Paparella IV: Section 1: Plastic and Reconstructive Surgery

Chapter 12: Scar Revision

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The objective of scar revision is the improvement of unsatisfactory scars: scars that are depressed, raised, uneven, widened, hypertrophied, contracted, pigmented, or otherwise too obvious. Three techniques are available to accomplish this objective. The first is fusiform scar revision (FSR), the oldest technique used in the treatment of linear scars. The two others are the zigzag techniques, Z-plastic scar revision (ZSR) and W-plasty, representing more recent technical advances in surgery.

"Unsatisfactory scar" is an inexact term since its meaning depends on the criteria being used for evaluation, whether by the patient or by the plastic surgeon. In the case of the latter, his experience with and knowledge of the treatment of scars influence his judgment as to the acceptability of a scar. Scars should be judged unsatisfactory or unacceptable when, although they might be relatively good aesthetically, they could be improved by one of the revision techniques. From a practical point of view, a satisfactory scar is one that cannot be improved by treatment, although at times it may be unaesthetic.

It is as important to revise an unsatisfactory scar that needs revision as it is not to revise a scar that might turn out to be the same or worse after revision. Admittedly it takes courage to increase the overall length of a clean lineal facial scar deliberately with the zigzag techniques, even if by so doing we know we will divide it into smaller segments and improve its direction. However, the consistently excellent results achieved in most cases have prompted many plastic surgeons to use these procedures more and more, and to apply them to scars that previously would have been left alone because they were categorized as satisfactory under a lenient criterion. After using these techniques for over 30 years, I have yet to encounter a case in which I have regretted its use; rather, I regret not having used it more frequently. But there are certain contraindications, which will be mentioned later, that preclude revision of certain unaesthetic scars.

Scar Analysis and Deductive Reasoning

It is rare for two cicatricial deformities to be exactly alike. Their endless variety has a fascination of its own, but makes it impossible to apply a cut-and-dried revision formula to any particular group of scars. Each case must be studied carefully on its own merits, and the various methods of repair weighed from every standpoint in relation to the particular patient. Some basic factors influence the choice of one procedure over another in all cases. By knowing the factors giving rise to the deformity and the aims of revision, the surgeon can intelligently inform the patient of the improvement to be expected with the technique that is best suited to him or her.

Location of Scar

Either too much overall skin tension (in the extremities or torso) or too little skin tension (in the eyelids or neck) favors the use of Z-plasty over W-plasty. In W-plasty a small amount of nonscarred skin on both sides of the scar is removed. This excision of tissue increases the overall tension of the region. Since skin tension is the most important factor causing a scar to widen, and maybe to hypertrophy, this increased tension is detrimental in regions in which skin tension is already normally high. Scars in flaccid regions with very little skin tension fare better with the revision (ZSR) that preserves the low skin tension. These are the main reasons why the W-plasty scar revision is not recommended in such regions.

Scars on the forehead, temples, cheeks, nose, chin, and abdomen that cross the relaxed skin tension lines (RSTL) at right angles or over 35 degrees of inclination from them are best treated by W-plasty in most cases. On the rest of the face and for depressed or bowstring scars in nonfacial region, Z-plasty is preferred if the scar does not follow the RSTL.

If an antitension line (ATL) scar involves an anatomic landmark (eg, the hairline or eyebrow), Z-plasty is contraindicated because it would dislodge or malalign the landmark. W-plasty, if otherwise indicated, does not alter the normal relations of the landmark segments on either side of the scar.

In ATL scars close to structures at right angles to the RSTL (the vermilion of the lips), Z-plasty is preferred. W-plasty either raises the upper vermilion border or moves the lower vermilion border down. This disadvantage becomes an advantage when it is desired to raise an abnormally low upper vermilion caused by paresis.

Direction in Relation to RSTL

It is a rare linear scar resulting from a laceration that does not cross a skin tension line at some point, and that cannot be improved by breaking it up into smaller components that follow the RSTL direction better than the original scar.

Scars that do not follow the RSTL on the eyelids, nasolabial folds, and lips are best improved only by Z-plasties. On the forehead, eyebrows, temples, cheeks, nose, and chin, either ZSR or W-plasty may be used, depending on the direction of the scar. Scars of 35 degrees or less of inclination from the RSTL in these areas are best treated with multiple Z-plasties, which result in two-thirds of the segments running in the RSTL direction and one-third running obliquely. Inclination from 35 to 60 degrees should be revised by the stair W-plasty, after which half of its segments, the smaller segments, are at right angles to the RSTL and the other half follow exactly the RSTL. Inclination from 60 to 90 degrees should be treated by the classic W-plasty. Incorrect use of a classic W-plasty for scars of less than 60 degrees would result in all segments running in a worse direction than the original scar.

