Abdominal Pedicle Flaps To The Hand And Forearm

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ABOUT THE AUTHOR

John C. Kelleher, Sr., M.D. died at age 84 on August 18, 2003 after a brief illness. His wife Rosemary and nine children survive him. He was born on September 7, 1918 in Youngstown, Ohio and grew up in Lorain, Ohio. He was a graduate of the University of Notre Dame in 1940 where he was a member of the varsity football team. He is remembered for kicking a field goal to beat Purdue University 3-0 in 1939. He completed his medical education at Jefferson Medical College, graduating in 1944. He then served in the U.S. Army Medical Corps during WW II. During his wartime experience, he became interested in plastic surgery. He trained in plastic surgery under Dr. Walter Coakley in New York and completed additional hand surgery training under Dr. Sterling Bunnell in San Francisco.

He entered private practice in 1950 in Toledo, Ohio where he was the area's first plastic surgeon. He remained in practice until 1995, realizing many accomplishments and accolades along the way. Among them were founding the region's first cleft palate clinic, the first burn unit, the first hand rehabilitation unit and the residency program in plastic surgery. Locally he was active in the Toledo Academy of Medicine serving as president in 1974. Nationally he was active in the American Society of Plastic Surgeons, the American Society for Surgery of the Hand, and was president of the American Association of Plastic Surgeons in 1986.

He had a real passion for his work, enjoying and excelling in virtually all facets of plastic surgery. He thrived on teaching residents and students, spending unending hours in teaching both in conferences and in the operating room. He was a perfectionist, which is what led him to refining the techniques to improve soft tissue coverage of the hand with the abdominal flap. Late in his career he became disturbed by many of the early free flaps to the hand and upper extremity that were being presented at meetings and in print. They were too bulky and thick and did not incorporate proper attention to resulting scars and other details required for optimum form and function. While these free flaps avoided multiple stages of surgery, he felt the end result was often inferior.

It was for this reason that he spent over a year after retirement going back and reviewing his cases and thousands of photographs to produce a monograph depicting the principles of the procedure. The rights for this publication were given to Interplast to reproduce digitally. A benefit of this medium is the worldwide availability to surgeons everywhere, including those in developing countries, where the ability to do free flaps is often limited. His greatest hope was that this material would be of help to those surgeons dealing with difficult soft tissue coverage problems of the upper extremity.

His initial drafts were extensively edited and revised by his son, John C. Kelleher, Jr., M.D., a plastic and reconstructive surgeon in Amarillo, Texas. Interplast is greatly indebted to the Kellehers for making it possible to deliver this valuable information to surgeons around the world.

Chapter One:
INTRODUCTION *by Dr. John C. Kelleher, Sr.*

This surgical monograph is dedicated to the memory of Sterling Bunnell, M.D.; Lot Howard, M.D.; and Donald Pratt, M.D. It is also dedicated to others who have provided so much to my fund of information on the topic of surgery of the hand. This would include my mentors in training in Plastic Surgery: Walter Coakley, M.D.; David Teplitsky, M.D.; Leonard Rubin, M.D.; Richard Walden, D.D.S., M.D.; and Stephen McCoy, M.D. Many others were involved in the sharing of their vast funds of information at various meetings and seminars that helped to give me the needed background on this particular area of surgery. To mention a few: Joseph Boyes, M.D.; William Littler, M.D.; Robert Chase, M.D.; William White, M.D.; Robert McCormick, M.D.; Harry Buncke, M.D.; Harold Kleinert, M.D.; Joseph Posch, M.D.; Martin Entin, M.D.; William Frackelton, M.D.; J. E. Flynn, M.D.; Brandon Macomber, M.D.; Brad Cannon, M.D.; and Sumner Koch, M.D. Perhaps those most involved in helping me develop an in-depth interest for this type of surgery were my associates: James G. Sullivan, M.D.; Robert K. Dean, M.D.; George J. Baibak, M.D.; and John H. Robinson, M.D. I would also like to recognize my son, John C. Kelleher, Jr. M.D., for editing and putting the final touches on this work.

The purpose of this monograph is intended to gather together and publish my thoughts on this special area of surgery of the hand which encompass a period of time from 1948 to 1995 involving more than 150 examples. I am going to emphasize the principals and technical requirements for successful abdominal flap coverage of the hand. Because the surgery has been modified over that period of time, I felt that it would be best to review the 52 cases from the most recent 25 years from 1970 to 1995. These 52 cases represent work done by one individual (J.C.K.) and represent my thoughts and opinions to best complete successfully this special area of surgery of the hand. It is intended as a detailed reference for those younger surgeons who might not have been exposed to this surgical technique.

Chapter Two:
HISTORICAL REVIEW OF FLAP RECONSTRUCTION OF THE HAND From 1890 to 1945

During this period of time, eleven case reports were found in the English written literature describing abdominal pedicle flaps for reconstruction of the hand. I found that throughout the history of pedicle flap coverage of the hand the problems that existed with early reconstructions are still some of the problems that plague us today.

1898: Biggs, M.D., of Boston, described a flap to a contracted palmar burn scar of the left hand. The case was presented before the Boston Society for Medical Improvement on May 7, 1900. It was then reported in the Boston Medical and Surgical Journal of October 25, 1900.

The article describes a release of palmar scar and coverage with an abdominal flap that was based just below the sternum. It is interesting to note that the surgeon used a paper pattern to define what limits of the flap, a technique that is still used today.

1900: W. E. Schroeder, M.D. described two cases performed by Christian Fenger, M.D., as well as cases of his own. Dr. Schroeder was Associate Professor of Surgery at Northwestern University Medical School. These cases were reported in the American Journal of Medical Sciences, 120:435, 1900.

One of the cases described was that of Dr. Fenger's, which was performed around 1890. In this report, Dr. Schroeder noted a number of principles and precautions:

1. No more than a quarter of an inch of subcutaneous fat should be taken with the skin.
2. No tension or twisting of the pedicles.
3. The skin must have some subcutaneous fat or its viability would be endangered.
4. The edges of the skin of the hand must be undermined a quarter of an inch to allow attachment with sutures.

1905: A case was reported by James S. Stone, M.D., of Boston in the Boston Medical and Surgical Journal of March 2, 1905.

This article reviewed the treatment of a woman with a palmar burn scar contracture that was treated with a superiorly based abdominal flap.

Dr. Stone made some technical points in this article:

1. All deep scar tissue should be resected.
2. All resistance to complete unfolding of the contracture should be overcome.
3. The edges of the skin, which are left, should be free from scar as much as possible.
4. The incisions to raise the abdominal flap should be accurately patterned with allowance for shrinkage of about one-fourth to fit the denuded surface.
5. The raised flap should include about 1 cm. of subcutaneous fat. He felt that more was objectionable in appearance and was unnecessary to maintain the nutrition of the flap
6. He felt that suppuration was inevitable because of the exposed tissues.
7. No reconstruction on the bones or tendons should be done at the time of flap application because of this inevitable suppuration.
8. The stem of the flap to be severed at 18 to 20 days.

1908: Restoration of the Palm with Skin Flap from the Thigh by R. W. Westbrook, M.D. A

case report presented in the Long Island Medical Journal, Vol. 20, 1908, and presented at the Brooklyn Surgical Society.

This article described a flap reconstruction to the palm and dorsum of the hand using a flap raised from the upper one-third of the thigh. Most of the flap was used to reconstruct the palmar surface, and skin grafts were applied to the dorsum of the hand.

1917: Plastic Flap from the Abdomen for Burn of the Hand by Clarence A. McWilliams, M.D., presented before the New York Surgical Society in 1917 and published in the Annals of Surgery, Vol. 66, 1917.

This report described a 21 year old man with burns on the dorsum of the hand, which had healed by secondary intention.

The scar was excised, and the reconstruction was done with a bipedicled abdominal flap.

1919: Skillern, in June of 1919, presented a case of hand reconstruction by double pedicled abdominal pocket flap before the American Orthopedic Clinical Day conference at Jefferson Hospital in Philadelphia.

This report described an injury to the dorsum of the hand from a sanding machine that avulsed all of the skin off the dorsum of the hand down to the bone. It was treated with a bipedicled pocket flap. The author made the following points in the article:

1. The flap must be large enough both in width and length so that the coverage can be obtained without tension.
2. "The flap must include all the fatty tissue that can be obtained from the donor site; if a great deal of fat is not included, the flap will be a failure."
3. Perfect hemostasis must be obtained.
4. Strict attention must be paid for asepsis.
5. The flap must be properly immobilized.

1924: Reconstructive Surgery of the Hand by Sterling Bunnell, M.D. Surgery, Gynecology, and Obstetrics (S. G. & O.), September 1924, Vol. 64, No. 3, 1924. In this article, Sterling Bunnell, M.D., often referred to as the "father of modern hand surgery," cites a number of important principles:

1. Maintain the position of function of the hand and the mobility of the joints.
2. Use the tourniquet to reduce the trauma of sponging and to allow more accurate dissection.
3. It is important to photograph the initial injury along with accurate diagrams and notations of the finding, such as: sensation, range of motion, scars, and lacerations.

1937: Pedicle Flap Patterns for Hand Reconstruction by George Warren Pierce, M.D., and Gerald Brown O'Connor, M.D., San Francisco, CA, appearing in S.G.&O., Vol. 65, pages 523-527, 1937. This was read before the Industrial Medicine Surgery Section of the California Medical Association on May 25, 1936.

This was a discussion of principles involving flap coverage of the hand that covered numerous principles:

1. The usual donor sites for the hand are the abdomen, lower chest, thigh, and buttocks.
2. A one piece pattern of the exact size, shape, and thickness will give the most efficient result.

3. All flaps, when possible, should be made to conform to Langers' lines.
4. Venous stasis is most often responsible for tissue necrosis. This is caused, most often, by torsion or kinking of the stem of the pedicle. They concluded that multi-pedicle flaps tend to correct this venous deficiency problem.
5. All donor areas should be approximated or closed with a split thickness skin graft to diminish the possibilities for infection.

1940: Transplantation of Skin and Subcutaneous Tissue to the Hand. Sumner L. Koch, M.D., F.A.C.S., S. G. & O., 72:157, 1941. This report was read before the Minneapolis Surgical Society, Minneapolis, Minnesota, February 1, 1940.

In this article, Dr. Koch reviews principles of skin grafting to the hand as well as the application of flaps to the hand.

1944: One Stage Abdominal Tubed Flap, Darrel T. Shaw, M.D., F.A.C.S, Robert L. Payne, Jr., M.D., S. G. & O., 1944. This article describes a one stage single pedicle abdominal tube flap based on the superficial inferior epigastric vessels. This flap was found to be practical, reliable, rapid, and effective for coverage on hand injuries. They described flaps varying in length from 5 – 18 cm. and width from 3 – 7 cm. This article also cited another publication in the Surgical Clinics of North America, 1944, April, pages 293-308.

1946: Plastic Problems in the Hand, Sterling Bunnell, M.D., presented before the American Association of Plastic Surgeons, June 3, 1946, Toronto, Ontario, Canada. This was also published in Plastic and Reconstructive Surgery, Vol. 1:265, 1946. In this lecture and article, a number of enduring principles were elaborated:

1. Nutrition of the affected part from the binding cicatrix which is then replaced by good elastic pedicled tissue.
2. In estimating the size of the pedicle needed to replace the excised cicatrix, one-third more is added to all dimension.
3. When supplying new skin to the hand, the amount should be ample to cover the hand when both the hand and wrist are in flexion. The border of the flap should be patterned with indentations and points.
4. Too much fat left on a flap is parasitic and an additional burden to the blood supply. Fat should be trimmed from the skin leaving just enough fat for coverage of the subdermal plexus and the passage of tendons if needed.
5. "In supplying pedicle skin to the many thousands of injured hands in our army hospitals, the direct abdominal flap in one stage, which is time saving, has been the method of choice, except where the tubed pedicle was needed or preferable."

