Surgical approaches to the shoulder

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The shoulder joint is perhaps the most complex joint in the body. Preserving function after a surgical procedure on the shoulder would seem to be difficult. For five common approaches to the shoulder, the application of priorities in shoulder surgery is discussed to illustrate how decisions have been made in the past and how new procedures should be designed. The priorities in shoulder surgery, in order of importance, are (1) to preserve tissue viability, (2) to preserve motor control of muscle tissue and maintain muscle geometry, (3) to achieve sufficient exposure, (4) to ensure postoperative cosmesis, and (5) to preserve skin sensations.

Choosing a surgical approach for the treatment of shoulder problems is a challenge that involves setting priorities for conflicting goals. The shoulder is the most mobile joint in the body and is richly supplied with nerve and vascular structures. The basic concern that directs the surgeon, of course, is the preservation of motion and function. Although each operation involves different steps, certain principles can be applied in any handling of tissues around the shoulder. The surgeon should consider five priorities in choosing the best approach.

The first priority is postoperative viability of the tissues. For postoperative function and resistance to infection, it is important that the tissues not be damaged or left avascular from the surgical procedure. In addition to ensuring the blood supply to the tissues, the surgeon must protect the motor nerves to the muscles around the shoulder as the second priority. The functions of the nerves in the shoulder that supply more distal structures must also be preserved. Maintaining muscle function also demands the preservation of the appropriate geometry (ie, attachments to bone). The third priority is to achieve adequate exposure to perform the procedure. The fourth priority, to ensure cosmesis, is important because the shoulder is so mobile and because it is frequently exposed. The last priority, to preserve skin sensation, is usually of greater consequence than cosmesis in other areas of the body. In the shoulder, however, complications from postoperative numbness are rare, whereas poorly planned scars are a more common cosmetic problem. In this article, we will discuss these priorities as they relate to the surgical approaches to the shoulder.

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PRIORITIES IN SHOULDER SURGERY

Tissue viability

Preserving tissue viability in the shoulder depends on how well the arteries and veins to the muscles are protected. The circulatory system develops so that vessels proceed from areas that are more stable and less mobile to areas that are less stable and more mobile.[20] Vessels usually cross planes of high mobility near points of bone attachment so that the relative motion on the vessel is lessened. They also tend to cross obliquely; the vessels are longer and there is less relative change in length of the vessels with motion than if they were short and straight. There tend to be fewer and larger vessels crossing the highly mobile tissue planes than crossing the less mobile planes. These planes are useful anatomic structures for surgeons because they allow for the desired exposure without damage to vessels.

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Muscle function

Protecting motor nerves and maintaining muscle geometry (eg, bony attachments) are prime considerations in preserving muscle function. Nerves follow a course similar to that of the vessels. They tend to stay close to the major axes of the skeleton so that their length changes less with motion. The presence of adipose tissue, which tends to cluster around nerves and vessels, is another clue at the time of surgery to the presence of nerves and vessels. There is danger of entrapment where the nerve traverses areas with confined borders and less adipose tissue. Several nerves of the shoulder are more likely than others to become entrapped. Areas with confined borders are also areas where surgical trauma is more likely to occur.

The following is a list of nerves and their known danger points:

- *Cranial nerve XI.* This nerve is not in danger of entrapment, but it is prone to being incised during neck surgery because of its relative superficial position in the posterior triangle of the neck (Fig 1).

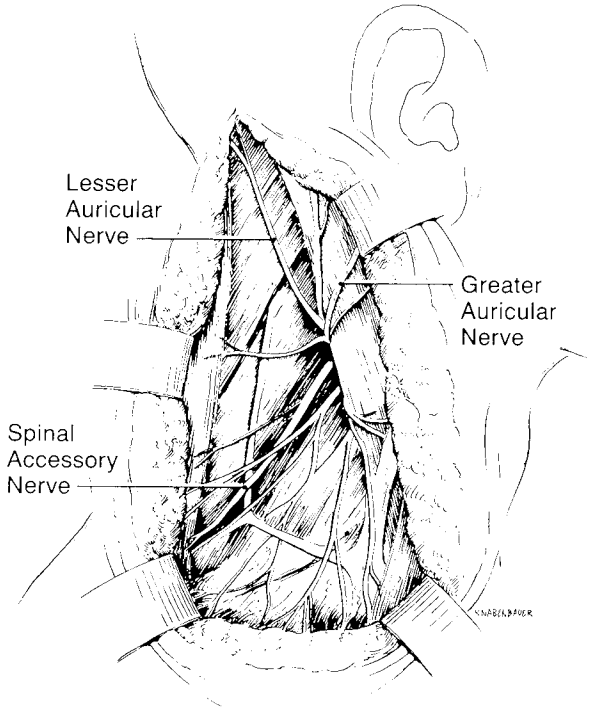

Fig 1. The superficial structures lying on the floor of the posterior triangle of the neck. The most important of these is the spinal accessory nerve that runs roughly through the middle of the posterior triangle where it is easily injured as part of a biopsy or is sacrificed as part of a radical dissection.

- *Long thoracic nerve.* This nerve crosses proximally from a relatively fixed portion in the scalenus medius muscle to its attachment to the highly mobile serratus anterior muscle. It has been theorized that the nerve may be entrapped by hypertrophy of scalenus medius.[9,13] This nerve is also endangered by injuries that involve depression of the scapula, to which the nerve is indirectly attached via the serratus muscle. Such injuries could thereby cause a stretch injury to the nerve. (Wood VE: Personal communication, June 1988).
- *Suprascapular nerve.* This nerve is endangered at two points. First, it may become entrapped by the transverse scapular ligament as it crosses the suprascapular notch.[4,7,17] Second, it may become entrapped as it wraps around the neck of the spine of the scapula, where the spinoglenoid ligament may create a rigid compartment.[8] In this position on the back of the glenoid neck the nerve is in maximum danger when the shoulder is approached posteriorly.
- *Axillary nerve.* The area of possible entrapment for this nerve is the quadrilateral space where it passes beneath the muscles of subscapularis and teres minor and above the muscles of teres major and latissimus dorsi.[3] The lateral border of the space is marked by the shaft of the humerus and the medial border, by the long head of the triceps muscle. The axillary nerve is tightly applied to the inferior capsule in the space. Also, it lies near the medial margin of the subscapularis muscle and may be cut during anterior shoulder approaches unless dissection is performed under direct vision.
- *Musculocutaneous nerve.* Because of this nerve's proximity (2 to 9 cm below the coracoid tip) to the coracoid process as it crosses to its muscles near the point of attachment, it may be endangered by surgery around the tip of the coracoid process. It may also become entrapped subsequently in a transfer of the coracoid process or with reflection of the conjoint tendon.[1,18]

