CURRENT OPERATIVE SURGERY

Plastic and Reconstructive Surgery

Edited by
Ian F. K. Muir, MBE, MS, FRCS

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Preface

The operations described in this volume are all of current interest and are representative of the different ways in which reconstructive surgery has developed over the last 15 years.

The most striking advances have been due to the introduction of micro-surgical techniques and this is illustrated by the use of transfers of free flaps in head and neck reconstruction. The majority of these flaps are of skin, but bone is sometimes also transferred and remarkable results have also been achieved by the use of segments of bowel. The development of musculo-cutaneous flaps is based on careful anatomical investigations of patterns of blood supply, and these flaps have greatly improved the results of both reconstruction in the head and neck and reconstruction of the breast after mastectomy.

Detailed anatomical investigation has also influenced the technique of the facelift operation: the dissection of the superficial muscular aponeurotic system is now becoming a standard technique in the facelift.

The number of operations for the correction of hypospadias is very large and the correction of these conditions demands a high order of technique. However, embryological investigations have led to a greater understanding of the details of deformity and this in its turn has greatly contributed to the planning and selection of techniques.

In congenital deformities of the face two quite different factors have influenced developments. In the common cleft lip and palate deformities long-term follow-up studies have highlighted the deformities which can be caused by operations on growing tissues and although there have been no major alterations in techniques the vital importance of causing as little damage as possible in the primary operations has been strongly emphasized. In more major facial deformities the widespread exposure obtained by modern craniofacial techniques has opened up new avenues; one of the conditions which has benefited from these techniques is Treacher Collins syndrome. Not all cases of this syndrome require major craniofacial operations, but the operations themselves have led to a much greater knowledge of detailed anatomy and this has put the less extensive operations on a much sounder basis.

Repair of flexor tendons in the hand remains a difficult problem, but increased knowledge of biology and the mechanics of tendon healing has raised hopes of achieving much improved results.

Ian F. K. Muir

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Primary Flexor Tendon Repair in the Hand

P. J. F. Wade

INTRODUCTION

Traumatic division of flexor tendons in the hand is a common problem in orthopaedic and plastic surgery and the results of treatment are often disappointing. Injuries of this type frequently produce unsightly hands with poor function and may cause disproportionate economic loss. The patient is typically a young adult and the injury is often due to the careless use of knives or occurs at work, particularly in industrial areas where safety precautions are lax (Figure 1.1).

The ideal management is immediate repair of the tendons, followed by an early return to work. This ideal is rarely achieved and results are poorer when the flexor tendons are divided in the fibro-osseous tunnel over the proximal phalanx.

Recent advances in microvascular surgery have enabled the replantation of amputated fingers. Unfortunately these often develop stiffness postoperatively and the tendon repair is also liable to fail. However skilfully a finger is reconstructed, it is useless if the tendon does not function.

Despite gradual improvement over the last 50

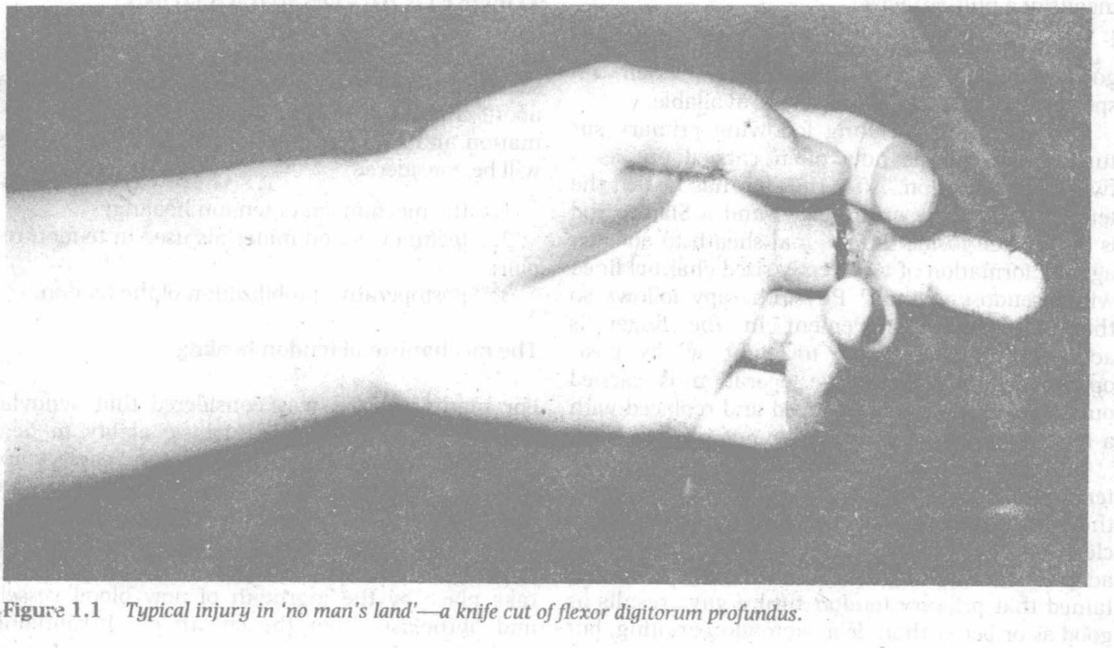

Figure 1.1 *Typical injury in 'no man's land'—a knife cut of flexor digitorum profundus.*

years it remains difficult for the inexperienced surgeon to achieve good results with primary flexor tendon repair in the hand.

