FACIAL FLAP SURGERY

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DEDICATION

This book is dedicated to our friends and mentors in dermatologic surgery. I thank David Leffell for providing me with an outstanding residency education in dermatologic surgery and Leonard Dzubow for teaching me his artful understanding of tissue motion. The core of this text reflects his insight into the complexities of biomechanics in facial reconstruction. I thank Joel and Jonathan Cook for inspiring me with their beautiful reconstructions and for sharing their expertise and criticism throughout my career. Jonathan has provided several of the figures for this text. I am grateful to my residents and fellows, with whom it is so much easier and more enjoyable to operate. To Todd Holmes I owe special thanks. He was my second fellow, and he is now my outstanding associate. His contributions to this book are artful. My last fellow, Christopher Yelverton spent hundreds of hours carefully editing and providing voiceovers for the DVD. Videography was ably provided by my medical assistant, Leah Fox. My first technician, Elizabeth Robson spent a dozen years cutting many thousands of histology sections, arranging my schedule, and assisting me in surgery as I learned my craft. Lastly I am indebted to the many inspired surgeons who created the path for us to follow. Every time I think that I have done something new, I find that someone else has been there before. Our goal in writing this text was to analyze the accomplishments of the many who came before us, and to distill their successes and failures into a guide for aesthetic and functional reconstruction.

CONTENTS

FOREWORD

A teacher affects eternity; he can never tell where his influence stops.

—Henry Brooks Adams

The honor of writing a foreword is usually bestowed upon wise, skilled, and qualified experts and teachers. As a perennial student of the authors of this superb work, I feel not only privileged and overjoyed but also humbled by the prospect of writing an introduction for an essential text for surgeons. Perhaps the youth of today's dermatologic surgery will take for granted yet another treatise on surgical reconstruction of the face. Yet it was not so long ago that a handful of dermatologic surgeons were pioneering their way into unchartered and at times what may have felt like unwelcome territory for their beloved specialty. We often forget that the surgical flaps we readily perform in our offices are the distilled product of years of surgical reconstructive evolution brought about by our multiple and diverse predecessors' creativity, curiosity, necessity, refinement, and courage sprinkled in with some serendipity. As readers of this text, we have the incredible good fortune to learn from two masters, an ingenious and magnificently understated teacher and his daring and creative student who pushes the reconstructive envelope further and is now teaching others.

This comprehensive text reviews the fundamental principles of surgical reconstruction and then describes the ideal use of those principles in each anatomic region of the face. Solely the work of its authors (and unlike edited texts), this book reads more uniformly and hence its ability to guide the reader from simple to more complex reconstruction never falters. That same uniform quality is manifested in the invaluable clinical photographs that capture the full story of the reconstruction with abundant intraoperative photographs. The text is replete with the complex and challenging defects surgeons face in their daily reality and it explains, using both clarity and honesty, how to progress from "preoperative" to "postoperative" with unpretentious warnings of pitfalls for the beginner. And the authors do not shy away from critically evaluating the limitations of beautiful yet theoretical geometric principles and their use in the very tangible and practicality of a patient's face. Finally, to top it all off, a collection of narrated videos revealing step-by-step instruction provides the reader with essentially the magician's secrets and perhaps the fulfillment of a seemingly impossible wish in the form of a virtual apprenticeship.

Just like a teacher who influences eternity, these authors have compiled their experience and wisdom to influence the lives of not only us, their humble students, but also countless grateful patients.

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PREFACE

There are few things more gratifying than the elegant repair of a facial operative wound. To be a good surgeon requires a thorough knowledge of anatomy, a mastery of operative technique, and an appreciation of the principals of tissue motion. About 20 years ago, Dr. Dzubow published his text on biomechanics and regional application. The field of reconstructive dermatologic surgery has matured greatly over the last two decades, but successful reconstruction still requires a deep understanding of how tissue feels, how it moves, and how it can be manipulated to achieve repair of wound.

The history of reconstruction is long and fascinating. It lies beyond the scope of this text. However, as we deftly and relatively easily repair an operative wound on the nose with a bilobed flap, it is worthwhile to recognize the tremendous efforts and abilities of those who came before us. In this entire text, there is a single figure that I believe may be novel. Otherwise, someone has always been there ahead of us. Where we have been able to do so, we have tried to identify and cite the strongest references we could find for each subject.

The purpose of this book is not to provide an algorithmic approach to reconstruction. It is the worst form of practice to have a cookbook formula to reconstruction. Each operative wound is profoundly different. The same size defect in the same location on two different noses with different sizes, textures, and shapes will call for entirely different reconstructive plans. A good reconstructive surgeon assesses a wound based on host anatomy, wound configuration, the shape and nature of the surrounding facial tissues, and then, perhaps most importantly, the desires and expectations of the patient.