In addition to those areas where the nerve is confined by rigid anatomic boundaries, the entire brachial plexus is endangered by the hypermobile nature of the shoulder joint. Because it is impossible for the course of nerves to completely overlie the instant center of rotation of a joint, the nerves that cross this joint will be lengthened and shortened by its motion. Lundborg and his associates[14–16] have shown that a nerve tolerates an 8% strain before there is venous occlusion and a 15% strain before there is total ar-

terial occlusion. Klein and his associates[11] have shown that, as would be expected, some positions of a shoulder held in traction produce more strain on the brachial plexus than other positions. In their study, forward flexion without horizontal abduction produced the least amount of strain.[11,14–16]

The principles for handling nerves are the same as those for handling vessels: know where they are, look for them, and perform dissection carefully in order to preserve them. Because of the large number of nerves in the shoulder and the importance of muscle function, blind clamping of bleeding vessels should not be done. Packing to control the sources of bleeding that cannot be seen is preferable to either blind clamping or blind application of electrocautery.

To maintain the geometry of the muscle, a surgical approach that splits the muscle rather than divides it is preferable. There are some limitations to splitting, however, as when a nerve lies transverse to the muscle fibers. For example, the anterior branch of the axillary nerve passes about 2 in below the edge of the acromion and thus limits the splitting of the deltoid muscle as an adjunct to the detachment of the deltoid from the acromion (Fig 2). Obviously, with more splitting, less detachment of muscle from the acromion would be necessary for exposure. A conflict may occur in splitting the subscapularis muscle because the innervation is different between the upper and lower portions. We usually split the muscle between the upper and lower subscapular nerve distributions, in roughly a 2:1 or a 4:1 ratio.

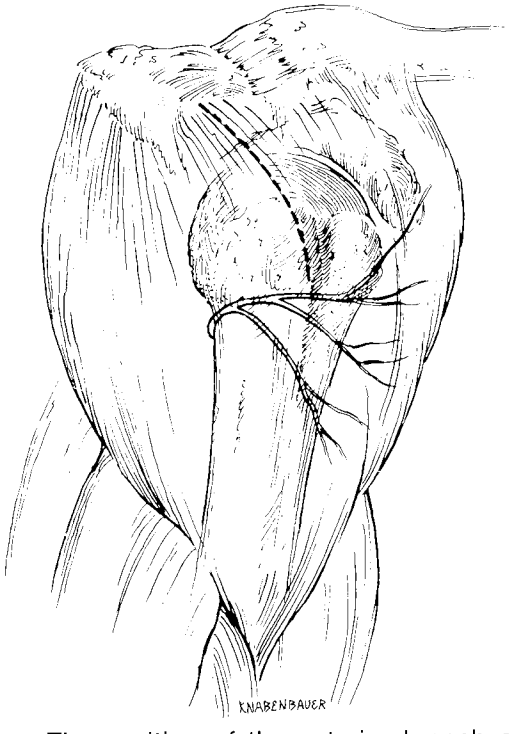

Fig 2. The position of the anterior branch of the axillary nerve that innervates the anterior two thirds of the deltoid. This illustration shows how the nerve limits the extent of the anterior deltoid splitting incision used for acromioplasty and rotator-cuff repair.

The amount of collagen available for reattachment may also limit the muscle detachment. Suturing and stapling techniques involve very small, exact points of reattachment—the holes occupied by the sutures or staples. Tendons rich in collagen, termed "direct insertions" provide better material (ie, greater collagen density) for reattachment at the end of the procedure (Fig 3). In the shoulder, a number of muscles have very broad origins,[19] termed "indirect insertions" (Fig 4).[21] Because these attachments develop only the collagen necessary to transmit the force generated in that section, the broad muscle attachment has a much lower collagen density than that of the narrow muscle. When it is necessary to detach these muscles (the deltoid muscle is most commonly detached), a secure reattachment can be difficult. Therefore, it is important to take additional collagen off the bone in the form of contiguous periosteum. Reattaching these collagen-poor origins necessitates drilling holes in the bone and using a mattress suture (Fig 5).

The preservation of muscle, nerve, and vessel function is also facilitated by the potential spaces within the shoulder. These spaces are referred to as "fascial spaces" or, in those cases where they have a mesothelial lining, they are referred to as "bursae." They develop in areas where there is a great deal of relative motion between structures and are therefore crossed by vessels and nerves only at the edge of the plane of motion. In addition, these crossing vessels and nerves tend to be relatively large and are well known to the surgeon. The most commonly used potential spaces in the shoulder are illustrated in Fig 6.

Cosmesis

For some 200 years, certain incisions have been preferred for wound cosmesis. In the 19th century, Langer attempted to define optimum lines of incision by making multiple holes in cadavers with an awl and looking for the linear split in the skin. In this century, plastic surgeons have found that relaxed skin tension lines, determined at the time of operation by pinching the skin and relaxing the tension, are more reliable than Langer's lines. The skin is observed for linear creases; the best-defined lines occur when the skin is pinched perpendicular to the lines of optimum incision.