Scars that follow the RSTL very closely should be improved by simple scar revision (FSR) and not the zigzag techniques.

Length of Scar

Small ATL scars (less than 1.5 cm long) show better results from a Z-plasty slightly smaller than the scar than from either a mono-unit W-plasty or a very narrow multiple-unit W-plasty.

A *mono-unit W-plasty* is one made up of one V-shaped skin strip and two triangles at the ends. Postoperatively there are two oblique ATL scars and two perpendicular ATL scars. On the other hand, in the postoperative Z of the single Z-plasty there are two good tension line scars and one oblique ATL scar. This oblique diagonal scar is cosmetically superior to the original oblique scar because it has much less pull at right angles to it owing to the skin added by the transposition of the flaps.

If a small and very narrow multiple-unit W-plasty is used it will produce a zigzag scar that does not have enough accordion-like elasticity, and results in an irregular straight scar after scar contracture.

A medium-sized ATL scar (1.5 to 3 cm) may be treated by either two Z-plasties or a W-plasty.

Large-sized ATL scars (over 3 cm) on the forehead, temples, cheeks, nose, or chin are best improved by W-plasty. Very long scars sometimes may be treated in some segments by W-plasty and in other segments by one or more Z-plasties, according to the relationship of these segments to the RSTL. Besides improving the direction of the scar and breaking it up in segments, the purpose of these Z-plasties is to give relaxation to the area where the scar is situated, thus restoring the normal convexity lost by the contracture of the ATL scar.

With regard to the length of scars on the face, where a cosmetically acceptable result is of the utmost importance, the W-plasty has the advantage over the Z-plasty of having smaller segments. The smaller the segments, the less is the bowstring effect and the less likely it is that the scar will be noticed. The ATL postoperative segments of the Z lines, although a great aesthetic improvement over the original scar, are much more visible than the smaller segments of the W-plasty. If multiple consecutive Z-plasties are made with segments of a size similar to those of a regular W-plasty, the gain of tissue in the direction of the scar from tissue in the opposite direction will be so great that bumps and furrows will result.

Depressed Scars

Very depressed scars are usually secondary to very deep lacerations or to healing by secondary intention. Scars healed by secondary intention may also be adherent to deep underlying structures.

Markedly depressed scars are corrected best by Z-plasties because of the procedure's powerful leveling effect. Either FSR or W-plasty is indicated in some patients and will result in some improvement, but the added laxity afforded by Z-plasty in the direction of the scar, without sacrificing any skin, makes it preferable to W-plasty or FSR.

Depressed scars occur most frequently over soft understructures such as the cheek, when maturation and shrinkage of the collagen in the scar cause it to be pulled inward toward the subcutaneous fat.

Raised Webbed Scars

When a straight scar crosses concave surfaces such as the umbilicus, suprasternal notch, axillary dome, concha auriculae, and nasolabial furrow, it produces bowstring disfigurement. Z-plasty is the treatment of choice for this deformity.

Shape

Curved scars, which give rise to the so-called "trap-door" deformity, are revised in such a fashion that the contracting forces are directed away from the central area. This is done by utilizing multiple Z-plasties. Circumferential scars on extremities (eg, congenital constriction band) cause a double trapdoor effect, which is also appropriately treated by Z-plasties.

Small stellate scars are treated by FSR.

Linear scars are treated according to the region where they are situated and according to their direction as related to the RSTL.

Raised skin deformities caused by healed bevel-edged wounds are treated by (1) excision of the scar followed by direct closure or (2) a Z- or W-plasty according to the region and direction of the scar.

Scars from Elective Surgery

Tension lines from elective surgical incisions, if they are unsatisfactory because of healing by secondary intention, may be improved by FSR. However, if they have healed by primary intention, excision and resuture will not improve them. Elective surgical ATL scars are corrected by ZSR or W-plasties, depending on their region and direction. *Unsatisfactory ATL scars from elective surgical operations can be prevented by making zigzag incisions during the initial surgical procedure.*

Sources

As already stated, wide scars that have resulted from the loss of integument (avulsions, excisions, or burns) are usually not amenable to any of the three linear scar revision techniques.