Chapter Three:
PRINCIPLES OF THE ABDOMINAL FLAP - The alpha and omega flap

The interval from 1946 to 1995 was the time from my alpha flap or my first flap until the time of my final flap or my omega flap.

1946 was the time that I completed my obligation for military service and began the struggle to obtain training in general surgery as well as plastic surgery. At that time, there were vast numbers of individuals competing to obtain the necessary required training in general surgery and then the even greater struggle to get the opportunity for training in the small surgical specialty of plastic surgery. I was fortunate to be appointed to the program at King's County Hospital in Brooklyn, New York, under the direction of Dr. Walter Coakley.

Dr. Leonard Rubin, who was on the staff at that time and since, implanted in me the precepts he absorbed from Dr. Brandon Macomber. I remember most vividly the teaching to keep all the fat on the flap or "it will die." The alpha flap shown in photo 3.A is the end result of these principles.

Photo 3.A

This is characterized as a fat biscuit flap with straight-line perimeter border scars. The function of the reconstructed hand was adequate but somewhat impeded by the bulging fat and straight-line scars. The omega flap or the last flap that I completed in 1995 was on a 28 year old white male in a motor vehicle accident with a fourth degree avulsion injury to the left hand as well as facial and ear trauma.

The principles that are enumerated below have evolved over a period of nearly 50 years. The application of these techniques makes the difference between skin coverage that looks like a "rising biscuit" on the hand that restricts function and coverage that meets the recipient site dimensions and preserves function.

The key points to consider and execute are listed below in chronological order and should be included in every flap. In the first stage of surgery the principles noted below should be carefully followed.

1. Debridement of dirt and other foreign bodies.
2. Debridement of severely traumatized and non-viable tissue.
3. Revision of the recipient site to avoid linear scars. Straight lines are broken up with V's and W's to prevent contracture.
4. Accurate flap planning to exactly match the size and shape of the recipient site.

5. The flap length to width ratio approximately 1:1 because the thinned pedicle becomes a random flap.
6. Axial vessels are incorporated in the base of the flap (superficial inferior epigastric, circumflex iliac and/or superior epigastric vessels).
7. The flap is raised on the plane of the abdominal aponeurosis.
8. The flap base or pedicle can be tubed when beneficial or necessary.
9. The flap is thinned to match the recipient site skin thickness. This is usually just deep to the subdermal plexus.
10. The flap thinning is done just prior to attachment to prevent desiccation and trauma to the subdermal plexus.
11. The donor site closed by advancement and split thickness skin graft, which is also used to line the raw surface of the pedicle.
12. The flap is attached with attention to matching the pattern of the flap to the recipient site. This prevents uneven tension and consequent loss of blood supply.
13. Position is maintained with balanced skeletal traction, with internal and external fixation as indicated.
14. The flap is inspected frequently in the early postoperative period.

Principles of the second stage of surgery are as follows.

1. Approximately three weeks later the pedicle to the flap can safely be divided. No "delays" are required unless extra tissue is being carried with the flap.
2. The pedicle is divided, trimmed to incorporate V's and W's and closed, inserting small Penrose drains at the edges.
3. The donor site can frequently be completely closed with the skin from the pedicle. The previously placed split thickness skin graft can frequently be removed and replaced with tissue remaining from the pedicle.
4. Early hand therapy should be incorporated to promote active and passive motion.

CPM is frequently useful. Additional stages of surgery may be required for a variety of reasons.

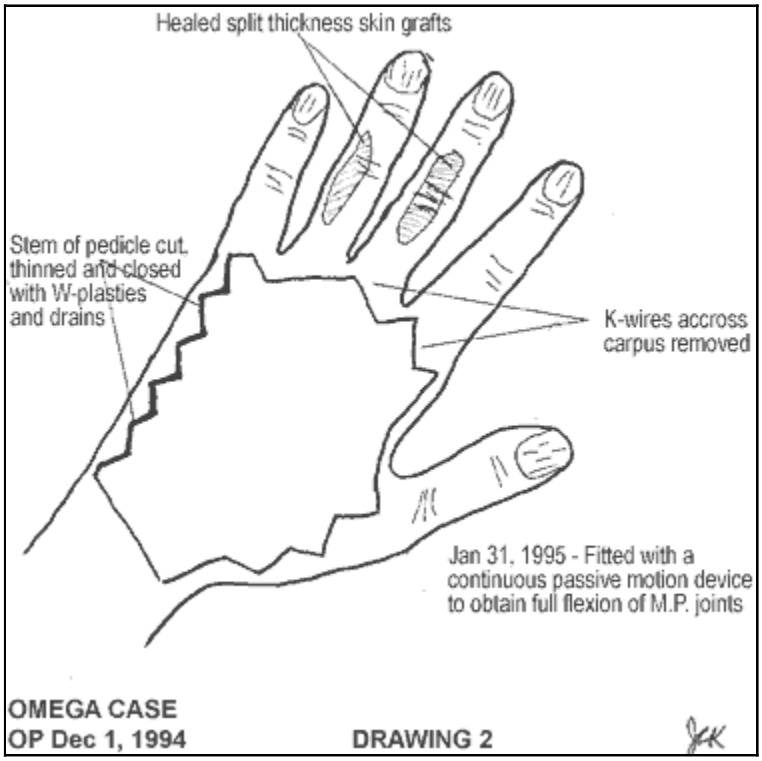
1. “Delays” may be required in extra tissue is been carried with the flap.
2. Reconstruction involving tendons, nerves, and/or bone may require extra stages of surgery.

The above principles are not technically difficult, but they do require experience and teaching to master. The material that follows will tend to demonstrate with case examples and color photos of proper execution of the abdominal flap. The flap that I termed “the Omega Flap" was the final flap that I performed in 1994 prior to retirement. I believe that it incorporates and demonstrates most of the principles outlined above.

Chapter Three:
PRINCIPLES OF THE ABDOMINAL FLAP - **The alpha and omega flap**

Operation December 1, 1994 Stage II: (See Photo 3.E) The pedicle was divided from the dorsum of the left hand. The base of the pedicle measured approximately 11 cm. in linear length. The distal border with its W's was approximately 42 cm. of linear length to allow for capillary inflow. The ulnar side of the flap was thinned of fat. The recipient area was W'd, and the ulnar edge of the flap was inset and drained with half cut Penrose drains. (See drawing 2)

Photo 3.E



On January 31, 1995, he was started on continuous passive motion (CPM) to the left hand and had almost immediate good motion of the metacarpal phalangeal joints. (See photo 3.F) The motion continued to improve until his next surgical procedure. I have found CPM to be quite effective in these types of cases.

Photo 3.F

Chapter Three:
PRINCIPLES OF THE ABDOMINAL FLAP - The alpha and omega flap

An outline of the details of the Omega flap is as follows:

Operation November 7, 1994: Irrigation and debridement with V-darts incised along the radial border of the hand and along the line of the metacarpal phalangeal joints.

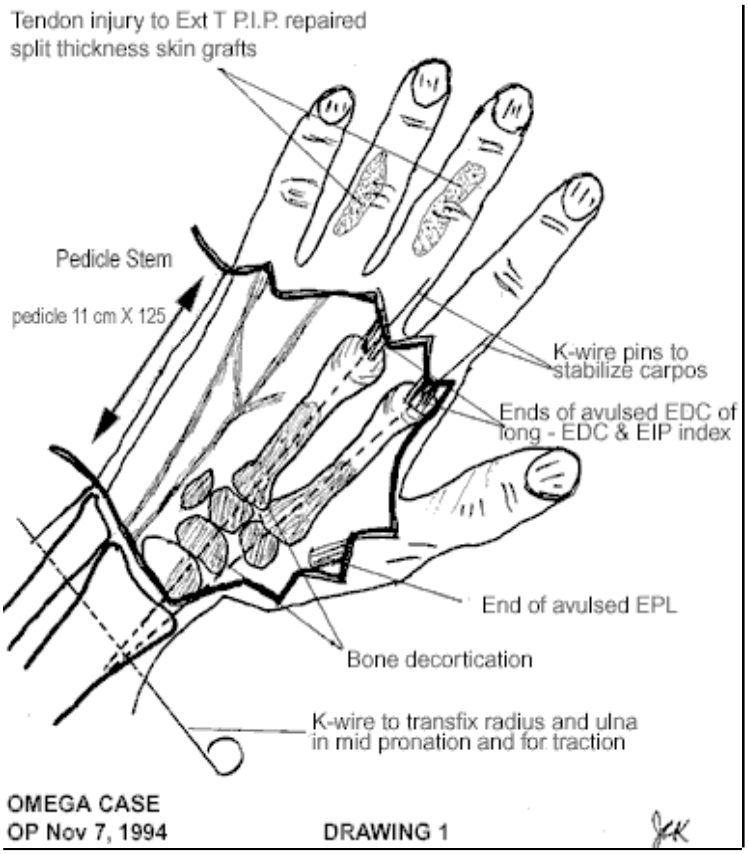
A 12 X 11 cm. Avulsion of the skin of the left hand dorsum and wrist is seen in photo 3.B.

Photo 3.B

Multiple extensor tendons (i.e., EPL, ECRL, ECRB, EIP, and EDCII, III) were avulsed. Cortical bone was abraded off the base of the left index and middle finger metacarpals, trapezium, trapezoid, capitate, scaphoid, and radial tubercle. (See drawing 1)

A tendon injury of the left ring extensor tendon over the proximal phalanx was repaired with a 4-0 Surgilon and covered with a splint thickness skin graft. (See drawing 1)

The left wrist was stabilized with two heavy Kirschner wires, one down the shaft of the index and one down the long finger metacarpals into the radius. (See drawing 1)



An abdominal pedicle from the left lower abdominal region based on the superficial inferior epigastric vessels measuring 11 X 12.5 cm. was used to cover the defect. It should be noted that W inserts at the transverse metacarpal border and radial border of the flap were used to break up the potential straight line scar. (See photos 3.C and 3.D) A split thickness skin graft was used to close the two digits and the donor site. (See drawing 1)

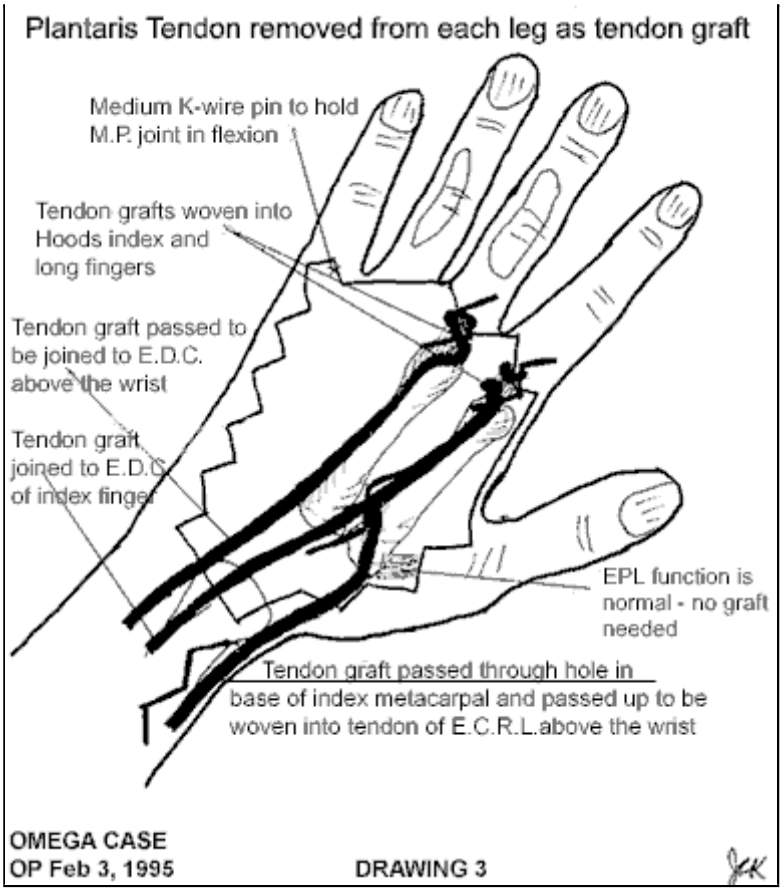
Photo 3.C

Photo 3.D

Balanced skeletal traction suspends the forearm and hand by Kirschner wire pins through the distal radius and ulna and through the olecranon. (See photo 3.D)

Chapter Three:
PRINCIPLES OF THE ABDOMINAL FLAP - **The alpha and omega flap**

Operation February 3, 1995 Stage III: Plantaris tendon grafts were taken from both legs and used as interposition tendon grafts to the extensor carpi radialis longus and the extensor digitorum communis tendons of the index and long fingers. (See drawing 3)



He was referred to traditional hand therapy and the use of CPM after healing of the tendon grafts. (See photo 3.G)

Photo 3.G

He regained most of the active and passive motion of the wrist and metacarpal phalangeal joints. The tendon grafts continued to improve and function as shown on December 1, 1996, twenty-five months post injury (See photo 3.H) The total reconstruction required twenty weeks from the time of injury until the completion of therapy.