BACKGROUND

Primary suture of flexor tendons has always been difficult. When Bunnell coined the phrase 'no man's land' it was because the results of primary suture in the flexor tunnel between the first annular pulley and the insertion of flexor digitorum superficialis were very poor. Indeed, suture in this area nearly always ended in failure, either because of adherence of the tendon within its sheath or because of separation of the sutured tendon.

As a result of his experience, Bunnell[1,2] in 1944 recommended treatment for tendon division as follows:

1. When both tendons had been cut in 'no man's land', skin only should be closed initially; at about 3 weeks, when primary healing had taken place, the two tendons should be excised and profundus alone replaced by a tendon graft.
2. If profundus alone had been severed, superficialis should never be sacrificed. A tenodesis of the distal end of the profundus or a distal interphalangeal joint arthrodesis should be performed.
3. If profundus had been cut near its insertion, the proximal cut end of the tendon should be advanced, reinserted into the bone and secured by means of a pull-out wire.

This suggested management is still regarded as good clinical practice, particularly when no specialized hand surgery service is available.

Delayed tendon grafting following primary suture of the skin is now often carried out as a two-stage operation. After the skin has healed the tendon or tendons are resected and a Silastic rod is introduced inside the original sheath to encourage the formation of a correctly sized channel lined with pseudosynovium.[3] Physiotherapy follows so that full passive movement in the finger is achieved and then, six to eight weeks postoperatively, a second-stage operation is carried out. The Silastic rod is removed and replaced with a tendon autograft; palmaris longus is often used.

In 1952 Verdan[4,5] revived the idea of primary tendon suture in 'no man's land' and suggested that this was a feasible proposition, especially in clean-cut 'tidy' hand injuries. Kleinert and others adopted a similar approach. These surgeons maintained that primary tendon suture gave results as good as or better than delayed tendon grafting, but with the advantages of a one-stage operation and of the patient returning to work within weeks rather than months.

Two major problems remain. The first is that even in the best centres, when both tendons in 'no man's land' have been divided only about 70% of primary tendon repairs achieve good results, and the results in less specialized centres are much poorer. In 1967 Kleinert[6] compared the results of his own private service with those of a teaching service. In the private service 87% of patients obtained good results, whereas in the teaching service 76% of patients had poor results. The second problem is that if primary suture fails, the patient is in a worse predicament than if Bunnell's more conservative grafting regimen had been undertaken.

In 1973 postoperative management was improved when Kleinert[7] introduced the principle of dynamic splinting. At the same time he refined the techniques for suturing the tendon and advised closure of the flexor sheath. He advocated the use of a Bunnell or Kessler-type core stitch, together with a circumferential running stitch.

More recently attention has been focused on improving techniques with better materials and instruments, increased use of the operating microscope and in different methods of postoperative mobilization, both active and passive.

THEORETICAL CONSIDERATIONS

In addition to clinical studies, a number of research projects have yielded valuable information about aspects of healing of tendons, and the formation and avoidance of adhesions. Three aspects will be considered:

1. the mechanism of tendon healing;
2. techniques and materials used in tendon repair;
3. postoperative mobilization of the tendon.

The mechanism of tendon healing

For many years it was considered that synovial covered tendons had no intrinsic ability to heal themselves. It was thought that the sparse tenocytes were unable to multiply and furthermore that the internal vasculature of the tendons was insignificant and incapable of supporting a healing reaction. It was thought that healing could only take place by the ingrowth of new blood vessels and fibroblasts from the sheath or surrounding tissues[8] and indeed the sheath was often deliberately sacrificed to allow this to take place more easily. Because the intrinsic blood supply was considered to be unimportant, vinculae were often sacrificed in the interests of mobilization of the tendon and easier placing of sutures.

More recent investigations, however, have changed this view. It is now thought that intrinsic healing is not only possible but highly desirable and that all efforts should be made to protect any undamaged vinculae, thus preserving the intrinsic blood supply. It has also been shown that the blood supply is not the only source of nutrition for tendon healing: the synovial fluid is also an important source. Matthews and Richards[9] emphasized the importance of the integrity of the tendon sheath in preventing adhesions. Lundborg,[10] in an experimental rabbit model, showed that it was possible for a sutured tendon to heal in the synovial fluid of a rabbit's knee in the absence of any blood supply to the tendon. Hooper[11] suggested that the synovial fluid contributes more of the flexor tendon nutrition than the blood supply. For optimal healing therefore it follows that not only should the blood supply be safeguarded but the tendon sheath should be repaired so as to assist nutrition of the tendon from the synovial fluid.

Techniques and materials used in tendon repair

The requirements of a tendon suture technique are these:

1. It should have sufficient strength to hold a tendon together, prevent a gap developing between the tendon ends and allow a limited amount of movement of the tendon within the sheath.
2. It should allow the raw tendon ends to be inverted, so as to create a smooth outer tendon surface to glide against the sheath.
3. It should provoke minimal fibrotic reaction and should not interfere with the blood supply or the synovial nutrition of the injured tendon.

A great number of different techniques for suturing tendons have been described. Some, although excellent in other situations, are too bulky for use in the digital canal. Unfortunately the less bulky and therefore more suitable techniques also tend to be weaker and this makes repair and postoperative management more difficult.

For many years the criss-cross suture of Bunnell (Figure 1.2) was widely used. More recently, however,[12] this stitch has been criticized for constricting the blood supply of the tendon. A series of sutures, the so-called 'core' sutures, have taken its place. These sutures work on the principle of embracing a small bundle of fibres in the core of the tendon substance, avoiding the main longitudinal vessels which run near the dorsal surface of the tendon. In actual fact, the most commonly used suture, that described by Kessler[13]—though now somewhat modified—takes a grip of two small bundles on the surface of the tendon anterolaterally but is still spoken of as a core suture (Figure 1.3).