Windshield injuries produce either multiple small scars or a few long scars. The multiple small scars require multiple FSRs, a few small Z-plasties, dermabrasion, and dermoplaning. The final result of these treatments will take longer to achieve than that seen with long, stablike windshield scars treated according to precepts presented throughout this chapter. Scars from dog bites are frequently very irregular and multiple and are often treated with Z-plasties. Lacerations from table corners frequently have a stellate configuration; if relatively small, they are treated with FSR. Traumatic injuries in which the lower teeth have cut through the lower segment of lower lip typically produce a transverse scar that is unaesthetic and requires W-plasty revision. Gunshot wounds leave a relatively small scar at the point of entry of the bullet and a very deforming scar at the point of exit; treatment varies among patients.

Hypertrophic Scars

Try to determine why the scar is hypertrophic. Is it located in the "no man's land" of scars, over the sternal or deltoid regions? Is it a true keloid, or is it hypertrophic because it crossed the RSTL? Microscopically, no difference is noted between a true keloid and a simple hypertrophic scar (a keloidal or pseudokeloidal scar) because they either are hypertrophic scars or represent overactive production of fibrous tissue.

Keloids are defined as hypertrophic scars within the skin that grow beyond the confines of the original wounds. In contrast, simple hypertrophic scars are raised scars that remain within the boundaries of the wound. The differentiation is important, since the treatment of a true keloid differs from that appropriate for a simple hypertrophic scar. The keloid grows slowly, and years may elapse before it obtains maximal dimensions. Spontaneous involution is rare.

Hypertrophic scars become paler, softer, and less conspicuous with the passage of time. Keloids are encountered most often in young, dark-skinned persons between 20 and 30 years of age.

Of interest are the experiments on keloids by Calnan and Copenhagen, who excised the keloids in ten consecutive patients (eight whites and two blacks). A circular graft 2.5 cm in diameter and 2 to 3 mm thick was cut from the keloid, and a defect of similar size was made on the anterior abdominal wall. Onto this bed, containing fat and a little dermis, the autotransplant of keloid was sutured. In nine patients the graft took completely and became a normal-looking full-thickness skin graft. All keloids recurred in the sutured donor area except one. These authors concluded that the results of the clinical experiments excluded the possibility of any general systemic influence and pointed very strongly to a local factor. In the presence of this factor, keloids have an almost malignant inclination to recur; in its absence, established lesions melt away. What kind of local factor this may be awaits inquiry.

Hypertrophic scars over the sternum or shoulder and true keloids anywhere should *not* be excised, except perhaps when the excision is supplemented by other forms of therapy such as radiation, corticosteroids, or pressure. Simple surgical excision and suturing in an attempt to get rid of a hypertrophic scar are useless. The new scar will certainly develop further hypertrophy, worse because of the tension engendered by the excision of integument. A scar that becomes hypertrophic because it crosses the RSTL may be improved by multiple Z-plasties. W-plasty is not recommended for use in revising widened hypertrophic scars.

Wide Scars

A wide scar from a wound that has healed by primary intention means that great skin tension is present at right angles to the scar's direction. If this tension is due to tissue loss by avulsion, necrosis, excision, or burns, the use of any scar revision technique is rarely indicated, since the resulting scar may be worse than the original one. If the tension responsible for the widening is only attributed to the scar's cutting across the normal RSTL of the region, a ZSR or W-plasty (for example, on the abdomen) may be indicated. If the widening is due to the scar being present in a region of high skin tension (sternum, shoulder, back), no treatment will improve it. Round, wide vaccination scars are best left alone since their revision may result in greater disfigurement. The postrevision scar may become hypertrophic or resemble a long stab wound. In many cases, treating wide, flat scars by means of a graft or flap results in little improvement. Repeated partial excisions (serial excision) of wide scars does not improve the deformity in most cases.

Pigmentary Variations

Traumatic tattooing is caused by the grinding of gunpowder granules or particles of oil, dirt, or pigment into the skin. These appear on the scars as bluish marks. Even if these scars follow the lines of skin tension and are of hairline width and level, they are very obvious and require treatment. Dermabrasion or dermoplaning may correct the condition if the tattoo lies superficially enough (eg, a gunpowder tattoo) but not if it is very deep seated. A deep-seated tattoo may require full-thickness skin excision, and repair of the skin defect by direct approximation of its skin borders or skin graft.