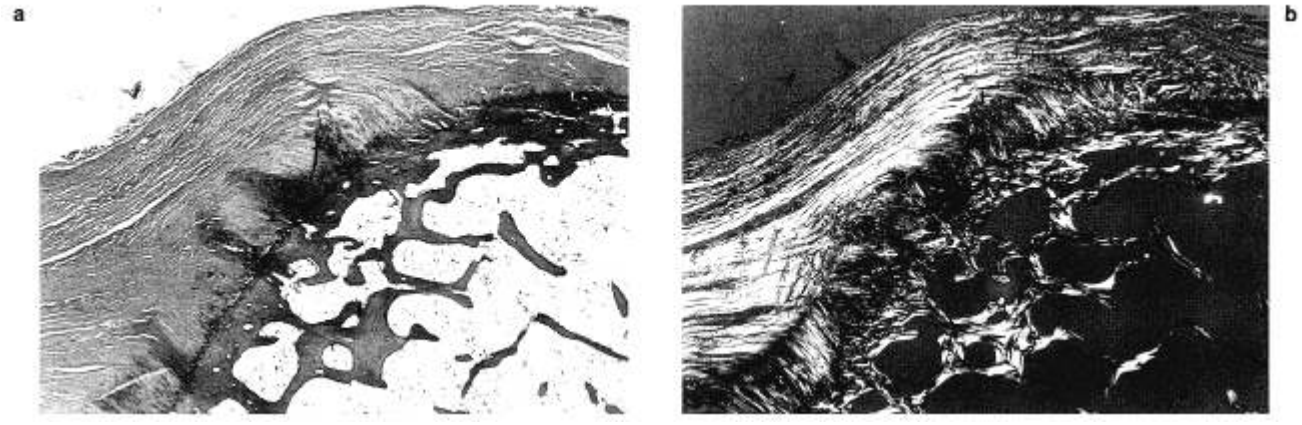

Fig 3. **(a)** A 1X view of the supraspinatus tendon insertion. A direct collagen rich insertion. **(b)** A polarized light view of the same insertion illustrating the density of the collagen and the fact that most of the fibers insert directly into bone.

Skin lines vary between persons and between men and women (Figs 7 and 8). It is believed that the lines develop from stresses caused by the convexities of underlying structures, with contributions from gravity and the motion of the adjacent joints. These underlying convexities have the most influence on skin stress. The lines represent the dominant orientation of the collagen in the underlying dermis and are important because the collagen in a healing wound aligns itself along the length of the incision, regardless of the orientation of the wound.[2,5,12]

The cosmetic incision may not be parallel to the underlying dissection; skin tension lines often form perpendicular to the long axis of the underlying muscles.[12] To make a cosmetic incision and maintain exposure in these cases, it is necessary to raise skin flaps while protecting the circulation of the skin (Fig 9). Anterior to the pectoralis major muscle, the skin is very mobile in relation to underlying muscle. In this and similar areas, the blood vessels cross at the edge of the mobile plane adjacent to the sternum and at the lateral edge of the pectoralis major muscle.[20] They form an oblique course to lessen the relative strain on them with motion. The most important vessels in this area are those that come around the lateral edge of the pectoralis major muscle. Additional perforating arteries to the skin over the deltopectoral groove come off the deltoid artery.

Under these conditions, dissection should be done on the superficial side of the deep fascia. It is not necessary or advantageous to take the deep fascia with the skin flaps because a fasciocutaneous flap offers no additional circulation to the overlying skin. The dominant secondary vessel to the skin over the middle third of the deltoid muscle is the posterior humeral circumflex artery, which lies deep to the

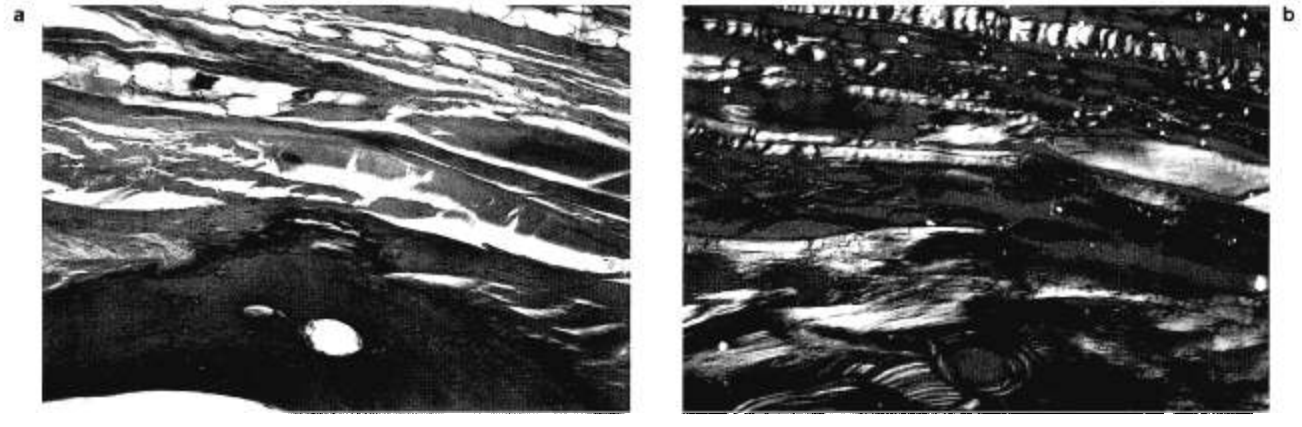

Fig 4. **(a)** A 4X view of the origin of deltoid, an indirect muscle insertion off the spine of the scapula. **(b)** A polarized light view of the same. Note that relatively little of the collagen inserts into bone, and the majority of the collagen that is present continues on to become continuous with the periosteum and with the collagen of trapezius. This we would call a collagen poor insertion.