Photo 3.H

Chapter Four:
INDICATIONS FOR PEDICLE FLAP COVERAGE

Local flaps are preferable to distant flaps but are limited for use by area requirements, rotation limitations, and blood supply which may be compromised by the original trauma.

In general, distant pedicle flaps are indicated for coverage of exposed bones, joints, tendons and nerves if these vital parts are to be retained and recover their maximal function in the restoration of the essential ingredients of pinch and grasp. Flaps may also aid recovery of motor or sensory nerve function by replacing firm constricting scar tissue with soft, well-vascularized tissue.

If the wound circumstances are such that the pedicle coverage is better done as a deferred procedure, then the use of the 'parasitic' skin graft or other biological dressings to obtain wound closure is indicated. Secondary flap replacement may afford the same advantage as we get with a primary flap, but there is usually some residual deep fibrosis and stiffness that remains. The primary pedicle flap has the benefit of providing a supple, soft, flexible skin coverage with its own vascularity carried in from the subdermal plexus.

Example case: A 24-year-old white male was involved in a motor vehicle accident and suffered a severe degloving injury to the dorsal radial side of the right hand and wrist. (See photo 4.A)

Photo 4.A

Operative note: After a full clinical and radiographic evaluation, the patient was taken to surgery and found to have a large soft tissue coverage loss from the wrist to the metacarpal phalangeal level and from the thumb-index web to the ring metacarpal area. All this tissue was contaminated with gravel and road material. There were no injuries to the volar side of the hand, and all digits were well perfused. Extensor tendons to the right index and long finger were avulsed. A portion of the extensor digitorum communis to the ring finger was destroyed.

The wound was debrided and irrigated with saline until considered surgically clean. The wound border defects were excised in "V" points to break up a straight line healing scar and to increase the linear length of capillary bridging from the flap to the recipient skin borders. (See photo 4.B)

Photo 4.B

This area of skin loss and planned flap replacement measured 15 cm. along the radial side of the hand and forearm and 9 cm. transversely. A sheet of plastic was laid over the debrided dorsum of the hand which included the "V" point flaps. A marking pen was used to outline a pattern on the plastic for the pedicle. This pattern was then cut out from the sheet of plastic and stapled to the **recipient site**. The arm and stapled pattern were then brought into the abdominal donor area. The stem of the pattern was then stapled to the appropriate area of the abdominal wall. The staples holding the pattern to the recipient area on the hand or upper extremity were removed to allow the pattern to then lie flat on the abdominal donor area. (See photo 4.C)

Photo 4.C

This then allows us to raise a donor flap of the exact size as the defect on the recipient hand. It is very important that the donor flap be of the **exact same size** as the defect to be covered on the dorsum of the hand. It is important because if the flap is not the exact same size and shape, there may be some oblique traction applied to the flap which may impede the arterial supply and venous return to the thinned abdominal pedicle flap. This flap is raised from the deep fascia of the abdominal wall and turned upward or downward as the need requires and for which the surgical plan calls. The donor area is then partially closed by advancing the borders of the donor area and tacking the deep corner of the dermis to the deep fascia with absorbable suture. The remaining open areas are closed with a split thickness skin graft and tie-over dressing. **It is important to leave all fat in place on the pedicle until the donor area is closed so as to avoid desiccation of the tissues of the pedicle**. At this

point, the pedicle is defatted down to the desired thickness to cover and replace the skin and subcutaneous tissue on the back of the hand.

Chapter Four:
INDICATIONS FOR PEDICLE FLAP COVERAGE

The technique of defatting is critical to the success of these thinned flaps. The surgeon allows the flap to drain over the non-dominant hand with the fat side up. The fat is best trimmed with scissors until there is only a thin layer covering the essential subdermal plexus. The deeper fat is contained in large globules; whereas, the more superficial fat near the subdermal plexus is contained in very small globules. This allows the surgeon to be aware when the subdermal plexus is near. This defatting should only be performed on the flap to be retained at the recipient site. The pedicle and the stem of the flap are left thick. In this case, the slides show a dotted line across the stem of the flap (see photo 4.D.) which indicates that the "parasitic fat" is removed to that point.

Photo 4.D

After adequate defatting of the flap and adequate hemostasis has been obtained, the flap is then inset with simple and half-buried mattress sutures only in the skin. Since the stem side of the flap is wide open, there is usually no need for any type of drain. However, in this case, Penrose drains were used in the suture line, which were removed 24 to 48 hours post-op. We can see some ecchymosis of the skin points at the distal edge of the flap (see photo 4.E) 2 days postop, however this will heal satisfactorily because of capillary bridging at the wound's edge.

Photo 4.E

Operation II: After three weeks, the flap is healing well to its recipient site and is ready for division. Photo 4.F shows the appearance of the flap just prior to division of the pedicle. The pedicle is divided, and the wound is closed in a zigzag fashion, primarily. Multiple Penrose drains are used for 2-3 days along the hand recipient border when the flap stem is cut, thinned, and inset.

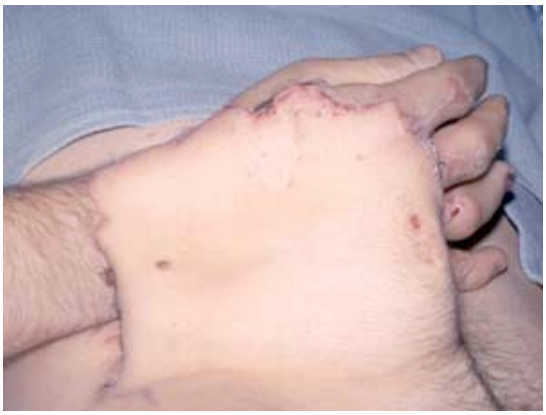


Photo 4.F

It is important to note that a number of well-respected plastic surgeons leave the stem open for 2-5 days before inserting the stem border because of a concern for possible infection and inadequate circulation. I have never found this necessary. In this case, at the time of the separation of the flap from the abdomen, the skin graft covering the donor site was excised, and the lower abdominal skin (pedicle) was advanced upward to leave only the peripheral scar. This technique of skin graft excision and coverage with the available abdominal skin can be obtained, in most cases, in either one or two stages of surgery leaving only an irregular scar on the abdominal donor site.

Operation III: Four months later, palmaris longus tendon grafts were used to reconstruct the extensor tendons of the index and long fingers. This is done by exposing the area through the borders of the flap. These flaps can be raised with impunity allowing tendon graft reconstructions and other procedures and then simply closing them in the original incisions.

Two years later, the function of the hand is good with full extension in all joints to a straight line and flexion in all joints to the distal palmar crease. A valid personal criticism would be that perhaps a little too much fat was left on the flap at the time of this procedure. Total reconstruction time was five months. (See photos 4.G & H)

Photo 4.G

Photo 4.H

Chapter Five:
SKIN REQUIREMENTS AND DONOR SITE SELECTION

The coverage requirements are determined after careful debridement, wound irrigation, and the creation of "V" darts at the borders, less than 90 degrees and about 1-2 cm. deep. A table of the area of skin requirements for various parts of the hand has been ascertained by cutting out the various parts of a tight fitting golf glove and measuring the areas.

AREA REQUIREMENTS

	WIDTH x LENGTH
A. DISTAL THUMB TO M.P. JOINT	9 cm x8 cm
B. DISTAL THUMB TO THENAR CREASE	13 cm x12 cm
C. PALMAR SIDE OF HAND	12 cm x10 cm
D. ENTIRE SURFACE - SINGLE DIGIT	7 cm x10 cm
E. DORSAL SIDE OF HAND	12 cm x10 cm
F. BOTH SIDES HAND AND DIGITS	20 cm x20 cm

This table is demonstrated by photos A and B. The forearm skin requirement can be determined by laying out a plastic sheet about the area of injury.

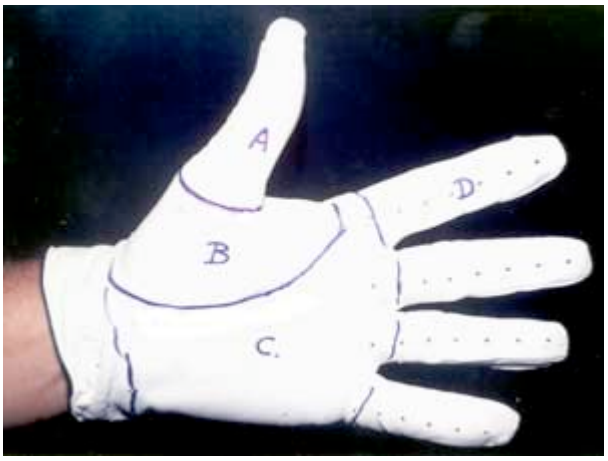


Photo 5.A

Photo 5.B

Skin requirements distal to the metacarpal phalangeal joint of the thumb: There is a requirement of approximately 9 cm. X 8 cm. This can be accomplished with a thinned tubed flap with "V" inserts at the circumferential proximal border of the thumb and can be obtained from almost any area of the abdomen or groin, keeping a major axial vessel in the tube.

Skin requirements for the palmar side of the hand: The above table indicates a need for a flap of approximately 12 cm. X 10 cm. A groin flap or a flap from anywhere on the abdomen is suitable because of the favorable length to width ratio; however, the blood supply can be increased if an axial vessel is incorporated, such as the superficial inferior epigastric system. For palmar wounds, it is desirable to position the hand so that the thumb is held away from the abdominal wall by placing the hand in full supination and holding it in this position with a Kirschner wire across the distal radius and ulna. This pin, preferably a heavy .065, can also be used as one of the points of balanced traction. This positioning of the hand enables the use of

a superiorly based flap making use of the superior epigastric vessels as the axial vessels into the base of the flap.

Skin for the dorsal side of the hand: The skin requirements for this coverage are approximately 12 cm. x 10 cm. The skin is best obtained from an inferiorly based flap with the thumb projecting away from the abdominal wall and held in a neutral position with a Kirschner wire across the distal radius to the ulna as noted above. This particular flap incorporates the superficial inferior epigastric vessels as the axial components.

Skin for both sides of the hand and digits: This requires a large area of skin and subcutaneous tissue of approximately 20 cm. x 20 cm. This flap is most often taken with an inferior base incorporating one or both of the superficial inferior epigastric vessels.

Skin for coverage of the volar surface of the forearm: This requires a broad, superiorly based flap applied to the forearm with the hand in full supination, maintained with a Kirschner wire across the distal radius and ulna. The size of this flap will depend upon the size of the defect. The fact that the usual dimensions result in a very broad based flap results in an extremely reliable flap that can be radically thinned to match the tissue requirements. Because of the broad base of this flap, an axial vessel is really not required.