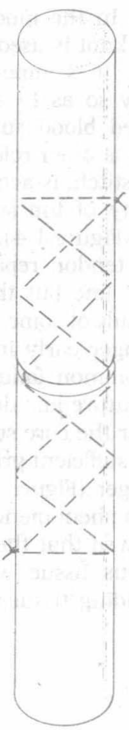

Figure 1.2 *Bunnell's 'criss-cross' tendon suture.*

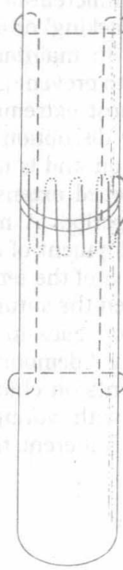

Figure 1.3 *Modified Kessler grasping suture.*

Urbaniak et al[14] studied the strengths of the various suture materials and techniques of tendon repair in dogs. They showed that the suture commonly in use at present (a modified Kessler) is a good compromise between strength, ease of insertion and lack of irritation between the tendon and its sheath.

Recent work on the modified Kessler suture has shown that with the use of a stainless steel core suture and a polypropylene circumferential stitch strengths of up to 4.5 kg can be obtained at tendon suture sites, but that the average strength obtained is only 2–3 kg before gap formation begins. In Kessler's original description of his suture[13] he placed four knots in the wire of the core stitch and did not use a circumferential suture. In the modified suture used by Kleinert, only one knot is used and that is between the tendon ends. It is important that the stitch is placed ventrally so as to avoid constriction of the dorsally placed blood supply. The circumferential stitch, which is often referred to as a 'tacking' or a 'tucking-in' stitch, is actually essential to maintain the integrity of the suture line and to prevent gap formation (Figure 1.4).

The most extreme failure of a tendon repair is complete disruption of the suture line but this is uncommon and is usually the result of some accidental forced extension of the finger early in the healing period. A much more common failure is the development of a gap at the suture line due to distraction of the tendon ends over the core suture even when the suture still retains sufficient grip on the tendon ends to move the finger (Figure 1.5).

Lindsay[15] demonstrated the gap phenomenon in experiments on chickens. He showed that the gap is filled with young active fibrous tissue which becomes adherent to the surrounding tissues and prevents tendon movement. Ejeskar[16] and Seradge[17] showed that a gap occurs in repaired tendons in man. In independent clinical series they measured the gap formation at the suture line by placing metal markers in both the proximal and distal ends of the tendon and x-raying them at operation and at intervals afterwards. They demonstrated that an increased gap at the suture site was associated with restricted finger movement. This often necessitated a subsequent tenolysis.

Postoperative tendon mobilization

It has long been thought that early movement of a repaired tendon is desirable in order to avoid adhesions, or if adhesions form, to ensure that the adhesions are stretched so that they do not limit movement. However, attempts at early movement often fail because within a few days, as healing progresses, a gap develops between the tendon ends with increased adhesion formation or actual dehiscence. Mason and Allen (1941) suggested

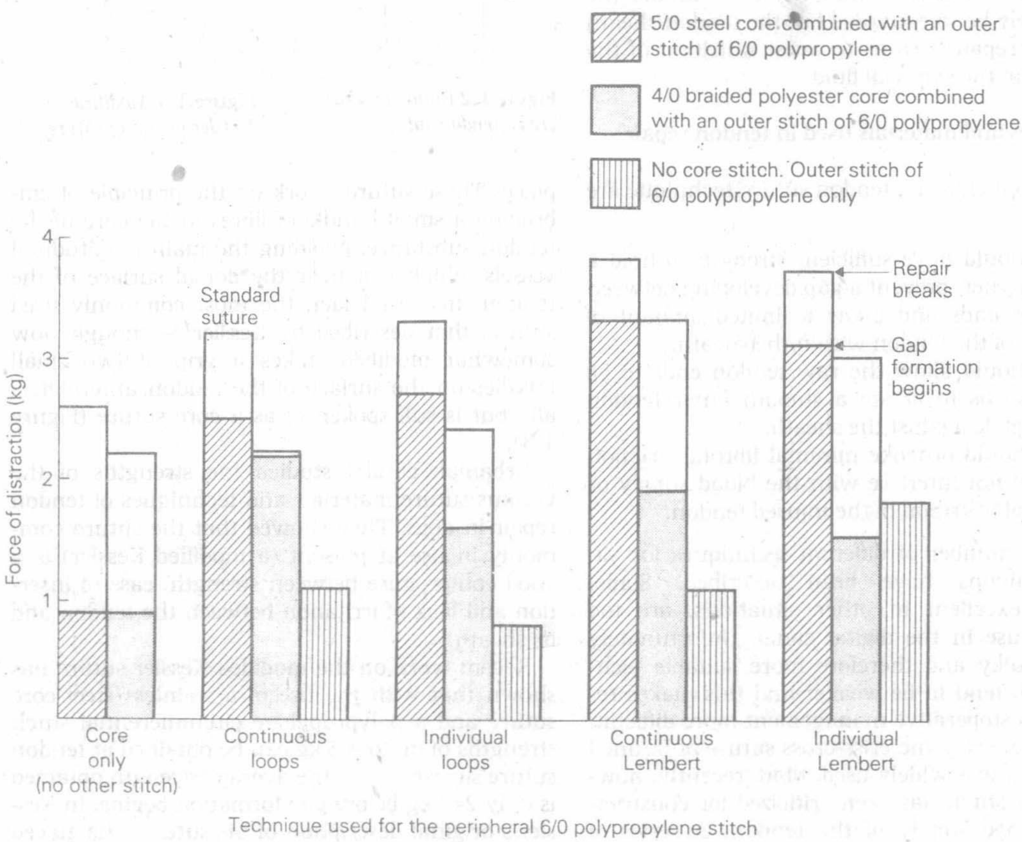

Figure 1.4 *Comparison of different techniques and materials within the 'modified Kessler' format.*