Confluent Scars

If, when planning the revision of an ATL scar, one encounters other nearby scars that have been revised or will need revision, the balance usually tilts toward the choice of Z- rather than W-plasty (although in some cases both may be used). Excision of tissue is required in a W-plasty, which increases the skin tension, a detrimental factor in a multiply scarred area where skin tension is already very high.

Stitch Marks

Stitch marks, which are called "crosshatch" scars, may be punctate or linear. They are usually created as a result of the pressure necrosis (strangulation) occurring along the line of the suture owing to stitches that are too tightly placed and left in too long. They are worse if there is a keloid tendency, if stitch abscesses develop, and in thick-skinned regions. In some cases they may be included within the zigzag strip of skin that is excised in a W-plasty. If a skin defect owing to its sizable width is closed with undue tension, it is almost impossible to prevent stitch marks (eg, closure of decubitus ulcer). In cases like this, stitches have to be tied tight and left for a protracted period to foretell dehiscence.

Step-Off Deformities

Step-off deformities are caused by improperly sutured wounds on the vermilion border of the lips, on the eyebrows, on the free margin of the eyelids, or on the nostrils. They necessitate reopening of the wound followed by proper suturing. A Z-plasty may correct this deformity but it will not give as good a result.

Distortion of Anatomic Landmarks

Contrary to what has been implied in the medical literature, linear scars crossing the eyebrow, the eyelid free margin, or the vermilion border of the lips resulting from wounds unaccompanied by tissue loss, rarely, if ever, distort these landmarks. Ectropion of the lower eyelid probably will not occur after contraction of ATL vertical scars when there has been no tissue loss. Distortion resulting from tissue loss is easily and adequately corrected by Z-plasties if it is minor, and by local flaps or skin graft if severe. The raised vermilion border of the lip following the repair of the cleft lip is due to defects in the technique used and not to scar contracture; probably insufficient excessive abnormal vermilion has been removed. If anatomic landmarks are distorted or the surface configuration is deformed (eg, loss of convexity of the cheeks), correction of these deformities takes precedence over cosmetic improvement of the scar by its revision.

Twitching Scars

Deep cheek lacerations may result in post-traumatic facial twitching that appears spontaneously and occurs more frequently under emotional stress. The greater the initial damage, the greater are the incidence and severity of facial tics. These arise from an injury to the facial nerve that has resulted in contusion to or division of axons. The spasm appears in about 2 months with the onset of nerve regeneration and the return of function. With complete functional return, tic progression is arrested; however, regression is unusual. Treatment is generally unsatisfactory.

Painful Scars

Some pain, discomfort, and itching are frequently seen in keloids and simple hypertrophic scars. Nerve compression may occur after injury if a sensory nerve is included in the scar. This is more often observed in injuries of the supraorbital or infraorbital nerves at their emergence from their foramina, and in injuries to the superficial radial nerve or its branches. Treatment is difficult.

Age of the Patient

The older the patient, the greater and more rapid will be the improvement obtained by scar revision. The younger person has greater overall skin tension, with its tendency to cause scar spreading and hypertrophy, and skin tension is one of the main factors determining the aesthetic outcome of scar surgery. The maturation of the postrevision scars takes longer in the young than in older patients. Scars are usually redder and remain so longer than do comparable scars in adult patients. Moreover, scars in children are more likely to be psychologically distressing to the child or the parents than are scars in older people.

Time Lapse Since Injury

It is important to consider the age of the cicatrix in evaluating the scar of a wound. The epidermal healing occurs extremely rapidly, but the healing process that takes place in the dermis is much more prolonged and, as far as the ultimate appearance of the resulting scar is concerned, is far more important. Most scars go through a definite cycle as they mature. They usually look their worst between 2 weeks and 4 months after the injury. In scars lacking a true keloid or a keloidal tendency, there is a progressive decrease in vascularity and cellularity. The reddish appearance of a young scar is due to the vascularity showing through the epidermis. As the scar matures, it becomes pale because the vascularity has decreased, not because of increased thickness of the epidermis. Ultimately, all scars become whiter than the normal skin because of the absence of pigment in fibrous tissue cells. The decrease in vascularity also softens the scar. Most of the maturing takes place within the first year, but improvement may continue for as long as 3 years. In a fair-skinned person, the easily recognizable fresh scar with its pinkish hue is more obvious at first than in dark-skinned individuals, and the appearance improves considerably with the passage of time.