Fig 5. The proper surgical handling of an indirect muscle insertion. In this case it is the detachment and reattachment of the deltoid origin to the acromion following a partial acromioplasty. Note that an abundance of periosteum is taken with the muscle and is important for the mattress suture reattachment to bone.

deltoid muscle. The skin is very tightly attached to the underlying deep fascia and there is no relative motion between skin and muscle. The vessels pass, vertically, from the posterior humeral circumflex artery through septa in the muscle to the overlying dermis, rather than following the oblique course discussed above. Subfascial dissection offers no additional circulation to the skin in this area; in fact, it offers the disadvantage of disturbing some of the overlying collagen of the deltoid muscle that is necessary for bony reattachment. Also, the result of this vertical blood supply is that there are more small vessels in the area and, because there is no protective extra layer of circulation, the elevation of large skin flaps over the middle one third of the deltoid muscle should be limited. The anterior and posterior thirds of the deltoid are protected by having additional secondary vessels. These are of the oblique type described above. They originate at the edge of the axilla and radiate toward the apex of the shoulder (Taylor GI: Personal communication, August 1988). When it is necessary to mobilize a large area of skin in other areas of the shoulder, as over the biceps muscle, it may be advantageous to take the deep fascia with the skin because there is an extra layer of vessels on the superficial surface of the deep fascia.

Skin sensation

The dominant patterns of the nerves on the skin of the shoulder are illustrated in Fig 10. Preserving skin sensation during shoulder surgery is unimportant compared with that during hand or foot surgery, with one exception; numbness in the intercostal brachial nerve distribution is unpleasant to a large number of patients.

APPLICATION OF PRIORITIES TO SURGICAL APPROACHES

Using standard surgical approaches to the shoulder, we will demonstrate how the above priorities are

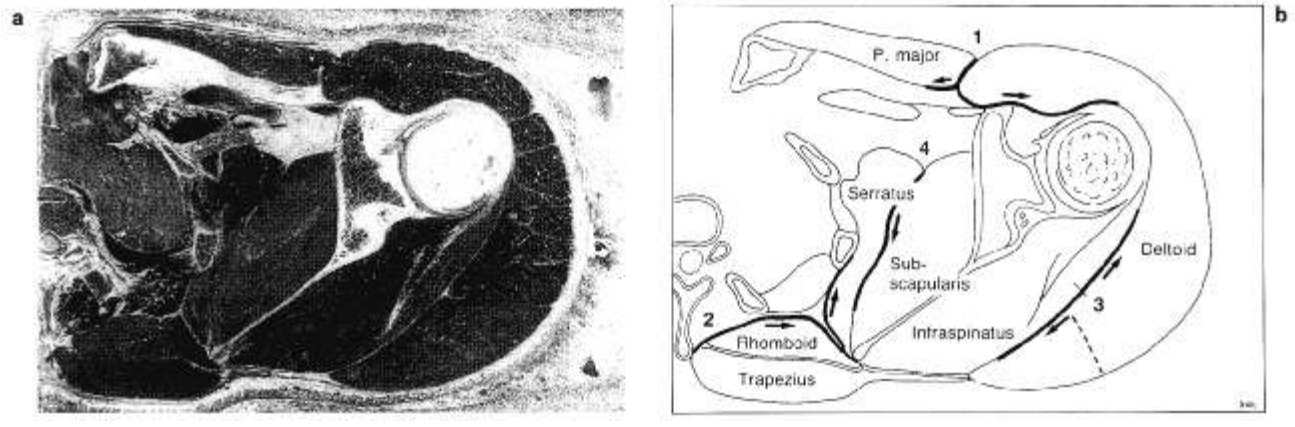

Fig 6. (a) A cross section of a male cadaver at the level of the coracoid to demonstrate the fascial planes commonly used in surgical approaches to the shoulder. **(b)** Diagram of **(a):** (1) The deltopectoral groove and the fascial plane deep to pectoralis major and deltoid. (2) The fascial plane deep to rhomboideus and serratus used in the corrections of Sprengel's deformity and for forequarter amputation. (3) A subdeltoid plane utilized in the posterior approach to the shoulder. The dotted line represents the deltoid splitting incision. (4) The least conspicuous on the cross section, the fascial plane between serratus and subscapularis. Note how in the undisturbed state these spaces are thinner than the ink line used to represent them.

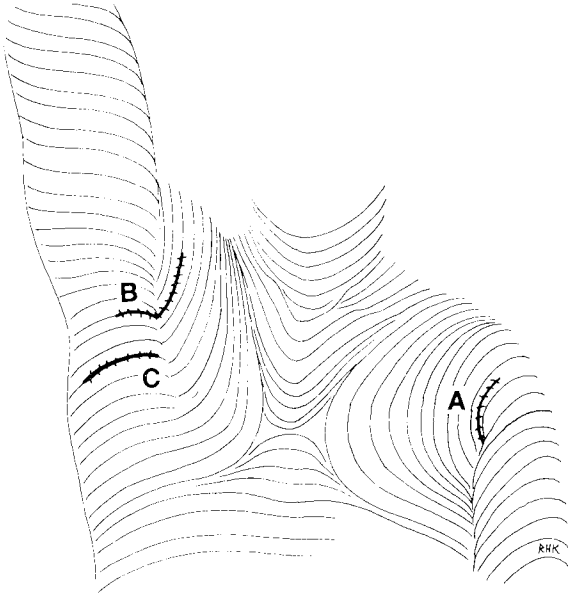

Fig 7. The usual position of the relaxed skin tension lines in the male. Incision A approximates the position of the usual anterior approach to the glenohumeral joint. B shows how in some individuals that incision can be made lower for cosmetic purposes and extended into the axilla. C is the incision within the lines of skin tension for the transaxillary approach to the thoracic outlet syndrome.

