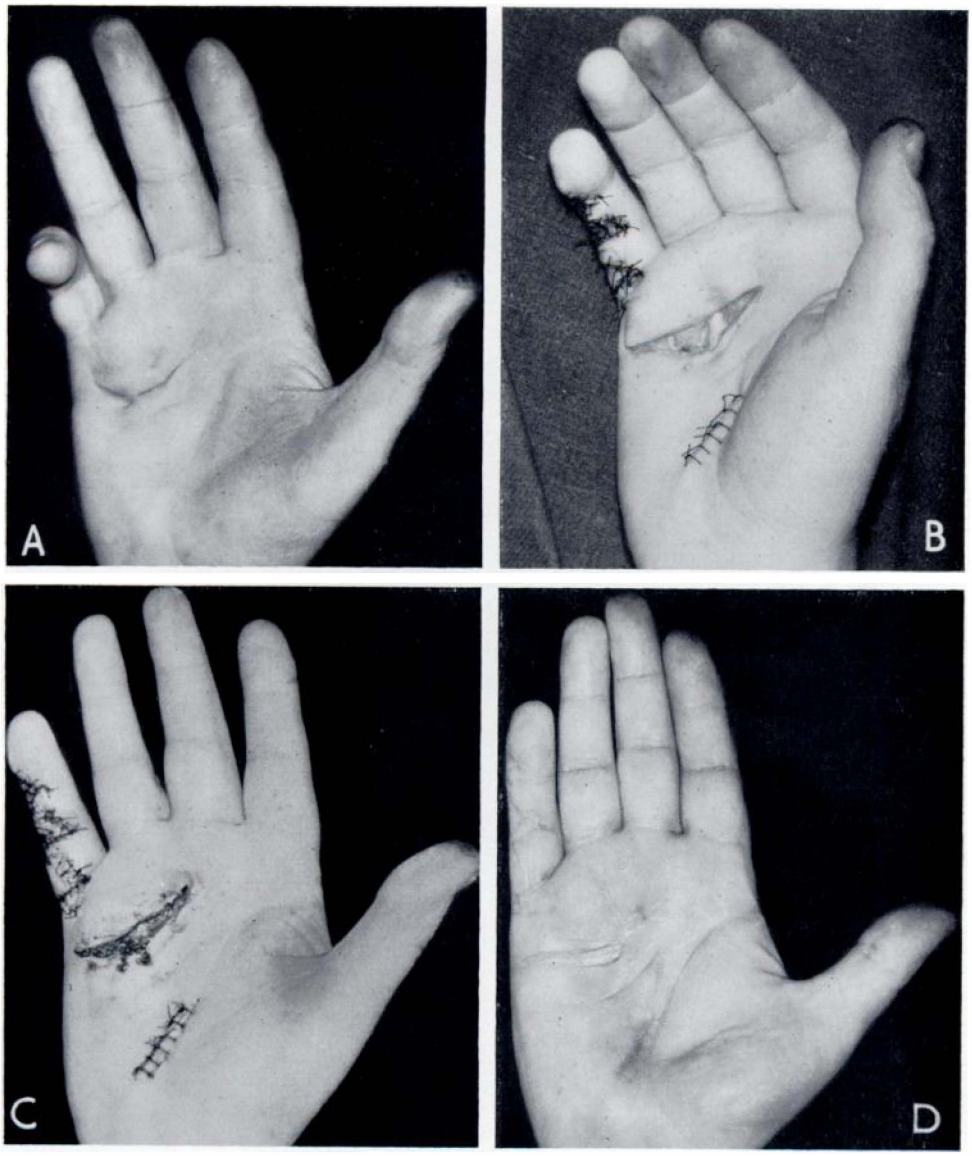

FIG. 10

The multiple continuous Z-plasty used in the little finger component of a Dupuytren's contracture, combined with " open palm " handling of the palmar component. The appearance is shown before operation in A, at the end of the operation in B. C is six days after operation and D is two months later.

USE IN CONTRACTED SCARS

The Z-plasty in the hand, as elsewhere, can be used to lengthen a linear contracted scar only when the adjoining tissues are normal, because the lengthening comes from the adjoining tissues and, if these are already contracted, no lengthening can take place. Planning and execution in contractures otherwise varies little from usage in Dupuytren's contracture (Fig. 11). A subsidiary use is in the marginal contracture which can occur between graft and palmar

skin in syndactyly. Such a contracted scar, moving with time further and further round to the palmar aspect of the finger, is ideally suited for the multiple Z-plasty and the procedure is most effective. Rank and Wakefield (1960) stressed the desirability of placing scars or