Skin for the dorsal surface of the forearm: The flaps for this purpose are based inferiorly anywhere on the abdomen as dictated by the recipient site on the forearm. These flaps can be radically thinned to meet the tissue requirements.

Skin for the volar and dorsal surfaces of the forearm: This coverage requires a very large area of skin, averaging 30 cm. x 30 cm., and must be transferred in stages using the "carry technique" with primary, secondary, and sometimes tertiary delays. (See a following chapter). It is important in this situation to plan from where the future skin requirements must come in the future stages. After the appropriate "delay procedures" to outline the skin requirements for the second side coverage (usually the volar side), the flap is raised, thinned, and applied with the usual "V" darts. These flaps have a very broad base and are very reliable.

Chapter Six:
EVOLUTION OF THE PATTERN DESIGN

My experience with flap design began with freehand outlines of the expected needs after the initial debridement of the wounds. Rulers and calipers were used to get a more accurate measurement. Briggs, in 1900, used a paper pattern, but it was more or less a freehand sketch of the area and was enlarged by a percentage all around to allow for "shrinkage" of the flap. Pierce and O'Connor, in 1937, emphasized the need to match, as closely as possible, the tissue thickness and the exact size and shape of the flap to the wound.

After using paper wrapping from sterile gloves, I decided that clear plastic used to package surgical drapes worked better. It can be laid over the wound after debridement and stapled in place. The borders of the new wound can then be traced with surgical markers to outline and trace the borders of the wound very accurately. With this plastic stapled into place over the recipient site, the hand or forearm can then be placed in a comfortable position on the abdomen, and the pedicle can then be traced, as needed, to form the flap. The base of the flap is then stapled, as shown in Fig. C chapter 4 and the staples on the wound are removed allowing the clear plastic then be set against the abdominal wall to allow for a very accurate tracing of the wound onto the skin. Ink tattoo dots can then be placed on the intended flap with corresponding dots on the recipient site to make alignment and insertion of the flap easier.

After carefully checking the incision lines drawn on the skin with the plastic pattern and the debrided wound, the flap is elevated and prepared for insertion onto the recipient wound. Because the pattern has been very accurately measured before raising the flap, there is no concern or question about the orientation or placement of the flap on the recipient wound. Furthermore, the exact matching of the flap to the wound eliminates any undo tension, kinking, or torsion of the flap thereby reducing the chances for ischemia.

Chapter Seven:
THE TECHNIQUE OF EFFECTIVELY DEFATTING AN ABDOMINAL FLAP

This is perhaps the most important chapter in this monograph. I am convinced that the ability to thin and defat the flap is the principle factor in the effective and successful transfer of these large flaps.

Once the plastic pattern is laid out on the abdominal wall, the skin is incised with a scalpel down to the plane of the abdominal aponeurosis, and the flap is then raised back to its planned stem. Bleeding is carefully controlled. The flap is not thinned until the donor area is completely closed and the flap is ready to inset onto the recipient site. This prevents desiccation of the final thinned flap and protects the subdermal plexus.

The donor area is closed by undermining in the plane of the abdominal aponeurosis and advancing the edges. The dermis is tacked down to the deep fascia after maximum advancement with multiple 2-0 gut sutures. If complete closure is not possible with this advancement, then a split thickness skin graft as a non-perforated sheet graft is sutured to the edges of the donor area and carried up onto the stem of the pedicle and held in place with a tieover dressing.

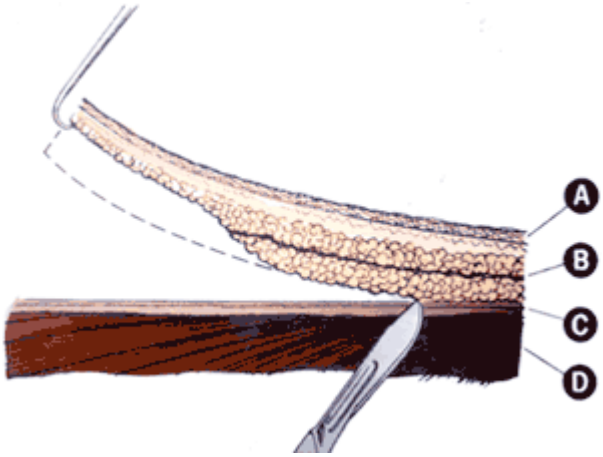


Figure 7.A

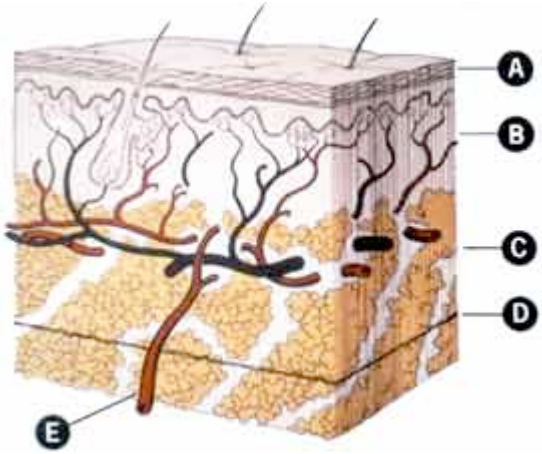


Figure 7.B

At this point, one begins the defatting of the flap to be laid on the hand. The very base or the stem of the flap is left full thickness (see figure 7.A) because there are major axial vessels deep in the fat that send perforators up to join the subdermal plexus (see figure 7.B). Only that portion of the skin flap that will be placed on the recipient site and remain as part of the reconstruction is thinned to the comparable thickness of the recipient skin area. All fat deep to Scarpa's fascia is removed, as is Scarpa's fascia itself. Occasionally Scarpa's fascia can be retained as an interpositional pedicle of tissue in special situations. This leaves the important layer of fat; that is, the fat between the Scarpa's fascia and the skin. The fat in this area can be carefully defatted just deep to the subdermal plexus. I have always used the palpable feel and the observation of the size of the fat lobules as indicators of the thickness of the flap being created. The fat is removed with sharp surgical scissors while holding the flap in the palm and fingers of the nondominant hand (see photo 7.C).

Photo 7.C

This removal of fat is done very carefully noting the size of the fat lobules. As one get closer to the subdermal plexus, the lobules of fat become much smaller. In the deeper fat, the lobules are larger (see photo 7.D). Excess fat retained in the flap does, in fact, increase the circulatory demands of the flap because the flap is parasitic and brings in no additional circulation. As Dr. Sumner Koch said, "It leaves more *mouths to feed*" (see photo 7.E).

Figure 7.D

Figure 7.E

It should be emphasized that the flap should be as thin as necessary to match the recipient site and supply the reconstructive needs. If one is replacing scar and skin only and there are no plans for further deep reconstruction, minimal fat is allowed to remain. If there will be a later need for tendon grafts or a need to cover bare bone, a little thicker layer of fat can be left. However, the overall tendency of most surgeons is to leave much more fat than what is really needed for the reconstruction.

Chapter Seven:
THE TECHNIQUE OF EFFECTIVELY DEFATTING AN ABDOMINAL FLAP

Example Case

A 21-year-old man sustained a near complete amputation of the left forearm when an acetylene welding torch caused a 50 gallon oil drum to explode. This resulted in open fractures of the radius and ulna and disruption of the vascularity of the forearm. A saphenous vein graft was used to repair the radial artery, and the radius and ulna were reduced and fixed with plates (see photo 7.F). I was called in consultation to manage the soft tissue injury. The wound was debrided, fascial compartments were released, and the area was covered with a sheet of split thickness skin graft, 4 x 8 inches. Postoperative course was uneventful.

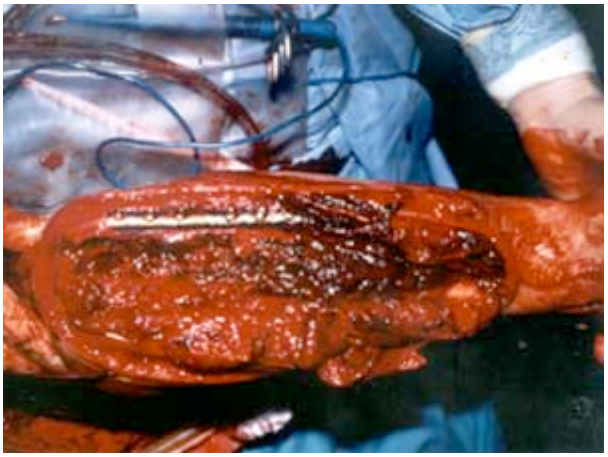


Photo 7.F

Eight months after the injury and this surgery, the patient was seen at our Hand Conference and was noted to lack extension of the fingers and wrist, which was felt to be due to a combination of adherence of the muscles in the skin grafted area as well as traumatic destruction of the muscles and scarring due to the extensive fractures (see photo 7.G). It was felt that he needed replacement of the split thickness graft and release of the scarring, as much as possible, and the coverage with an abdominal flap to provide good supple skin coverage in anticipation of subsequent reconstruction with tendon grafts and tendon transfers.

Photo 7.G

Chapter Seven:
THE TECHNIQUE OF EFFECTIVELY DEFATTING AN ABDOMINAL FLAP

Abdominal Flap 10 Months After Injury

The surgery consisted of:

1. Excision of the split thickness skin graft and other scar tissue adherent to the muscles of the forearm.

2. Elevation, thinning, and application of an abdominal flap from the upper abdomen to the prepared recipient site. Note, in photo H, the Scarpa's fascia being raised and discarded. Note the large lobules of fat (green arrow) to be removed with further thinning of the flap. The donor site was closed with a split thickness skin graft carried up to the stem of the flap.

3. Photo I shows a well-healed abdominal flap in position. There is also balanced skeletal traction to immobilize the arm.

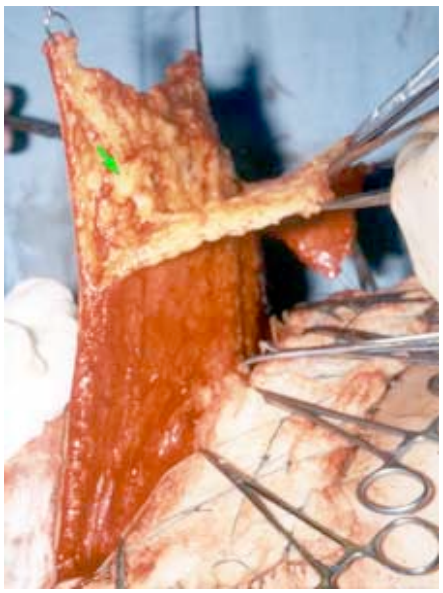


Photo 7.H

Photo 7.I

Division and Insertion of the Flap

Four weeks after application of the flap, Stage II of the reconstruction consisted of:

1. Sectioning of the stem of the flap and creating multiple "V's" in the recipient site and the flap (see photo 7.J). The flap was then sutured to the recipient site (see photo 7.K).

Photo 7.J

Photo 7.K

2. The flap donor site was undermined using the principles of an abdominoplasty (reversed in this case) and closed as a straight line scar across the upper abdomen (see photo 7.L). Nine months post insertion of the flap, the flap is seen, in photo 7.M, just prior to reconstruction with tendon transfers and tendon grafts. The flap provides an excellent supple site for the intended reconstruction.