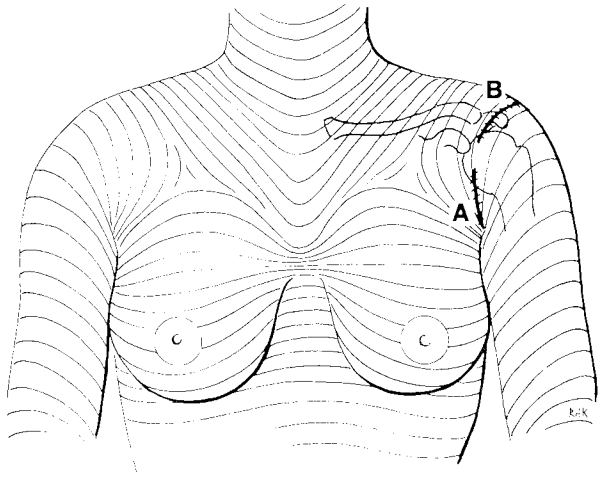

Fig 8. The positions of the relaxed skin tension lines in the female. Note how the change in underlying topography produces some variation in the position of the relaxed skin tension lines relative to the male. Incision A is the anterior incision for approach to the glenohumeral joint and Incision B is the cosmetic incision for acromioplasty and rotator-cuff repair. Incision B can be moved medially for operations on the distal clavicle and acromioclavicular joint and is equally cosmetic as long as the relaxed skin tension lines are used.

applied in practice. Knowing these priorities helps one make decisions when conflicts arise.

Anterior approach

The patient is placed supine on the operating table, with an arm board at the side. The limb is prepped and draped so that it can be manipulated freely. Using the relaxed skin tension technique, a vertical incision is made anteriorly 1 to 2 cm lateral to the coracoid process (Figs 7 and 8). Skin flaps are elevated medially and laterally in the plane between the subcutaneous fat and the deep fascia. Bleeding is most prominent from the rete cutaneum, a horizonally oriented network lying at the base of the dermis; the subdermal plexus, which lies deep to the superficial fascia; and the deltopectoral groove perforating arteries.[20] In fact, these perforating arteries are another operative clue to the location of the groove. The skin is retracted with Goulet retractors to demonstrate the deltopectoral groove, where the cephalic vein enters or may not be visible. In women with less muscle mass, this incision can be made more inferiorly for cosmesis. The cephalic vein may be absent and not enter the groove until it reaches the upper end where it goes deep to penetrate the clavipectoral fascia. The vein is preserved to decrease postoperative pain and is moved laterally with the deltoid muscle.[19]

Nearly the full length of the deltopectoral groove is opened while the skin is held back with Goulet retractors (Fig 9). Blunt dissection can be performed underneath the pectoralis major and deltoid muscles. The Goulet retractors are then moved to retract these two muscles. The lateral border of the conjoint tendon is dissected free of adjacent soft tissue, and the tendon is retracted medially with a long, narrow Richardson retractor. Some lateral fibers of the conjoint tendon may need to be released in order to obtain adequate exposure. In the Bristow procedure, rather than releasing the lateral fibers, the surgeon obtains adequate exposure by reflecting the conjoint tendon with the attached coracoid tip. In this procedure, the coracoid process is cut with an osteotome 1 cm proximal to the tip, and the conjoint tendon is reflected distally. Care is taken not to damage the attached nerve and vessels on the deep surface by either retraction or careless dissection. In addition to the musculocutaneous nerve, more than 50% of patients will have an additional nerve to the coracobrachialis that comes off the lateral cord of the brachial plexus.[8,10] Attempts should also be made to preserve this smaller nerve. In the soft-tissue procedures in which the coracoid tip is not being transferred, we

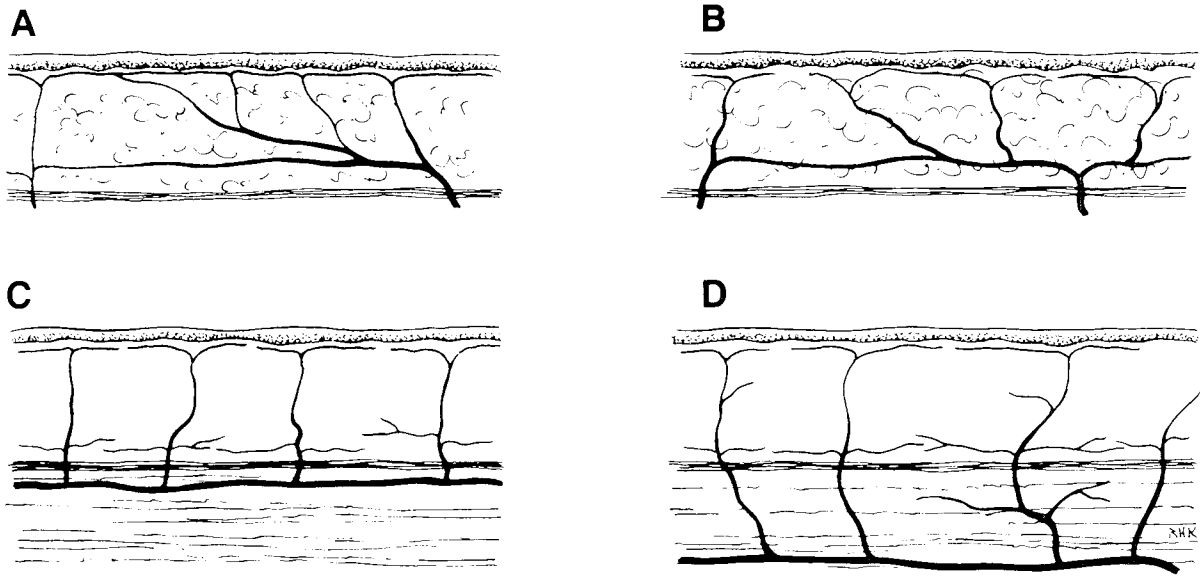

Fig 9. The four most common types of skin circulations. Type A is seen where there is a great deal of relative motion between the subcutaneous fat and the deep fascia. In these areas there tends to be a large axial direct blood supply to the skin as there is anterior to the pectoralis major. These vessels travel just deep to the superficial fascia as they send direct branches to the rete cutaneum. Dissection carried out between the subcutaneous fat and deep fascia in a relatively bloodless fashion. Type B can be seen where there is less relative motion between overlying skin and deep fascia. In this case the layer of direct vessels travel immediately on the outer surface of the deep fascia making it advantageous to use fasciocutaneous flaps when wide exposures are required. Type C is seen where the dominant circulation lies directly under a specialized deep fascia and is seen only in the palmar and plantar surfaces and is not relevant to our discussion here. Type D is seen where the skin is very tightly adherent to the underlying deep fascia and the dominant cutaneous supply comes from an artery lying on the deep surface of the muscle via perforating vessels through the intramuscular septa. This is seen over the middle ⅓ of the deltoid where the posterior humeral circumflex artery is the dominant vessel.

prefer a partial release of the lateral fibers of the conjoint tendon to obtain exposure rather than cut the coracoid tip. We feel that this is less likely to produce a retraction on the nerve from a distal reflection of the conjoint tendon or an impingement problem on the deep surface of the coracoid process by malunion after reattachment.