Patients usually do want to look normal. They do not all want to be perfect, but it is a mistake to assume that older individuals and those who may not be models (most of us) do not have a strong investment in their appearance. Too many times in my career I have seen physicians perform an expedient or “safe” repair, either out of a lack of confidence or out of the misguided feeling that as long as the wound healed the patient would be satisfied. There is a difference between accepting a repair and being pleased with it. Having said that, some patients do not want an involved repair, and in those cases, with appropriate discussion, very basic and simple repairs are warranted.

This text is divided into 16 chapters. The first five chapters deal with the concepts of tissue motion and the intricacies of advancement, rotation, transposition, and island flaps. The sixth chapter deals with interpolated pedicle flaps. Chapters 7-15 are regional reconstruction chapters. Chapter 16 deals with complications, how to deal with them, and how to learn from them to avoid repeating the same mistakes.

We have tried in as many cases as possible to include only photos that are of the same size and exposure for preoperative, intraoperative, postoperative, and long-term follow-up views. Most common flaps and variations are shown in this text, but there are a few we have not gotten around to. Every surgeon has his favorite and least favorite flaps, so the text is inherently biased, but not all flaps are created equal, and some flaps are more equal than others. In the accompanying DVD, we have filmed and edited 27 videos that have been cropped to 2-5 minutes each, all of them accompanied by narration.

My best friend in plastic surgery, David Leitner, once told me that no one should ever create a wound he or she cannot reconstruct. I would further that the greatest joy for a dermatologic surgeon is to remove a very challenging tumor and then perform an artful reconstruction. It is a true privilege that we have, the laying on of hands, and the responsibility we accept for our patients. As the practice of medicine becomes more complex than most of us wish to accept, this challenge, this gift is something that cannot be taken away. It is worth doing with excellence.

Glenn D. Goldman, MD
Leonard M. Dzubow, MD

CHAPTER 1
Introduction

The mobilization of soft tissues to reconstruct cutaneous operative wounds is more than just an exercise in geometry.[1] Instead, reconstructive procedures involve the manipulation of biologic tissues with the primary purpose being an approximation of the preoperative state of "normalcy." The mystical attainment of an invisible scar and a complete restoration of the presurgical condition is a worthwhile goal that can be closely approximated—even if perfection is unattainable. The degree to which a minimally perceived result is approached is dependent on a number of biologic factors beyond the surgeon's control. These include the patient's age and general health, the long-term use of certain medications, whether or not the patient smokes, and a number of uncontrollable cutaneous variables such as skin thickness, sebaceous quality, pigmentation, elasticity, actinic damage, prior surgical scarring, and individual variations in scar formation.

Many mechanical tissue parameters are amenable to manipulation. The interaction of the intrinsic biologic properties and the mechanical operations performed on tissues may be aptly described as the biomechanical aspects of wound closure.[2-4] The biology of tissue is a major determinant of its ability to move. This is readily observed in the skin tension lines on the face, where closure in one direction is facile, and perpendicular closure is challenging.[5] The response of tissue during reconstruction involves both intrinsic biologic and mechanical properties and the physics of forces and motion. Knowledge of the mechanics of reconstruction augments the surgeon's ability to design an appropriate wound closure. The limiting biologic properties dictate the available menu of reconstructive designs available for wound closure. Concepts that seem simple and intuitive often have hidden complexity that in select instances become important in optimizing the final closure result. The goals of a successful reconstruction procedure can be arbitrarily divided along biologic and mechanical lines, and each plays an important role in a successful reconstruction.

The mechanical plan of tissue movement is designed to achieve a closure: (1) under minimal tension; (2) without distortion of critical anatomic structures and landmarks such as the lip, nasal rim, eyebrow, and hairline; (3) using skin of matching pigment and texture to the affected region; and (4) with consideration to optimal placement of scars along cosmetic unit junctions. The mechanical reconstructive design is therefore implemented in an attempt to reestablish an aesthetic and functional baseline.

The biologic considerations to tissue movement involve: (1) maintenance of the viability of mobilized tissues; (2) preservation of sensory and motor innervation; (3) appropriate mobilization of tissues to allow for wound closure; and (4) prevention of morbidity such as hematoma, infection, and dehiscence. In order to understand macro-biomechanical concepts, an anatomic model for facial surgery will first be introduced.[6] This will be followed by a discussion of the manipulations used to modulate or decrease tension, redistribute tension vectors, and to reposition redundant tissue. Jointly, these topics are the crux of clinical biomechanics, as they pertain to successful adjacent tissue transfers.

BIOANATOMY OF TISSUE MOVEMENT

Rather than reiterating classical anatomy,[7,8] biomechanics is better understood by introducing, for the face, a heuristic, clinically applicable model of structural organization. The three units to be introduced are fascia, vasculature, and nerve distribution. The anatomic patterns are repeatedly underscored in order to emphasize the biologic implications and their influences on tissue movement.