In the author's experience, contrary to most teaching, 2 months after injury is the best time for scar revision in adults and older children. In children under 7 years of age, however, I prefer to wait at least 6 months before undertaking the surgical revision. Although postoperative management presents difficulties in younger children, one should attempt to improve a scar before the child becomes aware of the defect or before playmates begin to call derisive attention to it.

Many surgeons postpone treatment until a scar is more mature than it is at 2 months after injury. Nevertheless, since scars are at their worst after 2 weeks and before 4 months, revision done within this period will result in more obvious improvement and more satisfied patients. Revising scars more than 3 years old does result in some improvement, but it is never as obvious as when younger scars are revised. The scar remaining after revision of an old scar is hard and pink, like a fresh scar, and it is difficult to explain to the patient how it is an improvement over the original scar. Complete maturation takes about 3 years, and during this period the nonrevised scar spontaneously improves. But why wait so long for the unsatisfactory scar to spontaneously improve slightly if we know that, if it does not fall exactly over the RSTL, it will never be as satisfactory as it would have been had we performed a correctly indicated revision? Moreover, early revision with reorientation allows the scar to mature more rapidly.

Individual Factors

The tendency to form keloid or simple hypertrophic scars is an individual factor that bears on the decision to undertake scar revision.

The patient should be examined to detect the presence of other scars on the body, in order to determine whether there is a true keloidal tendency. However, the presence of well-healed scars in other areas may be misleading, since some areas are less susceptible than others to the formation of hypertrophic scars and keloids. Furthermore, a true keloidal tendency is not indicated by scars that have become hypertrophic simply because they lie in a position unfavorable to good scarring, ie, at right angles or obliquely to the RSTL. Many patients with hypertrophic scars are not true keloid formers, and their scars can be revised with relatively little risk of postoperative keloid development.

Disfigurement is not absolute but exists in the eye of the beholder and the mind of the sufferer. Patients' sex, profession, and attitudes should be taken into consideration in order to evaluate their understanding of what, by the surgeon's criteria, can be considered satisfactory, worthwhile improvement. By so doing we can communicate clearly with the patient and forestall any disappointment. We should emphasize that the scar can only be improved, not removed or erased.

Desirability of Scars

In some Latin American countries facial scars in a woman, whatever their actual origin, have the connotation of discovered adultery or actual prostitution. Among the black population in East Baltimore there is a similar tradition of marking the cheek with a knife when adultery or unfaithfulness is discovered. There patients show marked anxiety to rid themselves of the scars. Also in the port of Baltimore there are many seaman who have been similarly deformed in fights and often present complaining of a "birthmark". They further explain this as a "mark received from climbing into the wrong berth".

In contrast to these disfiguring scars, there are some that enhance beauty. An abdominal wall without an umbilical scar is very unaesthetic. Helen of Troy had a scar on her chin that Paris called "cosamoois", a whetstone of love. A scar received in some noteworthy encounter, as in a battle, was called *cicatrix lucenta,* "a glorious scar", by our ancestors. In like manner a scar in front, received in fighting an enemy, was called *cicatrix adversa*, whereas a scar behind, *cicatrix aversa*, was not so glorious. In Heidelberg, Germany, there used to be many students proud of their facial scars, received in duels. The Chinese regards the scars of smallpox as lucky, since they show that the person has been fortunate enough to survive.

Scars in an Unattractive Person

If an unattractive patient is not yet satisfied with the results of scar revision in spite of having done everything possible, the plastic surgeon should suggest some type of cosmetic surgery that will enhance her or his looks. The adjunctive operation for patients with facial scars may include rhinoplasty, blepharoplasty, chin implant, face lift, or a combination of these or other procedures. In this way we may distract the patient's critical awareness away from the scar deformity and direct it toward the aesthetic improvement obtained by the cosmetic surgery.

Previous Treatment

If previous scar revision has been done without success, the case should be studied carefully to determine whether the failure was unavoidable or attributable to the surgeon's choice of procedure. One should be extremely wary of performing a second scar revision unless one is very certain of being able to modify the factor responsible for the untoward result. If the patient has had dermabrasion or dermoplaning, the skin will have been thinned, and further use of this kind of treatment may be contraindicated. If x-ray therapy has been given, the patient should be examined for signs of radiodermatitis. Above all, extreme caution is required in prescribing further radiotherapy; also, radiotherapy in children may interfere with bone development.