Photo 7.L

Photo 7.M

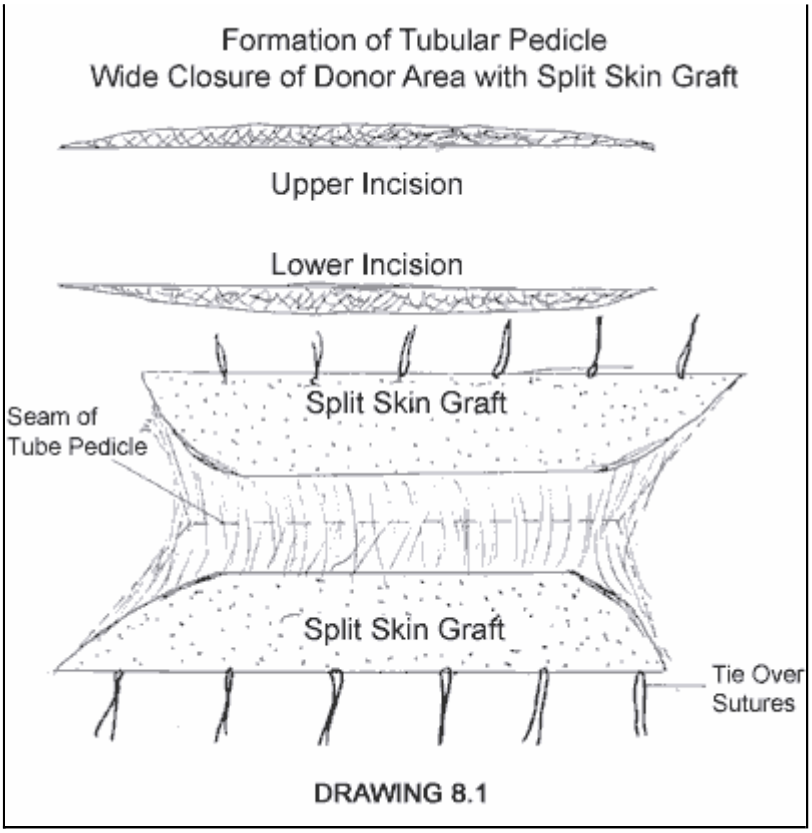
Chapter Eight:
TECHNICAL REQUIREMENTS FOR FORMATION OF A TUBED PEDICLE FLAP

Creating a tube pedicle is advantageous in many situations, therefore principles of tube formation are important.

Donor Site: Usually the abdomen or groin are the best donor sites. There are considerations:

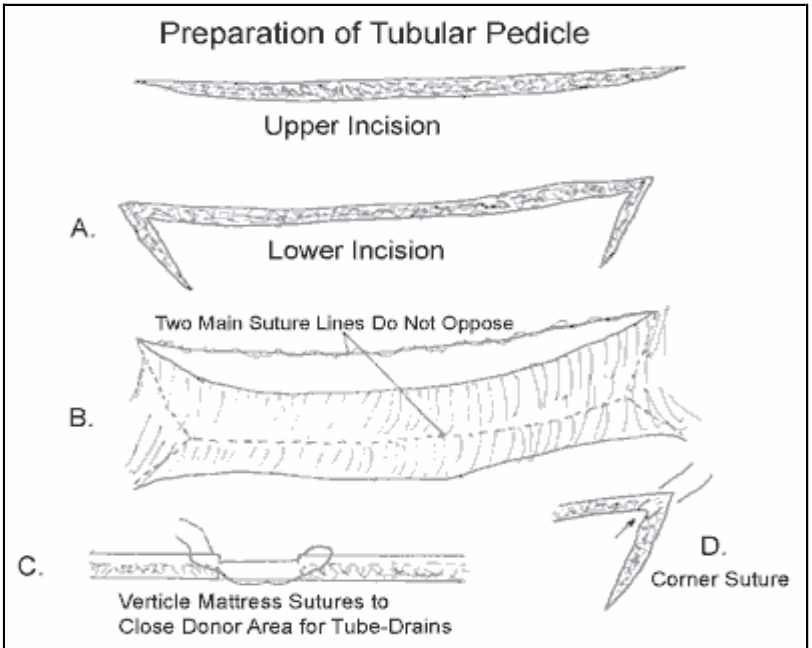
a. Scars from previous surgery or trauma
b. The amount of skin required should be planned (see chapter 5).
c. Blood supply must be considered. A major vessel should be incorporated into a tube pedicle when possible (superior epigastric, superficial inferior epigastric, superficial circumflex iliac) .
d. Avoid hairy areas when possible and consider moving the flap laterally if possible.

Layout of the Plan for the Tube Pedicle: It is well to layout this plan in the office or the hospital well before the time of the actual performance of the surgery. This allows the surgeon to think about the area of skin requirements and the previous scars that might interfere with the blood supply. Also other factors such as the presence of abdominal hair or the thickness of the abdominal fat can be considered. Usually one can grasp the roll of skin of the abdomen between the thumb and fingers to get an idea of how much skin needs to be carried between the parallel incisions in order for the tube to be closed with limited tension. This also gives a prediction of the ability to close the donor site. If the donor site area cannot be closed it can be covered with a split thickness skin graft (see drawing 8.1). Parallel lines are drawn on the skin of the abdomen of the appropriate length.



DRAWING 8.1

Parallel incisions are then made down to the deep fascia (see drawing 8.2). The surrounding skin is undermined and closed in layers with absorbable sutures and then interrupted 4-0 nylon sutures in the skin. Using traction sutures of nylon at the distal ends of the skin to be tubed, the seam of the tube is closed with interrupted 4-0 nylon sutures.



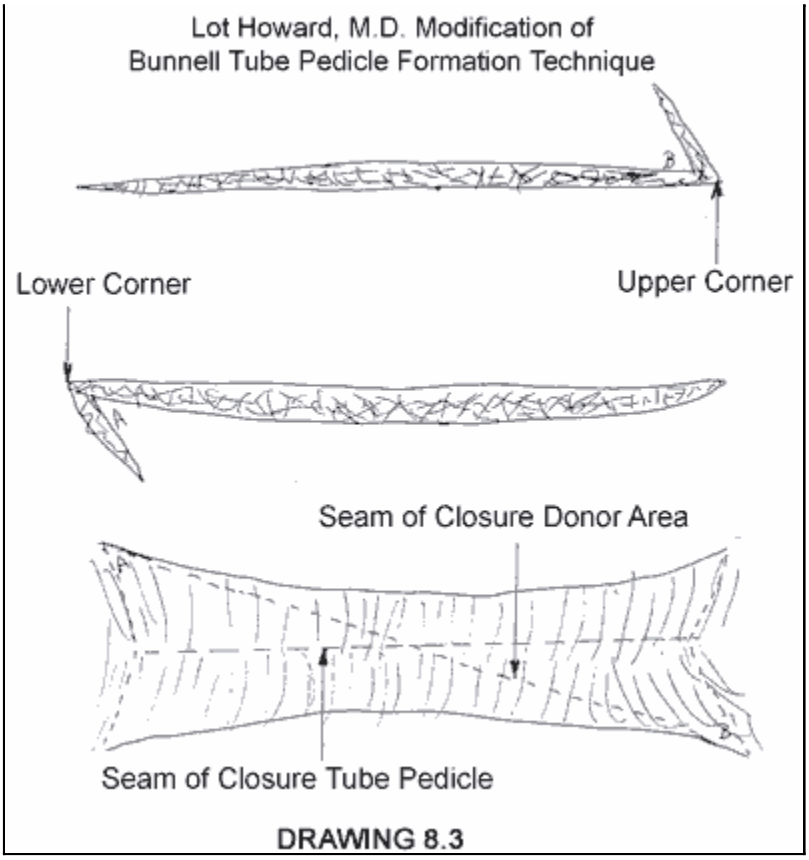
A. Incisions to form the tube. Wide area of undermining to facilitate closure of tube donor area.

B. Before pedicle is made into a tube-sufficient, fat should be trimmed away with sharp scissors so that the edges will approximate each other without tension.

DRAWING 8.2

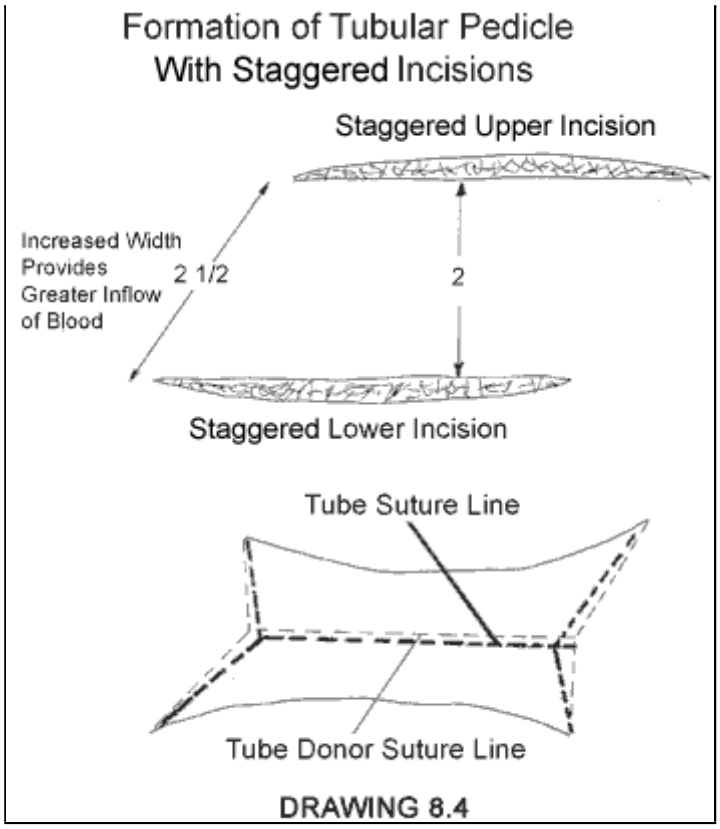
Chapter Eight:
TECHNICAL REQUIREMENTS FOR FORMATION OF A TUBED PEDICLE FLAP

If the tension with the closure of the skin edges is judged to be too excessive then it should be opened. Using sharp tissue scissors, some fat is removed until the skin can be closed without tension. Lot Howard described an alternate method of forming a tubed pedicle that gives a little more laxity to the skin and does not have opposing seams in the tissue closure (see drawing 8.3).



DRAWING 8.3

Another method is to make use of staggered parallel incisions which provide a wider pedicle of circulatory inflow at each end and make for easier donor site closure (see drawing 8.4). Drains are usually not required. Dressings consist of only a single dry gauze 4x4 between the tube and the donor site which is changed frequently. Of course a tie over dressing would also be used in the event of a split thickness skin graft covering the donor site. Alternate sutures are removed at two weeks and the remaining sutures are removed at three weeks.


Formation of Tubular Pedicle
With Staggered Incisions
Staggered Upper Incision
Increased Width
Provides
Greater Inflow
of Blood
2 1/2
2
Staggered Lower Incision
Tube Suture Line
Tube Donor Suture Line

DRAWING 8.4

Chapter Eight:
TECHNICAL REQUIREMENTS FOR FORMATION OF A TUBED PEDICLE FLAP

EXAMPLES OF HAND RECONSTRUCTION USING TUBED FLAPS - Case No. 1:

A 26-year-old man caught his right dominant hand in a paint roller and was taken to a local hospital for care. At the time of the injury, the little finger was amputated at the metacarpal base and 3 weeks later the thumb was amputated at the mid proximal phalanx. A meshed skin graft was applied. A month later a poorly planned "Alpha type" flap was applied to the palmar aspect of the hand. Note the inadequate size, straight line scars and biscuit shape of that flap (see photos 8.1A, 8.1B). These photos were taken 7 months after injury and this surgical treatment prior to his transfer here.

Photo 8.1A

Photo 8.1B

Our examination revealed heavy scarring and limited motion. Action of the extensor pollicis longus could not be demonstrated because of scarring in the area. It was decided to make use of a tubed flap because of the need for cover on both sides of the hand and wrist (see photos 8.1C, 8.1D).

Photo 8.1C

Photo 8.1D

A superior "pancake" of tissue with W darts is used on the border to replace the scar on the ulnar side of the hand (see photo 8.1E).