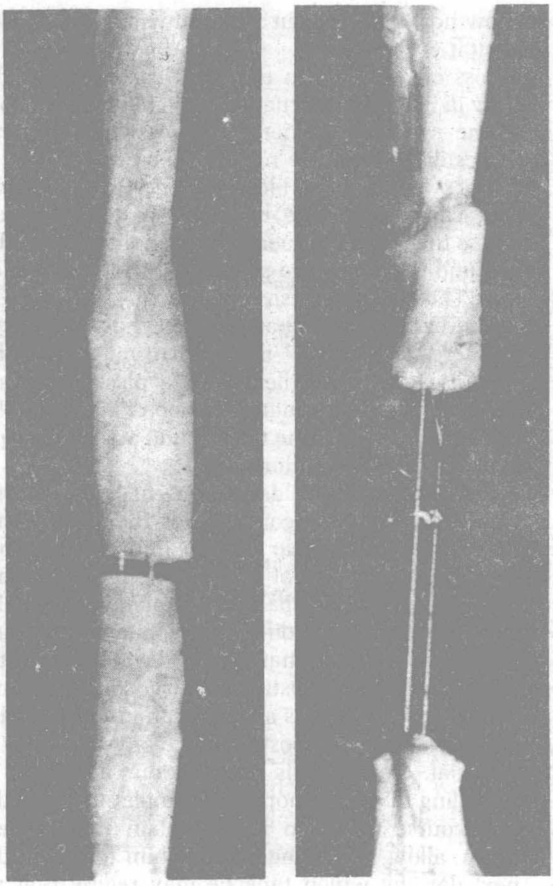

Figure 1.5 *Experimental testing of a Kessler suture without the peripheral stitch: gap formation begins at a tension of 0.9 kg and separation reaches 20 mm before the core stitch breaks at 3.5 kg.*

that this is due to softening of the tendon and subsequent cutting out of the stitches.[18]

The introduction by Kleinert of controlled passive movement of the sutured tendon has improved results. Kleinert's method[7] protects the repair whilst still allowing movement of the digit. The theory underlying this form of controlled movement is that active extension of a finger causes a reflex inhibition of flexor muscle contraction. An elastic band is used to replace the function of active flexion. In other words, extension is possible against the resistance of the elastic band, but when flexion is attempted the elastic band forestalls this by flexing the finger passively. Postoperatively, splintage is maintained for four weeks, after which active exercises are begun. Passive stretching is not allowed until six weeks have elapsed.

The Kleinert regimen, both for the repair of the tendon itself and for postoperative movement, has become a widely accepted method of treatment. There are reservations about the use of the Kleinert technique. There is no doubt that poorly motivated patients do not benefit as much as those who understand what is expected of them and who actually exercise the repaired finger at home. Careful supervision by a physiotherapist during the postoperative period is essential. Should the patient fail to use his hand, flexion deformity, especially of the proximal interphalangeal joint, is common, as well as tendon adherence to the sheath. Partly because of this, some surgeons have tried to institute active postoperative movement and many tendon suture techniques were originally designed to allow active movement.[13,19–21]

PATIENT SELECTION

There are a small number of patients who will not benefit from primary tendon repair or even tendon graft at a later stage. It is unlikely that a patient who is old, infirm or who has pre-existing hand disease will benefit from single digit tendon repair. Patient cooperation is essential for postoperative management and some individuals find this difficult. For example, a chronic alcoholic whose only interest is his ability to hold a glass would be unlikely to follow a postoperative regimen and would not be interested in the functional improvement of one cut finger.

CHOICE OF PROCEDURE

If the injury is clean-cut with healthy tissues the procedure of choice is primary repair of all damaged soft tissue including tendons, nerves and blood vessels. Primary repair need not be carried out in the middle of the night unless the circulation of the finger is compromised. Operation should be performed as soon as practical and preferably within eight hours. Delayed primary suture is practised in some centres and can be delayed as much as four weeks without seriously compromising results.[16]

Isolated division of a profundus tendon may cause relatively little disability and in patients with few demands on hand function a simple tenodesis or arthrodesis of the distal interphalangeal joint will often suffice. Indeed, this may give a functionally better result than a partially successful primary suture. There are, however, objections to this course of action because a fully retracted cut profundus tendon may interfere with lumbrical function in the palm, leading to an 'intrinsic plus' finger.

An intact superficialis should never be sacrificed to permit operation on a divided profundus tendon.

Severe crush injuries may be a contraindication to primary tendon suture. In most cases, however, the tendons are best sutured at the primary operation when the other injured tissues are being repaired. It is difficult to find cut tendon ends at a later exploration and at least suture of the tendons will have preserved the alignment of the tendon sheath, making tendon grafting easier in the future. The results of primary tendon suture in damaged tissue are far less satisfactory than when there is a clean-cut single tendon. However, there is little to lose in this situation and suture of the tendons need not preclude tendon reconstruction by grafting or transfer at a later date.

Finally, the option of merely closing the skin, mobilizing the joints postoperatively and grafting later, as recommended by Bunnell, should not be disregarded. This method of managing tendon injuries is still practised and is particularly useful where skilled hand surgeons are not available to perform primary suture. Unskilled attempts at primary repair do more harm than good.