Foreign Bodies Under Scars

Foreign bodies may or may not be well tolerated. If infection develops they may be expelled after drainage of the abscess, or may result in a fistula that will not heal until they are removed. If well tolerated, they may be felt through the skin and may cause pain or discomfort, in which case they should be removed. If they are small and cause no discomfort or deformity, they usually are best left alone, since their removal is not an easy task.

Aims in Scar Revision

After a scar is excised, the skin defect is closed, and the wound has healed, another scar will inevitably form. This postoperative scar may be cosmetically the same, better, or perhaps worse. *There are various factors that we should be able to change for the better if we expect the scar revision surgery to succeed.*

The main aims of scar revision are to improve the scar's direction, to divide it into smaller components, and to achieve a leveling effect. Other aims, which may be characterized as "fringe benefits", include improvement in the condition of the wound, halving in depth and in surface, camouflaging, and the creation of elasticity.

These aims are not always met when a scar is revised, nor are they attained to the same degree by the three scar revision procedures. One should choose the technique that will accomplish the greatest improvement and the best result in achieving the main aims.

Improving Direction of the Scar

The closer a scar follows the RSTL, the better is the cosmetic result achieved. Scar revision can improve a scar's direction, but this is accomplished to different degrees, depending on the direction of the scar and the procedure used.

The theoretical scar which follows the RSTL closely but not exactly, has been excised almost completely by including most of it within a fusiform segment of tissue, with its long axis following the RSTL perfectly in this transverse TL region. As can be seen, the improvement in the direction of the scar is minimal.

The almost vertical scar has been changed by multiple Z-plasties into scars that run either very well with the RSTL or obliquely but closer (by 30 degrees) to the RSTL than the original scar. This is the theoretical improvement obtained by the application of plane geometry (*center of diagram*). In practice (*right*) owing to the biochemical properties of the skin, the improvement is greater. The postoperative scars would be closer to the RSTL than that calculated geometrically, because the tissue added by the transposition of the flaps in the direction of the original scar creates a bunching up of triangular flaps, with narrowing of the angles.

When scars slanted 60 degrees or less from the RSTL are treated by multiple Z-plasties with limbs following the RSTL, the direction of each postoperative oblique scar (diagonal) is the same as that of the original scar. However, the relaxation in the direction of the scar (to be discussed subsequently) contributes to the improvement of the resulting cicatrix.

After a W-plasty has been performed on a vertical or almost vertical scar, each smaller component of the postoperative scar follows the RSTL much better than does the original scar, except that the distal ends follow the same direction as the original cicatrix.

Stair W-plasty is indicated on scars inclined from 60 to 35 degrees. Half the postoperative components follow the RSTL perfectly, while the other half may have the same inclination as the original scar but in the opposite direction, or may run at a worse angle to the RSTL but will be smaller in length. Since these latter segments are much smaller than the original scar and are not continuous, there is no bowstring effect, and thus the resultant scar is not so disfiguring as the original one.

Dividing the Scar Into Small Components

Division of a scar into smaller components relieves the original bowstring effect. The longer a straight scar, the more injurious its contraction will be, causing a bowstring tension effect that tends to produce depression of the scar. Three or more Z-plasties and a W-plasty can be used to divide scars into smaller segments. Single and double Z-plasties do not result in scars with smaller segments unless only part of the scar is included in the Z-plasties.

With only one Z-plasty whose diagonal runs the entire length of the scar, the postoperative segments are of the same size as the original scar. If only part of the scar is included in the Z-plasty, the postoperative segments are smaller than the original scar. The remaining distal segments of the original scar will have changed its direction somewhat, owing to the push exerted by the transposed flaps. When two Z-plasties are used, it will be found that in the postoperative zigzag there is a straight scar (two continuous limbs) of the same length as the original scar, but with the great advantage of following the RSTL perfectly. If three or more multiple Z-plasties are used, all postoperative segments will be smaller than the original scar.

Leveling Effect

All three revision procedures have a leveling effect to a certain degree. The FSR levels a depressed scar to a small degree by excising scars resulting from lacerations whose borders were not made perpendicularly to the skin surface. Moreover, when revising a scar, suturing the perpendicular excised, nontraumatized skin edges over an already healed deep structure provides a better outcome than that obtained by suturing a laceration.