Photo 8.1E

Although not depicted in photographs, this tube was then transferred after several "delays" to cover the Palm of the hand and thumb as seen in the final photos (see photos 8.1F, 8.1G).

Photo 8.1F

Photo 8.1G

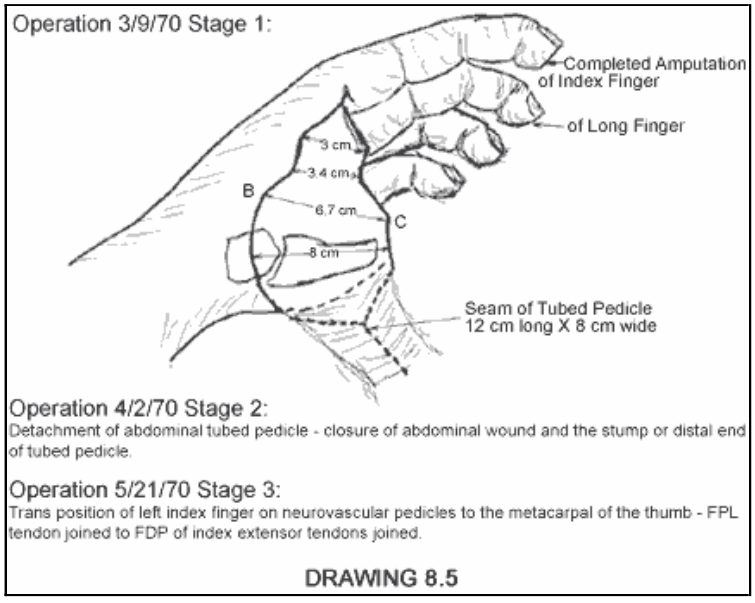
Chapter Eight:
TECHNICAL REQUIREMENTS FOR FORMATION OF A TUBED PEDICLE FLAP

Case No. 2:

A 35-year-old man caught his left hand in a punch press suffering loss of all parts of the thumb through the distal end of the metacarpal along with avulsion of the skin of the thumb-index web space. There was also a partial amputation of the tips of the index and long fingers. (see photo 8.2A). His surgical treatment involved 3 operations.

Photo 8.2A

Stage I. A patterned abdominal tubed flap was raised in the left lower quadrant based on the superficial inferior epigastric vessels. This type of skin coverage was selected to effectively cover the web space and to have additional skin and fat for future stages in the thumb reconstruction. (see drawing 8.5 and photo 8.2B).



DRAWING 8.5

Photo 8.2B

The donor site was closed primarily. The proximal portion of the flap was tubed as described above and the distal portion of the flap to be applied to the open web space was thinned of excess fat just deep to the subdermal plexus.

Stage II. Three weeks later the tube flap was detached with closure of the abdominal wound and closure of the distal stump of the tube flap. (see photos 8.2C and 8.2D). There was some delayed wound healing and a small foreign body that had to be removed in the healing phase.

Photo 8.2C

Photo 8.2D

Stage III. Nineteen weeks following the injury a transposition of the left index finger to the thumb metacarpal was performed. (see photos 8.2E and 8.2F). These photos were taken 18 years later.

Photo 8.2E

Photo 8.2F

Chapter Eight:
TECHNICAL REQUIREMENTS FOR FORMATION OF A TUBED PEDICLE FLAP

EXAMPLES OF HAND RECONSTRUCTION USING TUBED FLAPS

Case No. 3:

A 37-year-old man had a punch press injury suffering avulsion of the distal portion of the thumb and fractures of the proximal phalanx with amputation of the index finger through the mid proximal phalanx. There was also an injury to the distal phalanx of the long finger (see photos 8.3A, 8.3B).

Photo 8.3A

Photo 8.3B

Stage I. The injuries to the fingers were closed primarily and this required removal of the remaining proximal phalanx of the index finger. The tube flap was selected to cover the skin loss of the proximal phalanx of the thumb (see photo 8.3C). The tube was raised from the right lower quadrant of the abdomen based on the superficial inferior epigastric vessels. The distal end of the tube had multiple W' s or darts to break up the straight line circular scar around the base of the thumb.

Photo 8.3C

Stage II. One month later the tube was divided and closed. There was some delay in healing which is not uncommon and his appearance is noted five weeks later (see photo 8.3D).

Photo 8.3D

Stage III. It was felt that the patient would benefit from more length and better sensation in the thumb. We elected to do this by using a bone graft of the index metacarpal and by resurfacing the reconstruction with a neurovascular island flap based on the index finger. The bone graft consisted of the distal 1/2- 2/3 of the index metacarpal turned backwards and inserted ("Dunce hat") over the remaining proximal phalanx of the thumb (see photos 8.3E and 8.3F).

Photo 8.3E

Photo 8.3F

Chapter Eight:
TECHNICAL REQUIREMENTS FOR FORMATION OF A TUBED PEDICLE FLAP

EXAMPLES OF HAND RECONSTRUCTION USING TUBED FLAPS

Case No. 4:

A 26-year-old man suffered loss of his entire thumb including the metacarpal, the index finger at the MP joint and the long finger at the PIP joint. This was his dominant right hand. His initial repair was done elsewhere and consisted of a split thickness skin graft on the radial side of the hand and closure of the amputation of the long finger. The base of the thumb metacarpal was present, the abductor insertion was present and there was still some thenar muscle mass present (see photos 8.4A, 8.4B).

Photo 8.4A

Photo 8.4B

My operative plan was to provide the skin coverage necessary for the reconstruction with a tube flap placed initially on the dorsum of the hand in the area of the bases of the index and long metacarpals. The base or abdominal end of the tube will be delayed once then transferred to replace the skin graft and scar at the base of the thenar eminence. The tube flap is used for deferred coverage of both sides of the reconstructed thumb index web space. At the time of the bony reconstruction, this tube will be opened in the center to allow access for the thumb reconstruction. The tube should not be opened and defatted until the deep bone and tendon work is completed otherwise the tissue will dry out and cause problems with circulation.

Stage I. A tube flap was raised from the right lower quadrant measuring 9 cm in width by 18 cm in length. The superior end of the flap was defatted and inserted into a "Y" shaped incision on the dorsal aspect of the hand at the base of the ring and long finger metacarpals (see photos 8.4C, 8.4D). A heavy Kirschner wire was driven across the ulna into the radius to hold the hand in full pronation and provide a point of traction at the wrist.

Photo 8.4C

Photo 8.4D

Stage II Three weeks later a primary delay (see photo 8.4E).

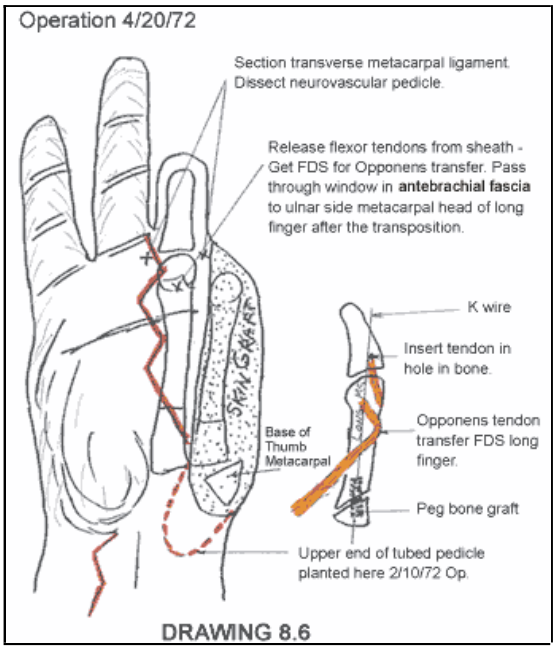
Photo 8.4E

Stage III. Ten days later the base of the flap was divided from the abdomen, defatted and placed over the proximal area previously covered by the split thickness skin graft at the base of the thenar eminence (see photos 8.4F, 8.4G).

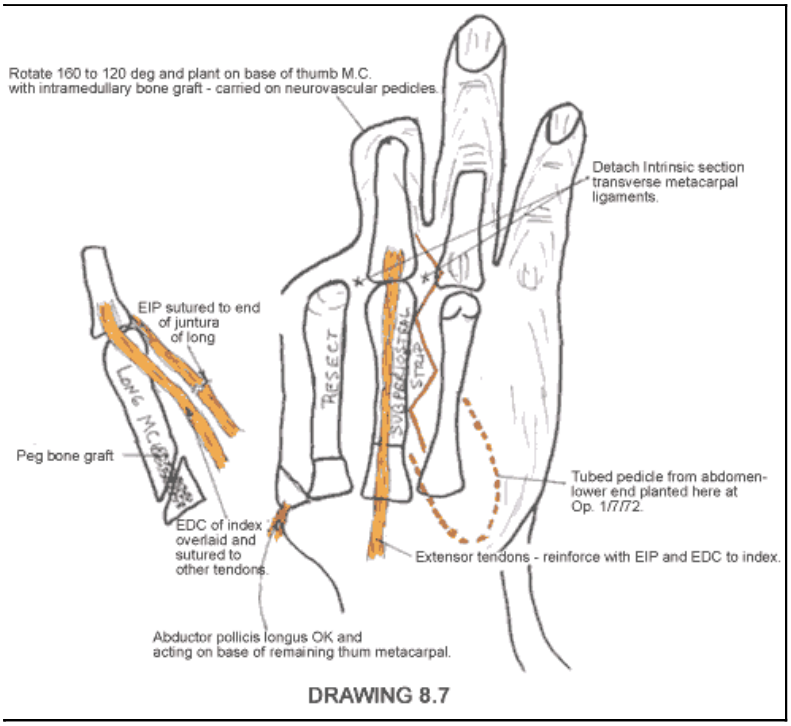
Photo 8.4F

Photo 8.4G

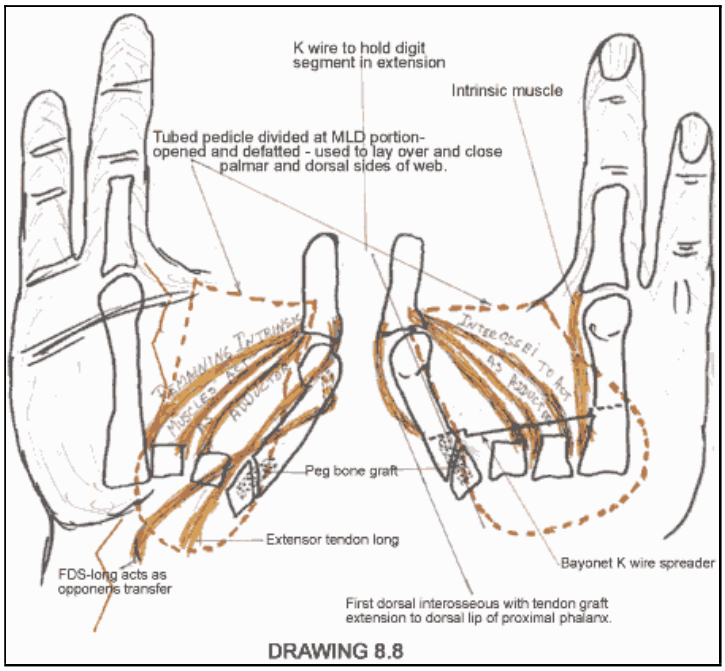
Stage IV Ten weeks later a transposition of the remaining long finger metacarpal and proximal phalanx was performed to the base of the thumb metacarpal with the use of bone grafts and internal fixation. A temporary bayonet shaped Kirschner wire, inserted into the metacarpals, was used to separate and hold the position of the new web space. (see drawing 8.6, 8.7, 8.8).