PREOPERATIVE ASSESSMENT

Assessment of the hand should include a full examination of tendon movement, circulation and sensation. This takes but a few minutes. A competent examination of the hand may still leave some doubt about which structures are damaged, but careful notes and a good diagram will provide a record of the initial assessment and it is when the patient is first seen that the best chance of a correct diagnosis exists. In this respect a printed form for the history and examination is most helpful.

Particular attention should be paid to the patient's description of any loss of movement or of sensation. It is common experience that tendon divisions are missed even when the patient knows that something has gone wrong. Some tendons may be intact at the first examination and rupture during the next few hours. Usually, however, if a tendon is found to be ruptured at exploration and it was not noticed in the first examination, then the examination was incomplete.

Children are difficult to assess, but their parents are quite frequently aware that the child is using his hand in a different way and they will probably know how deep the cut was and with what implement it was made.

Loss of sensation in the hand can present difficulty in diagnosis, particularly in children. The loss of the sympathetic nerve supply which accompanies division of the nerve can be detected by a loss of sweating which leads to a dry, slippery skin. This can be checked by running a plastic pen across the skin and feeling the friction between the pen and the skin—the so-called 'tactile adherence test'. This simple test is very effective.

The first-aid care that a patient has received is of interest. Richards[22] has pointed out that if the wrist is kept in full flexion in a plaster of Paris backslab after a traumatic division of a tendon, the risk of retraction of the tendon and associated rupture of vinculae is minimized.

Patients often consider that a cut hand is a trivial injury and it is common for them to be irritated or amazed to hear that the injury needs more than minor suturing of the tendon and skin. Some time must therefore be spent explaining that the operation is a long one, that a microscope may have to be used and that the hand will be in plaster with an unusual elastic-band traction apparatus for at least four weeks after operation. It must also be emphasized that postoperative physiotherapy is essential. If after this explanation, a patient is unwilling to accept more than simple suturing, the best course of action is to explain the problem again, allow him home and ask him to attend the next day, by which time he may realize that an operation is necessary. It will be appreciated that many patients with hand injuries are intoxicated at the time of injury and, if this is the case, it is likely that they will make a more rational decision at the second visit.

OPERATION—GENERAL

1. Tourniquet
2. Anaesthesia
3. Magnification
4. Other considerations

Not only is the operation important but the splintage and postoperative care of hand injuries is in itself a sophisticated discipline and is best dealt with primarily by a team who are experienced in this type of work.

If there is any doubt that a tendon or a nerve has been divided or that the blood supply is damaged then the wound must be explored. This operation must be done in a well-equipped operating theatre with good lighting and not in the casualty department. The hand should be explored under adequate anaesthesia, using a tourniquet.

Prior to formal exploration, the hand must be thoroughly cleaned and the nails scrubbed. Many patients are quite happy to wash their own hands and sit by the sink scrubbing their nails. This may save a considerable amount of operating time but if it is likely to cause distress, the cleaning can easily be carried out in the theatre after anaesthesia.

Tourniquet

Exploration of wounds of the hand should be done under tourniquet. It is difficult, if not impossible, to identify damaged structures, particularly nerves, in the presence of free bleeding. Once these structures have been identified haemostasis can be achieved and if desired the tourniquet can be released without increasing the difficulties of operation. This is particularly useful if the operation is likely to take several hours.

Anaesthesia

Anaesthesia may be by: (1) regional nerve block; (2) intravenous local anaesthesia; (3) general anaesthesia.

1. Regional block anaesthesia is ideal for hand injuries. Although a median or ulnar nerve block is simple and some patients can tolerate tourniquets for 20 minutes or more, it is not adequate for flexor tendon suture and an axillary or supraclavicular block is the anaesthetic of choice. This enables the use of a tourniquet together with full exsanguination of the limb.

If a long-acting anaesthetic agent such as Marcaine is used, not only are three or four hours of good anaesthesia obtained but postoperative analgesia up to about 12 hours is common.

The only disadvantage of regional nerve block is that even in experienced hands, adequate anaesthesia is sometimes not achieved and in this case general anaesthesia will be necessary.

2. Intravenous local anaesthesia (Bier's block) is satisfactory for procedures which can be completed with certainty within 45 minutes. Its advantage is that once the local anaesthetic has been injected anaesthesia is certain and profound.

Recently there has been anxiety regarding cardiac and cerebral side-effects from circulating lignocaine or Marcaine after removal or failure of the tourniquet. These drugs should not be used for intravenous anaesthesia. Prilocaine (Citanest) causes no adverse effects and is the drug of choice for Bier's block.

3. General anaesthesia is advisable for children and for adults who find operation under local anaesthesia distressing.

Magnification

Magnification is an advantage. The choice of instrument is a question of individual preference, but 2.5 × binocular loupes would seem to be the minimum requirement. Many surgeons prefer the better illumination and higher magnification that can be obtained with an operating microscope. Magnification facilitates accurate identification of divided structures, particularly nerves. It also permits easier suturing of the finer parts of the epitenon, the tendon sheath and divided nerves or arteries. It is possible to insert the Kessler core stitch without magnification, but the circumferential running stitch in the epitenon is more accurately placed with magnification and suture of the sheath is very difficult to do at all without it.

Other considerations

Fine hand instruments, microsurgical instruments and the correct suture materials should be available at operation. 5/0 stainless steel or 4/0 braided polyester are required for the core stitch and 6/0 polypropylene or nylon for the epitenon. 7/0 or 8/0 nylon can be used for the tendon sheath. 9/0 or 10/0 nylon are necessary for nerve or arterial suture.

The components of the Kleinert elastic band traction apparatus should also be available so that it can be applied at the end of the operation.