The leveling effect is better achieved with W-plasty. According to Ju, V-shaped scars produce a combination of transmitted contraction triangles at the intersecting end, and the direction of the resultant contraction is not along either segment of the V, but in between, from the tip of the V toward the base. Since a zigzag scar is composed of multiple, continuous, V-shaped scars, the direction of its contracting force would result from the summation of small contracting forces in V flaps running at right angles to the general direction of the whole scar. This would tend to give a leveling effect. The bowstring contraction of the whole scar is replaced by a shearing stress.

Z-plasties achieve an excellent leveling effect. Tissue is added from neighboring areas between the two ends of the original scar by the transposition of the flaps. Moreover, as in W-plasty, the contraction of the V flaps is at right angles to the direction of the scar. The leveling effect of Z-plasty is much greater than that of W-plasty because no tissue is discarded and because of the transposition of the flaps, which adds length by taking from adjacent skin.

Halving

Halving in Depth. Halving is a carpentry term used when two pieces of wood are joined by cutting from each, at the place of joining, a portion fitting that left solid in the other. The postoperative scars of the three revision techniques achieve halving in depth to a minimal degree in the FSR, but to a much greater degree in W-plasty and even more in Z-plasty.

Halving in Surface. Zigzag scars such as those seen in ZSR and W-plasty have greater cohesiveness than straight scars. Having greater length than a straight scar and yet covering the same distance, they have greater tissue contact. This cohesiveness is one of the reasons why they do not tend to widen as much as straight scars.

Improvement In Local Conditions

In FSR and in W-plasty, unsatisfactory scars are excised in the beginning. Also in Z-plasty, the scar is sometimes excised first. These scar excisions change bevel-edged scars into wounds with perpendicular skin edges. Moreover, at the time of revision, the deep tissues have already healed, thus aiding the closure of the elective wound. The skin edges of the wound resulting from the revision have not been traumatized, as is the case in lacerations. Finally, there is less probability of hematoma or infection in the closure of a revised scar wound than in the laceration. All these improvements in the local conditions in the wound work toward better healing.

These improvements of local conditions are more obvious in FSR than in the ZSR or W-plasty. In the latter two techniques, the creation and suturing of triangular flaps cause technical difficulties that cancel out the local improvement obtained by scar revision.

Camouflaging Effect

In a straight scar there is a sharp demarcation between normal and scarred skin, so that the scar is obvious. In zigzag scar revisions, there is an intermingling of small scars with normal unscarred tissue, which helps to camouflage the scar.

Accordion-like Elasticity

On the face, inelastic, contracted ATL straight scars tend to be more noticeable in repose and even more obvious when the facial musculature is active, as in speaking, laughing, crying, and squinting. Such ATL scar contracture and disfigurement can be corrected by the ZSR and W-plasty, since the postoperative zigzag pattern provides accordion-like elasticity.

Scar Revision Techniques

Fusiform Scar Revision

This is the simplest revision technique. It consists of excising the scar and closing the skin defect thus created. It was in use exclusively for many years before the advent of the zigzag revision procedures (ZSR and W-plasty). Unfortunately, the fusiform technique is still the only one being used today by some plastic surgeons who have not been trained in the zigzag techniques and are afraid of using them.

On the face the FSR has been relegate to the revision of unsatisfactory tension line scars or segments of scars that follow the RSTL or run very close to them. These unsatisfactory TL scars are most frequently the outcome of bevel-edged wounds or healing by secondary intention due to infection or hematoma formation.

The fusiform excision for small scars should be made up of two concave curved incisions of the same length and curvature facing each other, whether in a straight or a curved RSTL region. In order to obtain this design in a curved RSTL region, the long axis of the fusiform excision should lie over a tangential straight line to the RSTL that runs through the center of the scar.

For long scars the excision consists of two parallel incisions that are brought together at the ends.

Meticulous surgical technique should be used in excising the scar and in its subsequent closure. As already stated, wide tension line scars due to tissue loss by surgical excision, traumatic avulsion, slough, or burns will probably not be improved by the FSR.