DRAWING 8.6



DRAWING 8.7



DRAWING 8.8

The tube flap was then transected horizontally at its midpoint. The tube on the volar side was opened, defatted and trimmed to fit the skin defect on the volar side of the thenar eminence. The tube on the dorsal side was opened, defatted and thinned to cover the open dorsal and ulnar side of the web space (see photos 8.4H, 8.4I).


Photo 8.4H


Photo 8.4I

His final function was excellent and photos are shown taken six years post injury with excellent grasp and strong pinch between the reconstructed thumb and the remaining digits (see photos 8.4J, 8.4K, 8.4L).

Photo 8.4J **Photo 8.4K**

Photo 8.4L

Chapter Eight:
TECHNICAL REQUIREMENTS FOR FORMATION OF A TUBED PEDICLE FLAP

EXAMPLES OF HAND RECONSTRUCTION USING TUBED FLAPS

Case No. 5:

A 40-year-old man suffered a crush/avulsion injury of the left-hand with loss of the phalanges III, IV, and V and near complete degloving on both sides of the hand (see photos 8.5A, 8.5B).

Photo 8.5A

Photo 8.5B

Stage I. The wound was extensively debrided and W's were incorporated along the skin line of attachment for the flap. The W's were not as large as I would use today. A large patterned flap was planned on paper and placed over the left lower quadrant measuring 19 cm in width and extending from the midline of the abdomen and the left hip area incorporating the superficial inferior epigastric vessels. The proximal portion of the flap was tubed and the distal portion to be applied to the hand was thinned of fat. The tube was rotated 90 ° so that the palmar skin would be taken from the lateral flank which was free of hair. The donor site was closed by advancement and with a split thickness skin graft. Because of the concavity of the palmar surface, a suction drain was used to obliterate dead space. A spreader was used to maintain the thumb index web space. The Kirschner wire was used through the thumb as a point of suspension to keep the hand away from the abdomen and keep the flap in good position (see photos 8.5C, 8.5D).

Photo 8.5C

Photo 8.5D

Stage II. Three weeks later a primary delay was performed close to where the flap joined the hand.

Stage III. Four weeks after attaching the flap, the pedicle was divided. The remaining tube was opened to replace the split thickness skin graft previously used to close the donor site. The postoperative result is shown eight years later (see photo 8.5E). This case illustrates the usefulness of the tubed abdominal flap to cover both sides of the hand.

Photo 8.5E

Chapter Nine:
THE OPEN ABDOMINAL FLAP

The open or standard abdominal flap is frequently used to cover large areas on the hand and upper extremity. We try to incorporate axial vessels into the flap and leave the flap thick except where it is applied to the recipient site. The raw surface of the flap is best lined with a split thickness skin graft. The donor site on the abdomen is usually covered with a split thickness skin graft either permanently or temporarily. Frequently the portion of the flap not required on the reconstruction can be replaced back onto the abdomen and the split thickness skin graft removed.

EXAMPLES OF HAND RECONSTRUCTION USING OPEN DIRECT FLAPS Case No. 1:

This case is an example of a flap with storage of additional tissue "banked" at the end or side borders of the flap. The skin is stored in a role or tube of skin over the MP joints to later replace burn scar contractures on the dorsum of the fingers. After detachment of the flap it is possible to extend this skin down over the digits to cover them. It is very important to retain all or most of the fat in the stored tubed skin when used in this manner otherwise the skin contracts and the surface area is decreased. A 16-year-old boy sustained deep burns of the left upper extremity which were covered with split thickness skin grafts elsewhere. When seen about six months later, there was a heavy burn scar contracture with hyperextension of the MP joints and flexion contractures of the PIP joints of the index, along, ring and little fingers (see photos 9.1A, 9.1B).

Photo 9.1A

Photo 9.1B

Stage I. The burn scar and skin graft of the dorsum of the left-hand and distal forarm were excised with W's at the radial border. Today these W's would be equilateral triangles approximately 2 cm on each side. The excision was down to the plane of the extensor tendons. And internal bayonet shaped Kirschner wire spreader was placed between the thumb and index metacarpals to abduct the thumb. The pattern of the proposed flap was laid out on paper (see photo 9.1C). Today I would use clear plastic sheeting. The W's of the flap are designed to match those on the recipient site exactly. The flap measured 18 cm by 15 cm and the stem included both superficial inferior epigastric vessels.

Photo 9.1C

A split thickness skin graft was used to close the donor site (see photo 9.1D). A heavy Kirschner wire was used to hold the forearm in neutral position and as suspension for the flap. The excess skin stored on the distal border of the flap can be seen as a roll (see photo 9.E). This portion of the flap was left thick and not defatted.

Photo 9.1D

Photo 9.1E

Stage II. Three weeks later thought abdominal flap was detached and inserted along the all or border of the hand and forearm with W' s and small drains were inserted. In later cases I would make those W' s more exaggerated and deeper (see photo 9.1F).

Photo 9.1F

Stage III. One month later scar was excised from the dorsum of the fingers and MP joints (see photo 9.1G). Capsulotomy of the MP joints was performed with excision of the ulnar collateral ligaments placing the MP joints and flexion and holding them with Kirschner wires. Kirschner wires were also used across the PIP joints to maintain these joints in extension. Next the tube of skin was opened, defatted and sutured into place.

Photo 9.1G

Several additional stages of surgery followed to fuse the PIP joints, reconstruct the web spaces and remove orthopedic hardware. The postop appearance and function were excellent. Photos are shown 2 years postop (see photos 9.1H, I, J).

Photo 9.1H

Photo 9.1I

Photo 9.1J

Chapter Nine:
THE OPEN ABDOMINAL FLAP

EXAMPLES OF HAND RECONSTRUCTION USING OPEN DIRECT FLAPS Case No. 2:

This is an example of an abdominal flap that is eventually "delayed" to carry more tissue onto the recipient site. This is a 16-year-old boy who suffered fractures and soft tissue injuries to the forearm (see photo 9.2A)

Photo 9.2A

He was treated by the orthopedic surgeon with open reduction and split thickness skin grafts. One year after the accident there were multiple flexor tendons adhering to the graft and limiting range of motion. We elected to use a flap to release the inherent muscle and tendons and to fill the soft tissue defect. (see photos 9.2B, C)

Photo 9.2B

Photo 9.2C

Stage I. A. plastic sheet pattern was designed over the left upper abdomen with w' s at the inferior border and along the elbow side of the flap (see photo 9.2D). The flap was raised based superiorly measuring 19 cm wide by 10 cm long. A split thickness skin graft was used to close the donor site (see photo case 9.2E)

Photo 9.2D

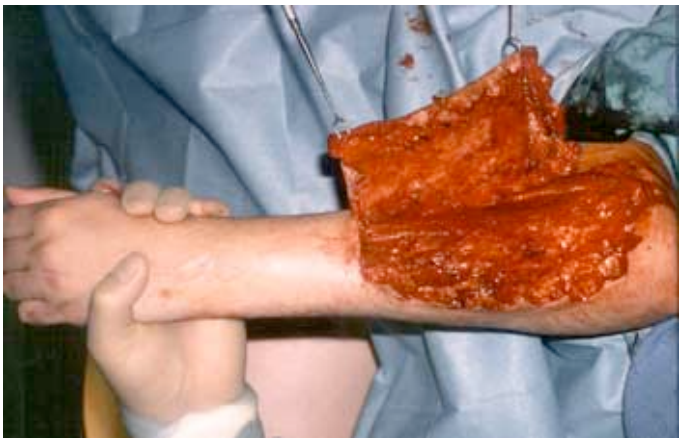
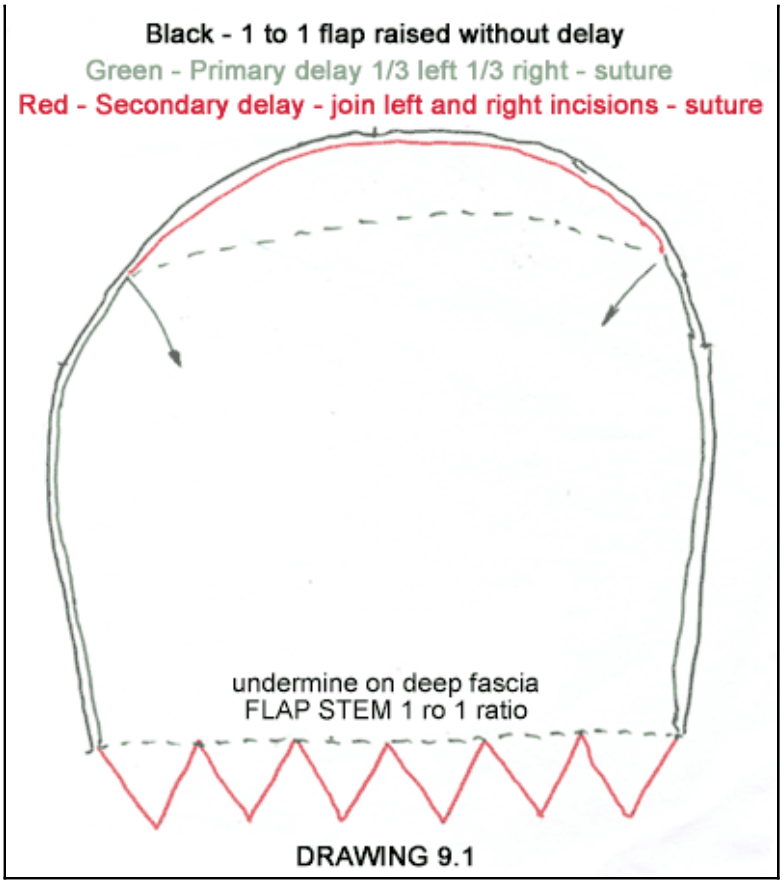


Photo 9.2E

Stage II. Primary delay. Three weeks later. The previously designed plastic sheet pattern of the proposed pedicle was laid over the stem of the flap to determine the amount of flap that would need to be carried. The delay divided two-thirds of the flap, one-third on each side (see drawing No. 9.1 and photo 9.2F)



DRAWING 9.1

Photo 9.2F

Stage III. Secondary delay. 10 days later. The final one-third is divided. Stage IV. Three weeks following the secondary delay, the remainder of the flap is elevated, defatted and inset using the pattern in the closure. (see photo 9.2G).

Photo 9.2G

The patient went on to develop a full range of motion without restriction and the postop photo of the flap is noted (see photo 9.2H).

Photo 9.2H

Chapter Nine:
THE OPEN ABDOMINAL FLAP

EXAMPLES OF HAND RECONSTRUCTION USING OPEN DIRECT FLAPS Case No. 3:

This case is an example of the exaggerated, relatively deep W incisions that were used on my later flaps. Besides allowing more flexibility, these deep W edges provide increased length for additional capillary bridging and therefore better blood supply in the flap. While not the case in this particular flap, I believe that this allows more tissue with better blood supply to be carried if needed for additional areas to be covered in later procedures. This case also illustrates the use of Scarpa's fascia to interpose between repaired tendons and underlying bone.

A 17-year-old boy was seen after an industrial grinder accident that lacerated all of his extensor tendons, deeply abraded the bones, and resulted in significant dorsal skin loss (see photo 9.3A).

Photo 9.3A

Stage I The wound was excised with deep W's and a pattern was created. The tendons were repaired (see photos 9.3B,C, D).

Photo 9.3B

Photo 9.3C

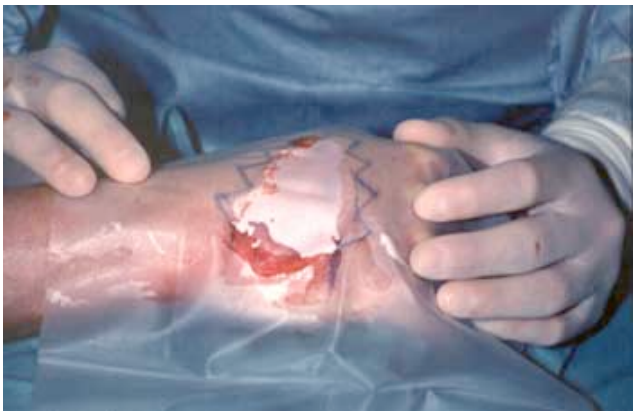


Photo 9.3D

The flap was based on the superficial inferior epigastric vessels and measured 15 cm long by 6 cm in width. The fat tissue deep to Scarpa's fascia was excised. Scarpa's fashion was then elevated on a plane keeping the stem of the fascial flap intact. The skin superficial to Scarpa's fashion was then thinned down to the subdermal plexus. The donor site was closed primarily (see photos 9.3E, F).