OPERATION—TECHNICAL DETAILS

1. Skin
2. Subcutaneous
3. Tendon
4. Sheath

Considerable care is required in the handling of tissues in primary tendon repair. Rough treatment of tendon ends and sheaths leads to an increase in fibroblast reaction and the formation of adhesions. Poor handling of the skin flaps may cause flap necrosis and increases the risk of infection.

The technique for the repair of flexor tendons in zones 1–5 is essentially the same in each zone, although there are some variations. Detailed steps for the repair in zone 2 will be described because this is technically the most demanding area. Variations from this procedure are described later (Figure 1.6).

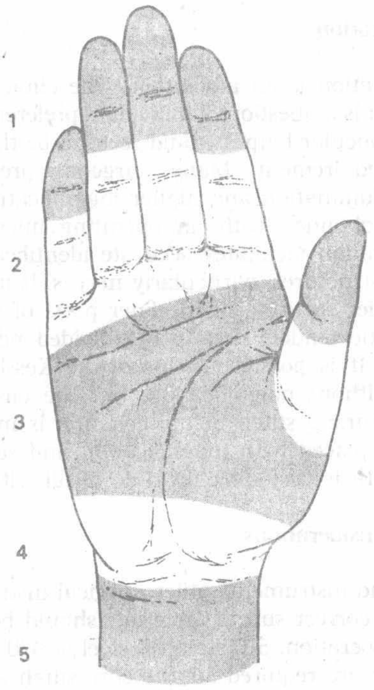

Figure 1.6 *Flexor tendon zones in the hand.*

Skin

Skin incisions are to some extent dictated by the original wound and by local contusion (Figure 1.7). It is not essential to follow rigid criteria for fashioning skin flaps, but there are general guidelines.

1. As in all surgical operations, exposure must be adequate.
2. Under no circumstances should an incision cross a flexion crease at a right angle.
3. No flap should be fashioned with an inadequate base or a distally based blood supply because of the risk of flap necrosis.
4. A flap must have sufficient subcutaneous tissue to ensure nutrition of the skin.
5. Handling of skin edges should be kept to a minimum; retraction must be gentle and preferably with skin hooks. Suture should be with fine sutures and without tension.

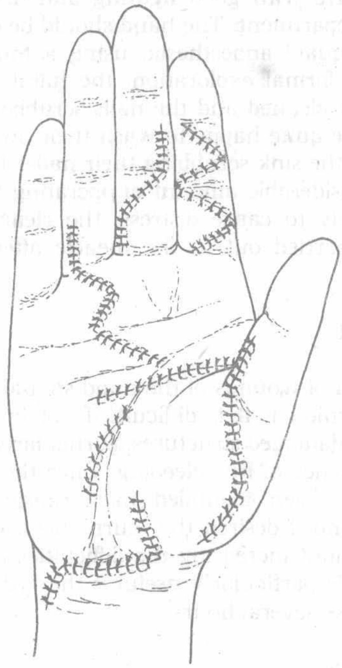

Figure 1.7 *Examples of conventional incisions, or extensions of lacerations in the hand.*

If the skin cannot be closed, an attempt should be made to cover the repaired tendon with a full thickness skin flap. This is best done by rotation from the same finger and the donor area covered with split skin graft. If skin loss is so extensive that a flap from a distance is necessary, for example a cross-finger flap, then it may be that primary tendon suture is not appropriate treatment and skin cover should be obtained prior to secondary tendon repair or grafting.

When flexor tendons are divided the original cut is often transverse or very nearly so and it is almost always possible to incorporate the cut into the incision. This can be done by means of the midlateral or Bruner incisions or a combination of both (Figure 1.8). Retraction of the flaps to ensure easy access to the cut tendon is often best achieved by temporary tacking sutures, thus releasing the assistant to help with the anastomosis itself.

Subcutaneous

The incision is carried directly down through the subcutaneous tissue and the neurovascular bundle

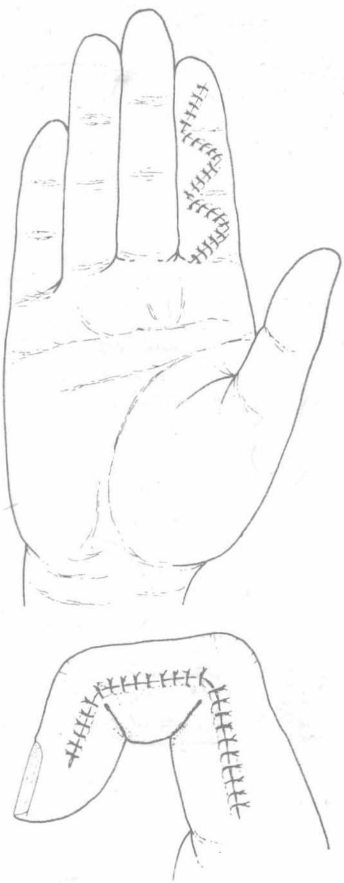

Figure 1.8 *Bruner and midlateral incisions in the hand.*

identified as soon as possible (Figure 1.9). Identification of the nerves near a divided tendon is sometimes difficult and it may be necessary to dissect proximally to identify the main nerve in normal tissue and follow it distally in its course. If indicated, microvascular repair of vessels and nerves is performed at this stage. Magnification is useful for distinguishing nerves from vessels and essential for their suture. Suture using 9/0 or 10/0 suture material is a relatively straightforward procedure using a microscope.

If there is loss of nerve tissue and direct suture would lead to tension, immediate nerve grafting is advisable.