Scar Revision by Z-Plasty

The ZSR is the application of the classical Z-plasty procedure, single or multiple, to the improvement of antitension line scars. The single Z-plastic revision consists of a Z-shaped incision with its diagonal falling on the scar and the limbs following the RSTL on ATL scars with inclination of 60 degrees or less. When the angle of obliquity of the scar is greater than 60 degrees, the limbs of the Z should angle only 60 degrees from the diagonal, on the side that more closely follows the RSTL. In long scars, multiple Z-plasties are made with the limbs also following, up to 60 degrees, the direction of the RSTL. These incisions delineate juxtaposed triangular flaps, which are then raised and transposed into the skin defect created by the transposition of the adjacent flap. All three segments are of the same size and their limbs are parallel.

On the face, in most Z-plasties, the segments should measure approximately 1.5 cm.

The scar tissue itself is *not* excised in most patients undergoing ZSR. Such excision would thin out the triangular flaps of the Z-plasties, making suturing more difficult, affording less accordion-like elasticity to the postoperative zigzag scar, and placing each segment too close to each other. Moreover, postoperatively the scar segments not excised will spontaneously improve. Later, if these segments remain unsatisfactory, they can be improved by FSR. If the scar is very wide, nothing should be excised, because wide scars connote excessive skin tension, and their excision would increase further the skin tension of the region. Nonetheless, in some patients in whom the scar is very depressed or in whom there will not be too much skin tension after transposition of the flaps, the excision of a thin sliver of scar tissue is permissible.

W-Plasty

W-plasty is the scar revision technique first presented in 1958 in which pinking shears type of incisions are made on each side of an ATL scar, and the tissue thus circumscribed is excised; the skin defect is closed in a straight advancement fashion. This was done to improve the direction of ATL scars and divide them into smaller segments, as in the ZSR, but without the disadvantage of creating postoperative bulgings and depressions.

There are two types of W-plasties: the classic and the stair W-plasty. The first is indicated for ATL scars inclined 90 to 60 degrees of diversion from the RSTL, and the latter for oblique scars of 60 to 35 degrees. W-plasty revision on vertical or almost vertical scars is shown. The base of the last triangles should be at right angles to the scar. The tip of corresponding angles should also be in a line at right angles to the scar. The angles should be approximately 55 to 60 degrees. The length of segments on the body of the W-plasty varies between 5 and 7 mm, depending on the size and location of the scar. A W-plasty with larger segments excises too much unscarred adjacent skin, thus increasing markedly the skin tension on closure, and results in too long postoperative zigzag scars, which are more visible than smaller segments. When the segments are 6 or 7 mm in length, they should be made shorter toward the ends of the W-plasty to prevent the formation of dog ears or the production of a long ATL postoperative scar at that level.

In the stair W-plasty, half of the segments follow exactly the RSTL and the other half run from 60 to 90 degrees, depending on the inclination of the scar.

Ten years after the advent of the W-plasty a modification of this zigzag technique was presented, called "geometric broken-line closure". It actually consists of a broken-line excision of a scar and subsequent closure of the very irregular skin defect. This technique may give an unfavorable result because (1) it is very difficult to design, execute, and suture the broken line defect; (2) those segments that have very small triangular flaps will give rise to a straight, slightly irregular scar after contraction that may become depressed; (3) the straight segments that run at right angles to the RSTL will be unsightly; (4) if the broken-line excision is performed without taking into consideration the whereabouts of the RSTL, an unsatisfactory result will ensue; and (5) square-shaped flaps have a grater tendency to create a trapdoor deformity than the triangular flaps of the W-plasty. The proponent of the geometric broken-line closure prefers this

technique to the W-plasty because it is theorized that the randomly patterned rectangular, square, and triangular flaps produce a less conspicuous scar than that resulting from a series of similar triangular flaps. This is a valid theoretical objection to the W-plasty, but in practice it does not hold its ground. The random pattern has the disadvantage that it can produce random results, for the reasons stated. Nevertheless, the broken-line excision offers improvement in many cases, and a result decidedly better than that from a straight fusiform excision if done on ATL scars.

Indications

Fusiform scar revision is indicated for unsatisfactory scars that follow or run very close to the RSTL.

The *Z-plastic scar revision* is indicated for (1) ATL scars on eyelids, nasolabial folds, and nonfacial regions; (2) ATL scars on the forehead, temples, cheeks, nose, and chin that run at any angle of less than 35 degrees to the RSTL; (3) very depressed ATL scars anywhere and of any length; (4) ATL small scars; and (5) areas with multiple scarring.

W-plasty is indicated for long ATL scars running at an angle over 35 degrees from the RSTL that are not too depressed when situated on the forehead, temples, cheeks, nose, and chin.