The subscapularis tendon is split in line with its fibers between the superior, two thirds or four fifths, and the lower, remaining portion (Fig 11).[8] The boundaries of the tendon are the subscapularis recess superiorly and the anterior humeral circumflex artery inferiorly. It is usually necessary to cauterize the branches of the anterior humeral circumflex vessels that supply the anterior surface of the tendon. The tendon is split near its musculotendinous junction because it is easier to separate the tendon from the underlying capsule at that point. The capsule and tendon are too tightly adherent more laterally, and it is difficult to split the tendon without also dividing the capsule. A periosteal elevator is used to develop a space deep to the subscapularis muscle and tendon and to clear off a small area on the neck of the glenoid. The glenoid neck retractor is placed into the wound to retract the conjoint tendon and the medial portion of the subscapularis medially, and a Gelpe self-retaining retractor is used to separate the split subscapularis tendon. With this visual field, the tendon is further separated from the capsule. The further subperiosteal exposure of the glenoid neck is done as necessary. Division of the distal tendon of the upper portion of the subscapularis is required when a capsular shift or similar procedure is to be done.

The capsule is then split in line with the incision in the subscapularis muscle and tendon and a humeral head retractor is placed into the wound. A division of the capsule as for a capsulorrhaphy or capsular shift may be initiated to allow the head retractor to be placed. This exposure allows for debridement of the joint and for visibility in screw placement if one is performing a Bristow procedure. It also allows one to check the optimum point of division of the capsule if one is performing a Bankart procedure, capsulorrhaphy, or capsular shift.

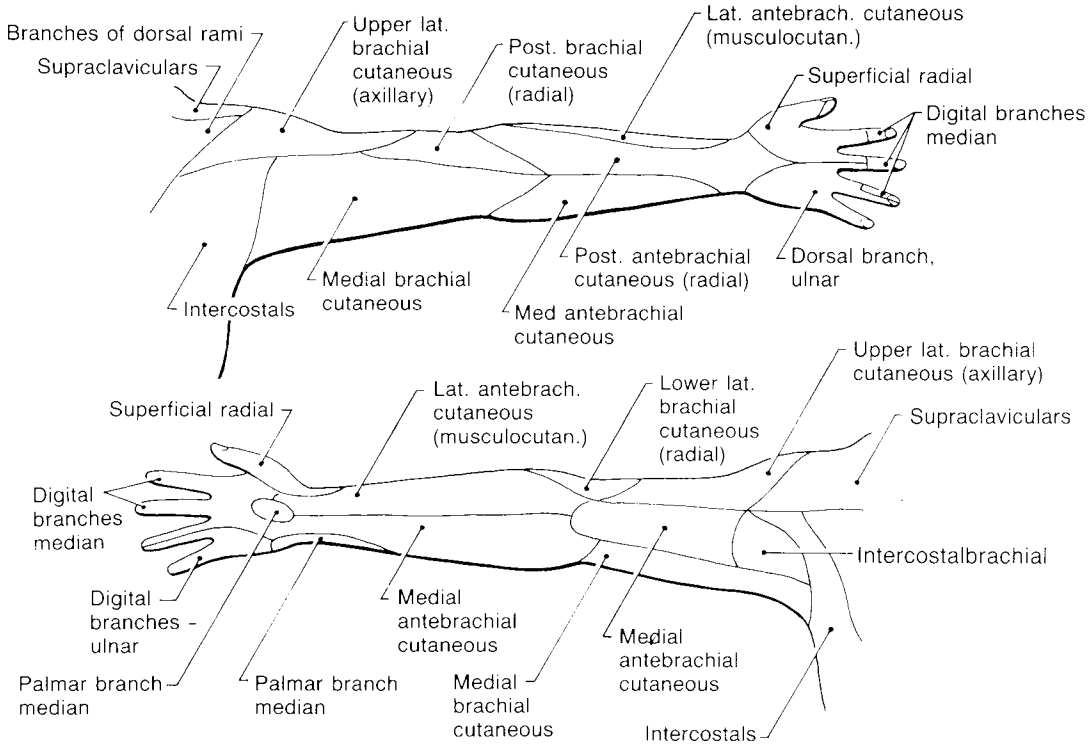

Fig 10. The cutaneous representation of the nerves of the upper extremity.[8] Note that only the axillary nerve among the nerves of the shoulder has a cutaneous representation on the shoulder. Recall also that there is a high degree of overlap rather than demarcation especially between the areas of medial brachial cutaneous and intercostal brachial.

A major modification in the anterior approach is required for placement of a shoulder prosthesis. Because a much wider exposure is needed for this operation, the vertical cosmetic incision would require some detachment of the deltoid muscle. This area is the collagen-poor attachment of the deltoid muscle, however, so reattachment may be difficult and subsequent function may be compromised. Preservation of deltoid function takes precedence over cosmesis in such cases; the longer skin incision is made parallel