Photo 9.3E

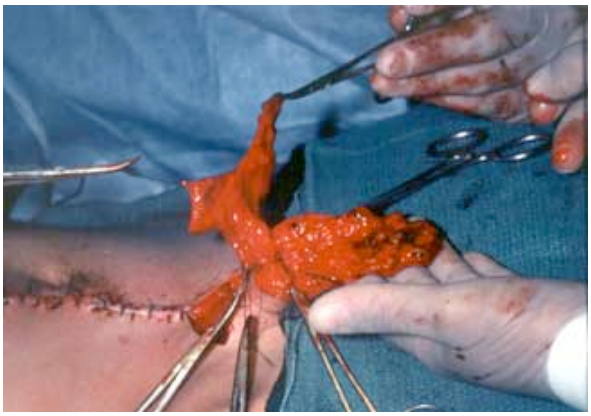


Photo 9.3F

Stage II Three weeks later the flap was divided and inserted into the ulnar side of the hand (see photo 9.3G).

Photo 9.3H

Eight weeks following the injury he has excellent range of motion although I would judge at this time that the flap is just a little fat (see photos 9.3H, I)

Photo 9.3I

Chapter Ten:
UNUSUAL FLAPS AND COMPLEX RECONSTRUCTIONS

A thin flap for reconstruction of the palm:

A flap for the palm must be thin to be effective. A superiorly based flap is often used and the hand and wrist must be held in full supination with the use of a Kirschner wire through the radius and ulna. Because the distal ulna is small it is always better to place the Kirschner wire through the ulna first then into the radius while they are held in the desired degree of supination/pronation. A suction drain is frequently helpful because of the concavity of the palm.

Case No 1:

A 31-year-old man caught his right dominant hand in a printing press roller. Examination revealed a distal based ulnar avulsion flap extending up onto the dorsum of the hand on the ulnar side. Most of this was nonviable (see photos 10.1A, B).

Photo 10.1A

Photo 10.1B

Stage I. He was taken to surgery. His wounds on the hand were debrided and W's were made along the borders of the wound. The dorsal wound could be covered with a split thickness skin graft (see photo 10.1C). A large flap based superiorly was designed by tracing the recipient wound of the palm on a sterile plastic drape.

Photo 10.1C

It was raised and thinned leaving the base of the flap full thickness (see photos 10.1D, E). At the end of the procedure, the relatively thin flap can be seen with the full thickness stem of the flap (see photo 10.1F).

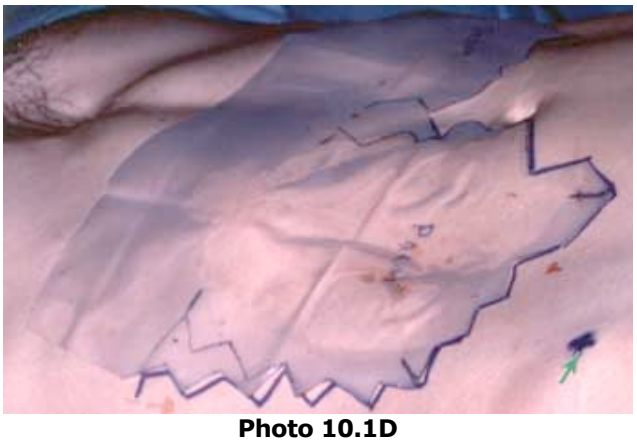


Photo 10.1D

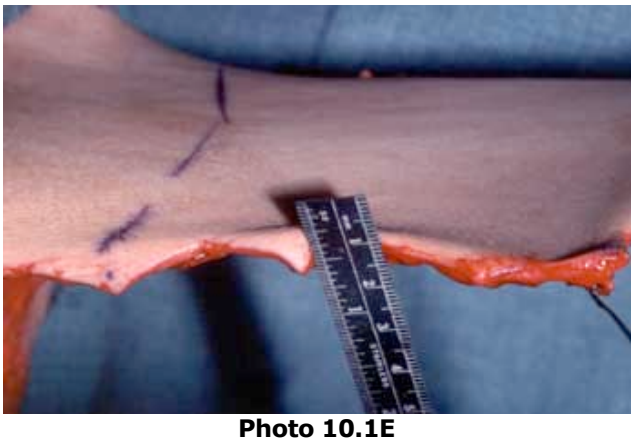


Photo 10.1E

Photo 10.1F

Stage II. Twenty-two days later the flap was divided carrying some additional tissue along the ulnar side and dorsally. Final photos show the result at 2 years postop (see photos 10.1G, H).

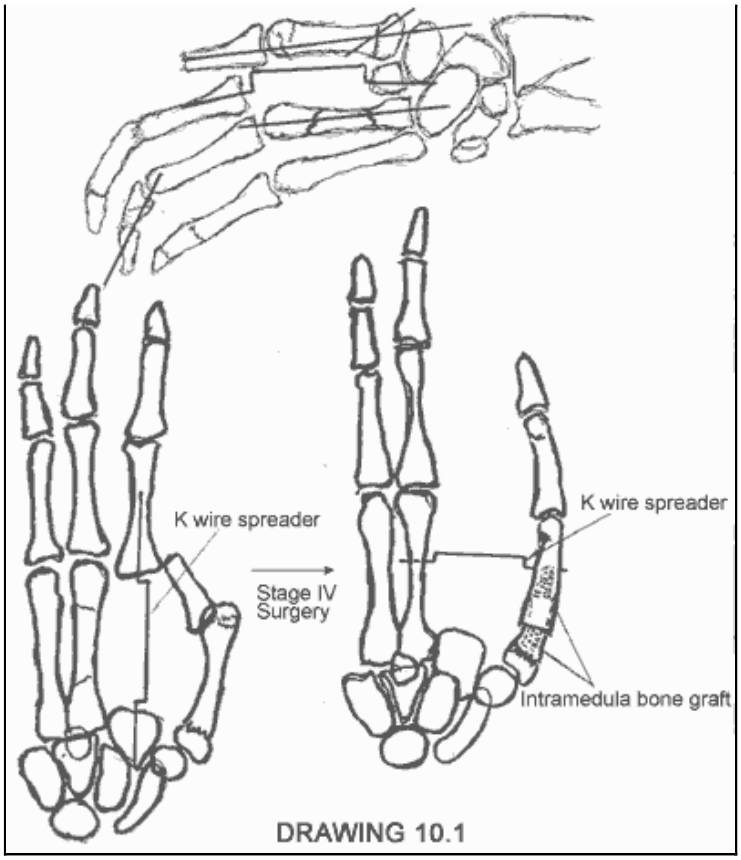
Photo 10.1G

Photo 10.1H

The use of internal fixation with abdominal flaps in complex injuries:

Kirschner wires can be used in a variety of ways to hold the hand in the position of function while undergoing the flap reconstruction. The Kirschner wire can be used to hold the hand in various positions of supination and/or pronation by drilling a 0.62 inch Kirschner wire across the ulnar and into the radius while the wrist and hand are in the desired position. The Kirschner wires can be bent into a bayonet shape to hold

space where there has been significant bone loss. The bayonet Kirschner wire can also be frequently used as a spreader to maintain the distance in the thumb index web space (see examples in drawing 10.1.).



DRAWING 10.1

Chapter Ten:
UNUSUAL FLAPS AND COMPLEX RECONSTRUCTIONS

Case No. 2:

An 18-year-old female suffered a punch press injury to her left hand. She suffered significant degloving of the skin of the thumb as well as they severely crushed index finger and complete absence of the metacarpal III presumably lost by the mechanism of the injury. There was also severe degloving of much of the palm as well as the dorsal surface of the hand.

Stage I. the patient was taken to surgery where extensive debridement was performed, fractures were stabilized and the metacarpal III bone loss was splinted and the space maintained with a bayonet Kirschner wire (see photos 10.2A, B).

Photo 10.2A

Photo 10.2B

A large abdominal flap based inferiorly was designed to cover both the dorsal and volar areas of skin loss. The flap incorporates both superficial inferior epigastric vessels as well as the left superficial circumflex iliac vessels. In the photo the anterior superior iliac spine is noted with the "X". The design of the flap and planning is noted on the glove wrapper paper (see photos 10.2C, D).

Photo 10.2C

Photo 10.2D

The flap is seen in its final application to the hand with the stem of the flap wrapping around the metacarpal and other remnants of the thumb (see photos 10.2E, F).

Photo 10.2E

Photo 10.2F

Stage II. One month later the stem of the pedicle was transected, excess fat excised and closed.

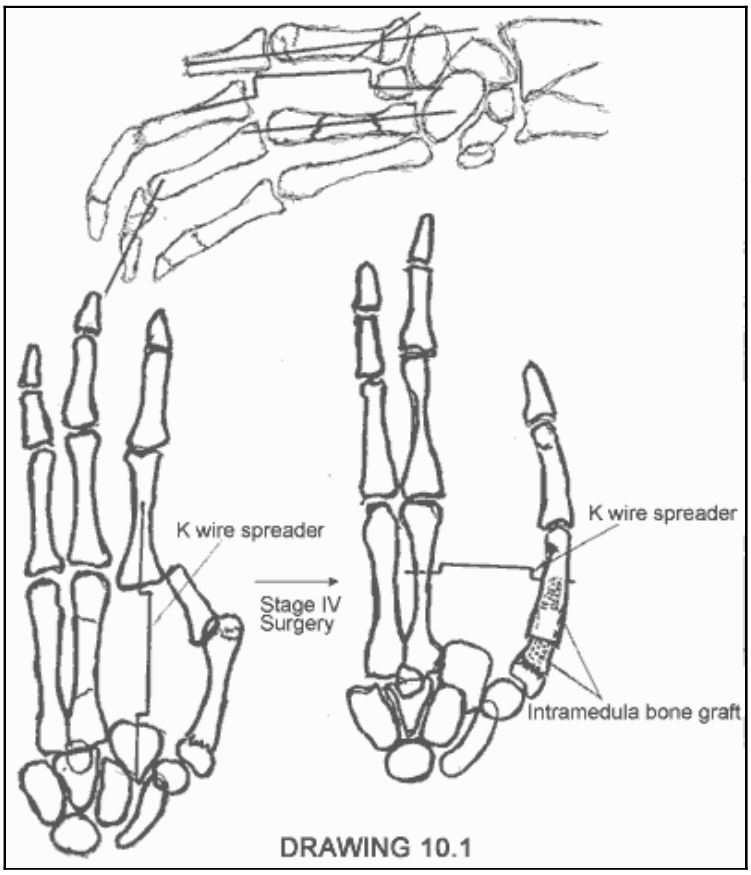
Stage III. Two months later or three months following the injury, the flap was revised to a minimal degree.

Stage IV. Four months later or seven months following the injury along the finger remnants were transferred to the thumb remnants, amputating the thumb metacarpal at the big portion and amputating the long finger through the middle of the proximal phalanx (see photos 10.2G, H, I) Using a peg type bone graft, fusion of the proximal phalanx to the thumb metacarpal was performed (see drawing 10.1).

Photo 10.2G

Photo 10.2H

Photo 10.2I



DRAWING 10.1

Final result at ten years with excellent function (see photos 10.2J, K, L).

Photo 10.2J

Photo 10.2K

Photo 10.2L

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