Tendon

After exposure of the sheath, the cut tendon should be identified. The tendon ends may be some distance from the cut in the sheath, depending on how flexed the finger was when it was cut. The more flexed the hand, the more the distal tendon ends will have retracted. If a tendon is cut in extension, the distal end may be found close to the cut in the sheath and will probably have its blood supply intact, whereas the proximal end will have retracted.

One pitfall occasionally met with is dislocation of a retracted profundus tendon out of the decussation of superficialis. It is essential that the correct anatomical relationship of these tendons is re-

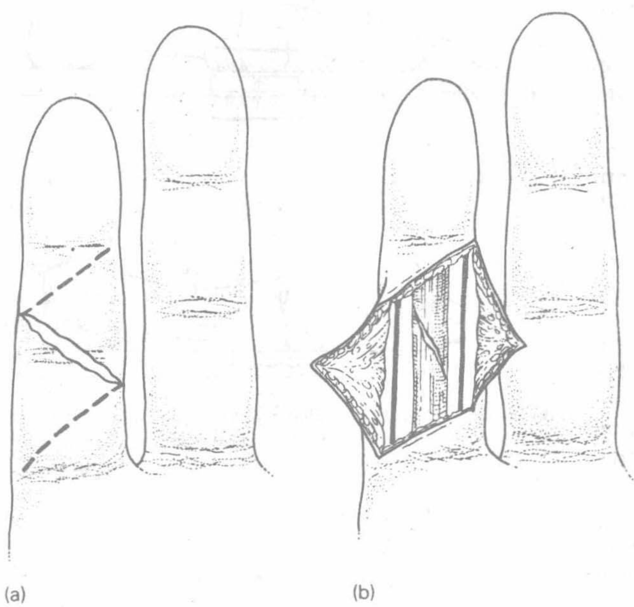

Figure 1.9 **a,** *Extension of an existing incision.* **b,** *Retraction of flaps and exposure of the neurovascular bundle and the tendon sheath.*

stored before suture. This may mean exploration proximally in the palm.

The original cut in the sheath may need extension to gain access to the tendon. The fibrous flexor pulleys (Figure 1.10) must not be disturbed, but

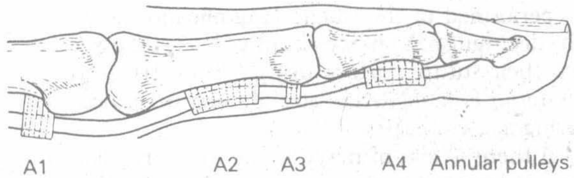

Figure 1.10 *Flexor tendon sheath pulley system.*

the loose cruciate part of the sheath between the pulleys can either be incised, or have a small flap created in it. Lister[23] described a practical way of dealing with difficult access to tendons, particularly when the cut lies directly below one of the annular pulleys. He suggested that windows should be cut in the tendon sheath either side of the pulley. The core stitch should be inserted into the tendon through whichever window is easiest, and then passed under the intact annular pulley and inserted into the other end of the tendon. The tendon ends are then approximated and the circumferential running stitch, which requires less exposure, inserted (Figure 1.11).

The tendon core suture is carried out using a strong material of low stretch. 5/0 stainless steel or 4/0 braided polyester is preferred. The circumferential suture should be of finer material, such as polypropylene 6/0. This is inert and slippery, to allow even distribution of tension across the suture line, and stretchy to allow for swelling at the suture site. Atraumatic needles should be used to minimize damage to the tendon.

Throughout this procedure the tendon ends can be held in place by needles passed distally and proximally through the tendon sheath or by nylon tape at the cut ends (Figure 1.12). This ensures minimal handling of the tendon ends.

The circumferential running suture must be placed accurately. It is occasionally impossible to rotate the tendon sufficiently after putting in the core stitch to allow easy placing of the peripheral running stitch. In this case the back layer of the running stitch is inserted at the beginning of the operation. It is best to pick up the epitenon only or the epitenon together with a small amount of tendon material and, if there is any doubt about the hold that the suture has in the epitenon, a

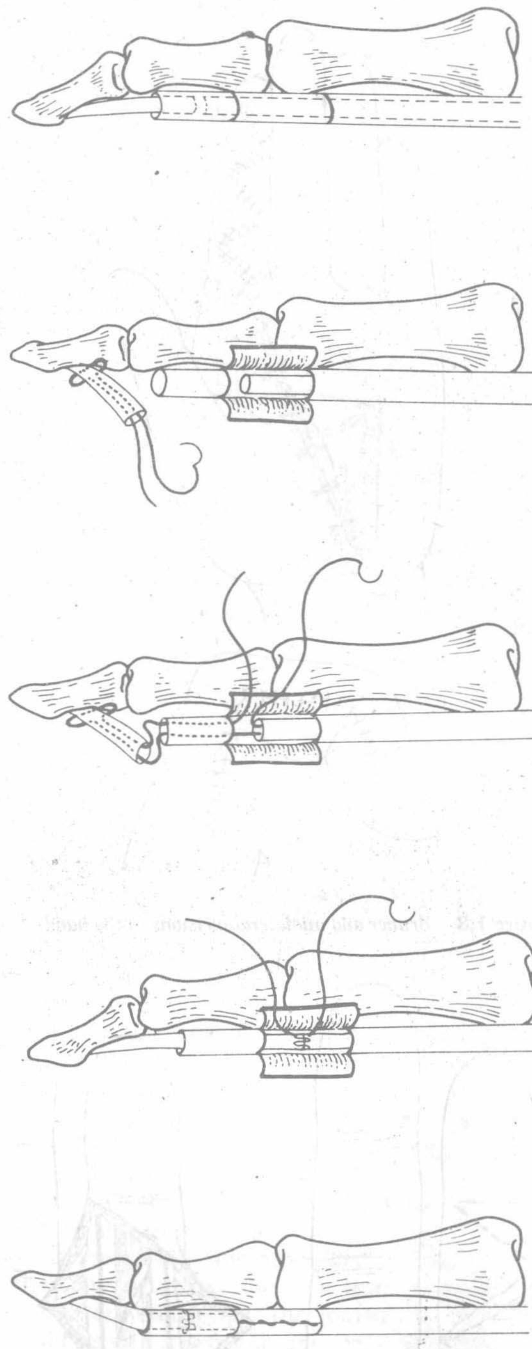

Figure 1.11 *Suture of a tendon divided under a flexor pulley — Lister's 'proximal combined window repair'.*