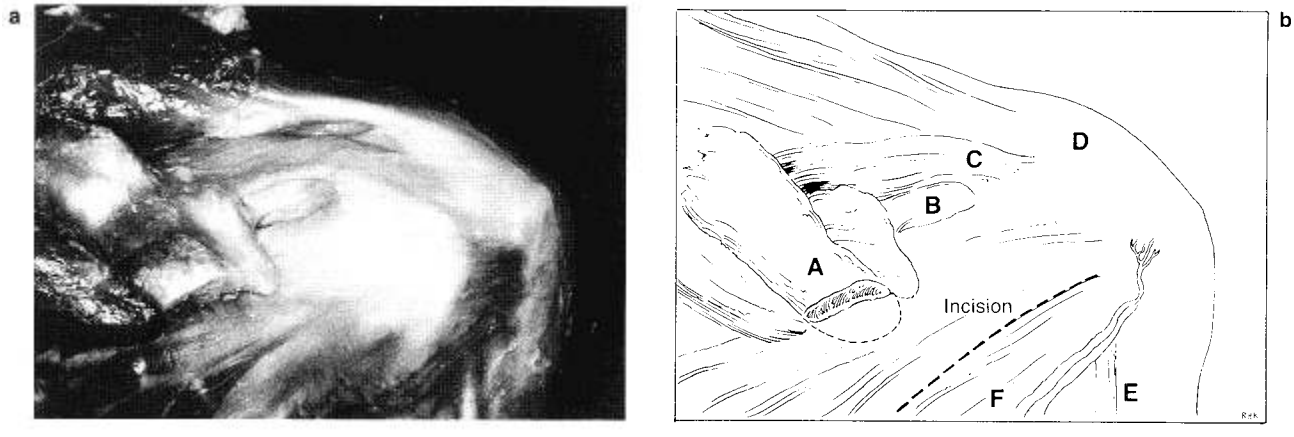

Fig 11. (a) The important anatomic landmarks on the subscapularis tendon. **(b)** A: the coracoid process with its tip amputated for exposure and the adjacent fringe of coracoacromial ligament. The acromion has also been excised. B: Subscapularis recess. C: Coracohumeral ligament. D: Supraspinatus tendon. E: Long head of the biceps. F: Anterior humeral circumflex vessels denoting the inferior border of the subscapularis muscle and tendon. Note the branches of these vessels going superiorly onto the anterior surface of the tendon. The usual position of the incision is shown by the dotted line.

to the deltopectoral groove rather than in a more cosmetic, vertical line.

Superior approach

A skin incision is made in line with the relaxed skin tension lines, which tend to run anterior to posterior above the shoulder (Fig 8). The incision is made where the operation will be performed, either medially for acromioclavicular surgery or laterally for rotator-cuff surgery. The most common source of bleeding is the rete cutaneum; the next layer of bleeding is encountered at the deep fascia and periosteum. The skin here is more tightly attached to the underlying structures, and the skin vessels tend to be vertically oriented, greater in number, and smaller in caliber. Medial and lateral flaps, where necessary, are raised in a conservative fashion. Two fleshy muscle attachments must be considered when performing an acromioclavicular operation such as resection of the distal clavicle: the deltoid and trapezius. These attachments are elevated subperiosteally, preserving the greatest amount of periosteum possible. The ligaments of the acromioclavicular joint are elevated with the muscles. For a rotator-cuff repair, the deltoid muscle is elevated off of the acromion process with periosteum and split in a raphé at the anteromedial corner for a distance of 1½ in. The reattachment of the deltoid muscle to bone, as illustrated in Fig 5, is as important as what is accomplished below the exposure.

Posterior approach

The posterior approach utilizes a vertical incision with relaxed skin tension lines (Fig 12). The patient is placed in the lateral decubitus position with the involved limb and shoulder draped free for ease of manipulation. The key point is similar to the posterior portal for arthroscopy—approximately 2 cm medial to the posterior corner of the acromion and 2 cm inferior to the spine of the scapula. The cosmetic incision crosses this point. The maximum bleeding in this area occurs in the rete cutaneum, with a lesser amount occurring in the superficial portion of the fascia over the posterior portion of the deltoid muscle. Because the skin incision does not lie parallel to the fibers of the deltoid muscle, the skin is elevated in all directions, especially medially and laterally. Dissection is carried out between the deep fascia and overlying fat.

The deltoid fascia is divided and the fibers are split. Again, the split that is chosen is directly over the key point. The space deep to the posterior deltoid is entered through a dense layer of fascia, which is split in line with the deltoid muscle fibers. Retraction is easily accomplished in the highly mobile space deep to the deltoid (Fig 6). The distal limit of the deltoid split is the teres minor muscle, which will avoid the axillary nerve. Any additional exposure, if needed, can be gained proximally by detaching the deltoid muscle from the scapula and observing the techniques mentioned above for indirect insertions.

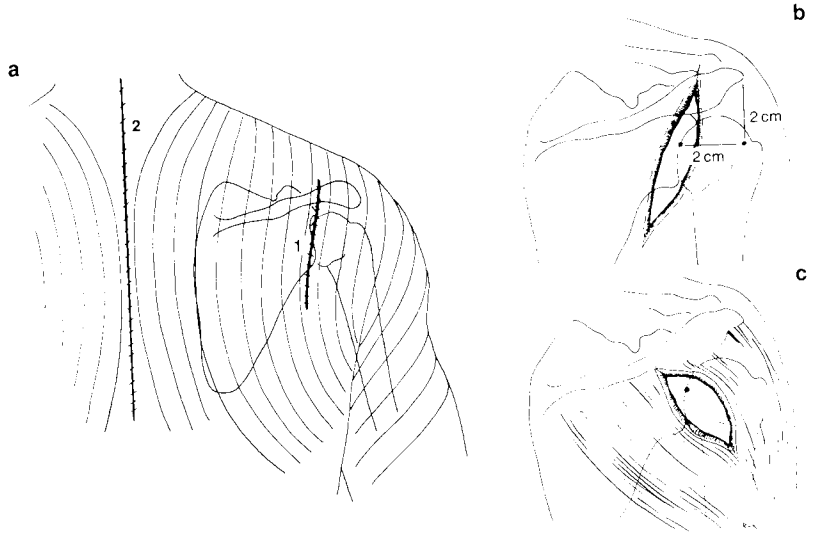

Fig 12. (a) The usual position of the relaxed skin tension lines on the posterior shoulder and the two most common incisions. Incision 1 is for a posterior approach to the glenohumeral joint and Incision 2 is for the Woodward procedure. **(b)** The incision is made in the lines of skin tension in such a way that it includes the key point that is the usual posterior portal for arthroscopy of the shoulder and lies 2 cm below the posterior corner of the acromion and 2 cm medial. **(c)** The deltoid muscle split is in line with the muscle fibers and is also centered over this point.