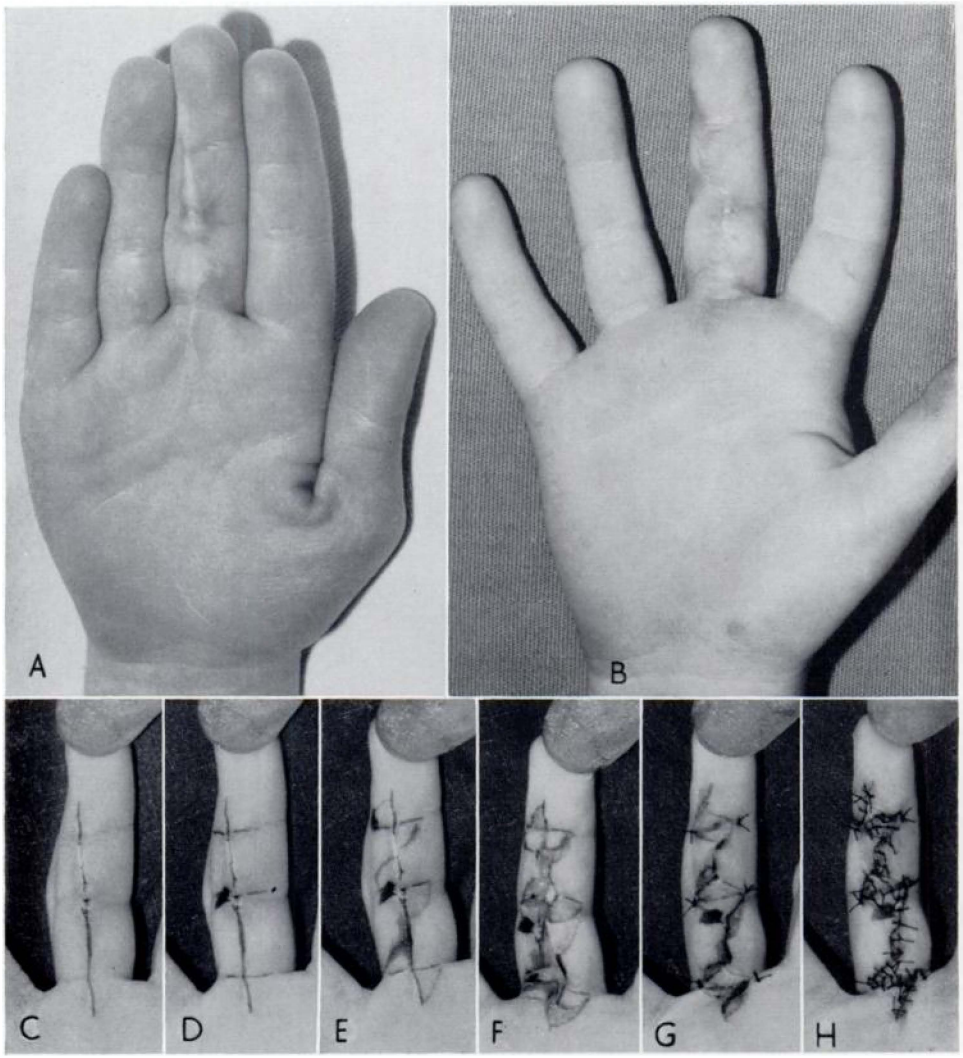

FIG. 11

The Z-plasty used to correct a linear contracture. A shows the hand before operation, and B is the end-result. In C the contracture is delineated, the transverse creases are shown in D and the multiple Z-plasty flaps in E. The flaps are cut in F, transposed in G and sutured in H.

junction lines between grafts or flaps and palmar skin in a neutral line—for instance, the mid-lateral line of the finger—but the badly placed scar or junction line with contraction can readily be improved by a Z-plasty, single or multiple, depending on its length.

DISCUSSION

The principles which underlie Z-plasty practice and the reasons for the effectiveness of the technique remain constant wherever in the body it is used. Local conditions, anatomical as in the hand for example, pathological as when scarring is present, may dictate modifications of design but these will still conform to the basic pattern of Z-plasty principles. It is the hand

which primarily concerns us at present and here, as has been stressed, it is the limiting factors in design which are all-important.

As soon as flaps are raised anywhere in the body, the surgical situation acquires a fresh dimension for the possibility of flap necrosis and the disasters consequent on necrosis arise. It is for this reason that the plastic surgeon treats a flap with the respect which he might not automatically accord a free skin graft. It is for this reason also that flaps are planned with care and not embarked upon lightly. This applies with especial force to local flaps. Possibly the most important aspect of planning is to design such a local flap so that it is capable of being moved to the defect and of filling it adequately without undue tension. Tension is recognised as probably the most potent cause of flap necrosis.

The Z-plasty consists of two transposed flaps and as such is subject to all the ills that beset flaps in general. In Z-plasty as in other flap practice good design is all-important and good design means flaps which will transpose without undue tension. In the hand this almost always means lateral tension. This lateral tension is the manifestation in practice of the shortening in the transverse axis which must accompany the transposition of Z-plasty flaps. The use of a multiple Z-plasty as has been demonstrated can reduce this lateral tension by dividing the total transverse shortening by a factor equal to the number of Z-plasties. There is nevertheless a limit to the extent to which shortening can be reduced. It should be possible in any event at the planning stage of the Z-plasty and before actual flaps are cut, to estimate the amount of shortening which will take place and to judge whether or not excessive tension will be created. In this way the danger of tension leading to ischaemia and necrosis will be avoided.

SUMMARY

1. The modifications of standard Z-plasty technique that are necessary for its successful use in hand surgery are discussed with particular reference to the limiting factors imposed by the anatomical characteristics of the hand.

2. The use of the Z-plasty in Dupuytren's contracture and contracted scars is discussed.

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