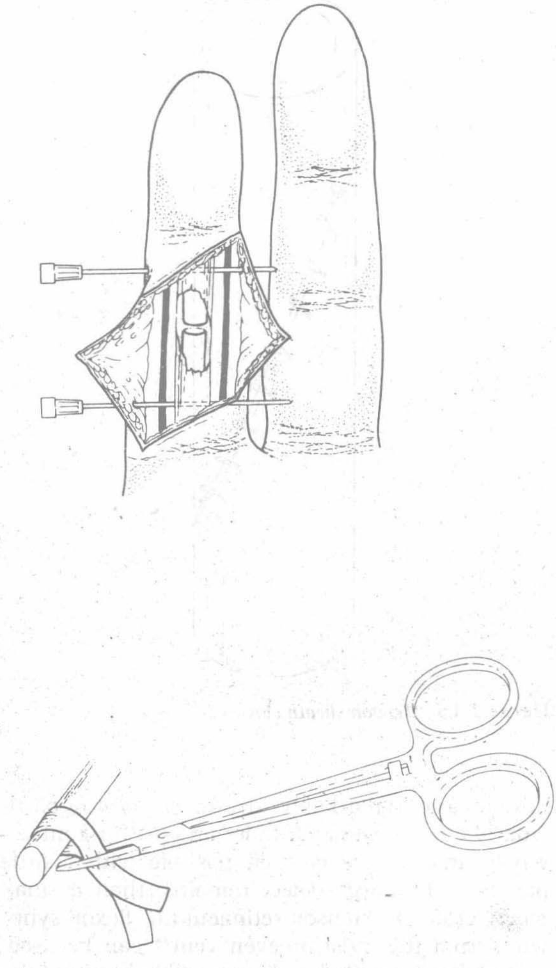

Figure 1.12 *Technique for holding tendons during suture.*

Lembert-type of stitch can be used. Epitenon is, however, much stronger than it looks and usually the running stitch will hold very well without the larger Lembert bites being used.

Inversion of the tendon ends can be achieved by picking up the epitenon just short of the cut tendon end (Figure 1.13). The back layer is then left loose while the modified Kessler core suture is inserted.

The core stitch is inserted a distance of about 1 cm into proximal and distal ends of the divided tendon. A single knot is tied between the tendon ends. If wire is used for the Kessler core suture, it is essential that a proper reef knot is used. The 'granny knot' that surgeons sometimes use will slip. Apart from the knot, the core suture must be capable of slipping in the tendon and no knots or

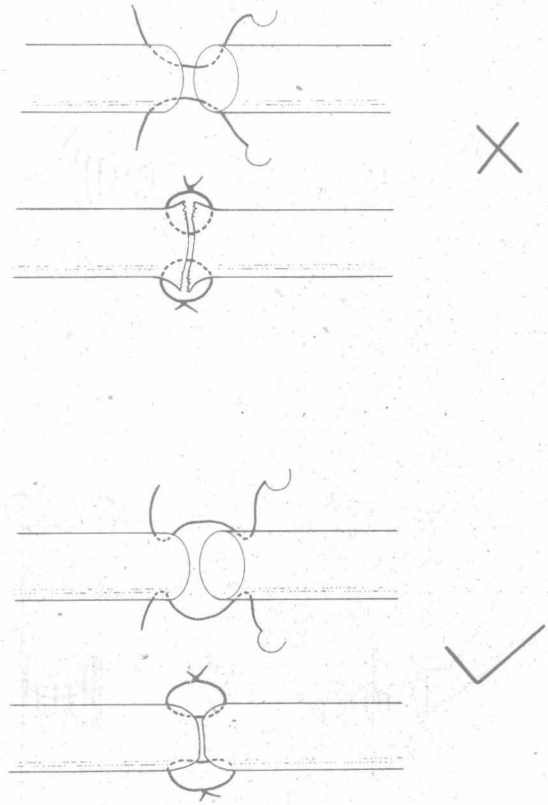

Figure 1.13 *Technique for achieving inversion of the tendon ends.*

kinks in the material can be tolerated. The two ends of the repaired tendon are then neatly opposed.

After the core stitch is tied the back layer, which has been loose, is gently tightened and the peripheral suture completed anteriorly (Figure 1.14). A continuous circumferential stitch is preferred to interrupted sutures. The tensile load is spread among six or more loops, therefore allowing a very much weaker material to be used than in the two strands of the core stitch. If a continuous suture cannot be inserted, six or more interrupted sutures are as strong although less neat.

The integrity of the repair should be tested at this stage by moving the finger passively to make sure no gap appears at the suture site.

Repair of both flexor superficialis and flexor profundus tendons should be done if both have been divided. If superficialis is cut near to its insertion where the tendon is rather flat, a modified Kessler suture will not be possible and it is best sutured with interrupted fine nylon. Profundus is sutured