An intermuscular interval is selected over the most prominent part of the glenohumeral joint. Although this interval appears to be that between the infraspinatus and teres minor muscles, in most patients it is the median raphé of the infraspinatus muscle and one is actually splitting a muscle (Fig 13). The limit of dissection should be 1 cm medial to the rim of the glenoid so as not to endanger the suprascapular nerve. The interval between the infraspinatus and teres minor muscles may be sought but the exposure may be compromised because the interval is more inferior. This is particularly so in obese persons or those with heavily developed muscles that compromise the exposure. The use of a glenoid-neck retractor provides clear exposure of the medial edge of the capsule. The infraspinatus muscle can be spread with the Gelpe retractor. The joint can be opened and exposed as in the anterior approach, using a humeral-head retractor. A capsulotomy, or osteotomy, or other procedure can be performed as desired. Repairing the posterior wound after reconstruction has been completed involves only the superficial layer of the deep fascia of the deltoid muscle, the subcutaneous fat, and the overlying skin.

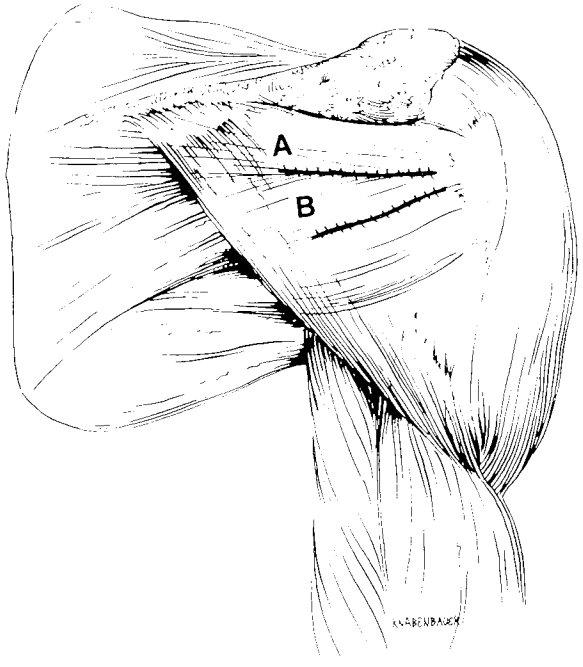

Fig 13. The position of infraspinatus and teres minor deep to the deltoid. Incision A is actually a muscle splitting incision within the substance of infraspinatus, the medial limit of which is the suprascapular nerve. Incision B is a true internervous plane between infraspinatus and teres minor but is more difficult to reach in muscular individuals and is not utilized as frequently.

Axillary approach

The patient is placed in the lateral decubitus position with the involved shoulder elevated and the thorax tilted posteriorly, up to 60°. The skin tension lines run horizontally in the inferior portion of the axillary fossa. The arm is held in the abducted position and an incision is made where the skin reflects away from the chest wall, at approximately the level of the third rib (Wood VE: Personal communication, June 1988). Dissection is carried down to the level of the deep fascia of the serratus anterior muscle and then superiorly. The long thoracic nerve is located and preserved (Taylor GI: Personal communication, August 1988). The lateral thoracic artery and accompanying vein are visualized and sacrificed; blunt dissection is used to elevate the adipose tissue from the muscle in a superior direction. The intercostal brachial nerve in the second intercostal space is identified and maintained.[22] In the first intercostal space, the superior thoracic artery and vein are identified and sacrificed. Then, the first rib can be reached and the scalene muscles, the brachial plexus, and the subclavian vessels can be seen through this exposure. Proper exposure depends on proper arm traction. Because the axillary approach is made through an avascular plane (except for "named" vessels) and does not divide any important musculature, only the subcutaneous fascia and skin are closed.

Posterior subrhomboid approach

The posterior subrhomboid area of dissection is utilized for the reconstruction of Sprengel's deformity and for forequarter amputations. The exposure described here is used in the Woodward procedure for congenital elevation of the scapula (Figs 6 and 12**a**). Skin flaps that are used for forequarter amputations obviously are chosen for purposes other than cosmesis.

The patient is placed in the prone position with the shoulder and limb draped for free manipulation. The cosmetic incision is made on the midline, close to the relaxed skin tension lines (Fig 12). Dissection is carried down to the level of the deep fascia. The trapezius muscle is detached from the bone where it is broad and tendinous and then dissected free from the underlying latissimus dorsi origin at its inferior portion. The rhomboid muscles are detached in like fashion and the dissection is continued laterally in this potential space (Fig 6). The artery encountered here is the deep transverse cervical or dorsal scapular; the nerve is the dorsal scapular. These cross the potential space at the superior extent.

In forequarter amputations the dictates of tumor

resection of course do not always allow for the use of cosmetic incisions; deep to the skin, however, the same principles of soft-tissue dissection and preservation of tissue viability are followed (Fig 6). The posterior portion of a forequarter amputation follows a path similar to that of the Woodward procedure for Sprengel's deformity. In this procedure, as described by Enneking,[6] dissection continues even farther forward into this loose alveolar tissue, deep to the serratus anterior to allow for a bloodless dissection. The next vessels to be encountered would be the lateral branches of the intercostal vessels, which are encountered in the midlateral line. After the Woodward procedure has been completed, the collagen-rich portion of the posterior musculature is reattached to a new position on the spines of the vertebrae and a cosmetic closure of fat and skin is done.

CONCLUSION

The shoulder is the most highly mobile and perhaps the most complex joint in the body. The pursuit of one surgical goal may conflict with the pursuit of other surgical goals. However, setting priorities to attain these goals and applying sound surgical principles, as illustrated in these five common surgical approaches to the shoulder, will simplify the decision-making process.

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