Fascia

Fascia provides the structural skeleton for the anatomic organization of vascular and neural structures.[9-11] The fascia of the face is nosologically divided into a deep and a superficial component[12] (Fig. 1.1). Superficial fascia is composed of a fatty subcutaneous portion and a deeper fibrous layer that appears to be derived from the interlobular septae of the fat. The fibrous component of the superficial fascia integrates and connects the various muscles of facial expression. Where there is an absence of facial musculature, the fibrous component is a thick, nonstretchable membrane. Clinically, this is observed as the galea of the scalp, as the superficial temporal fascia, and as the superficial musculoaponeurotic system (SMAS) of the cheek. In the presence of the facial musculature, the fibrous portion of the superficial fascia bifurcates to envelope the muscle (Fig. 1.2). The component that splits superficial to the muscle is typically thin and mobile, but the deep component retains the thick, inelastic quality of the fibrous fascia of the nonmuscular areas. This network of fibrous fascia interlinking and enveloping the facial musculature integrates and coordinates complex facial movements (Fig. 1.3).

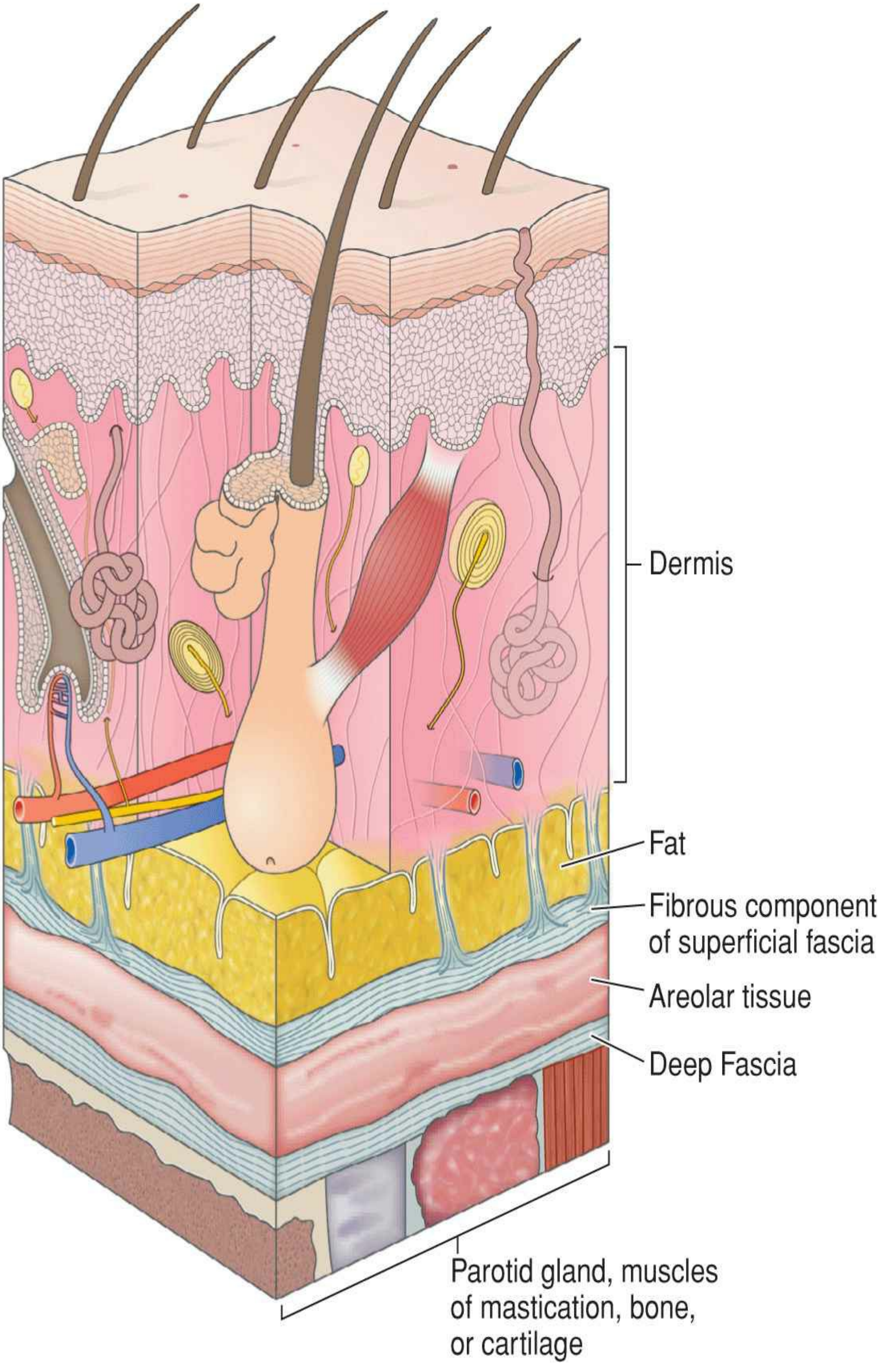

Dermis
Fat
Fibrous component
of superficial fascia
Areolar tissue
Deep Fascia
Parotid gland, muscles
of mastication, bone,
or cartilage

Figure 1.1 *The superficial fascia has two layers separated by loose areolar tissue. The superficial fascia attaches to the overlying adipose through small fibrous attachments. The deep fascia envelopes the facial musculature and parotid gland and is more densely adherent*

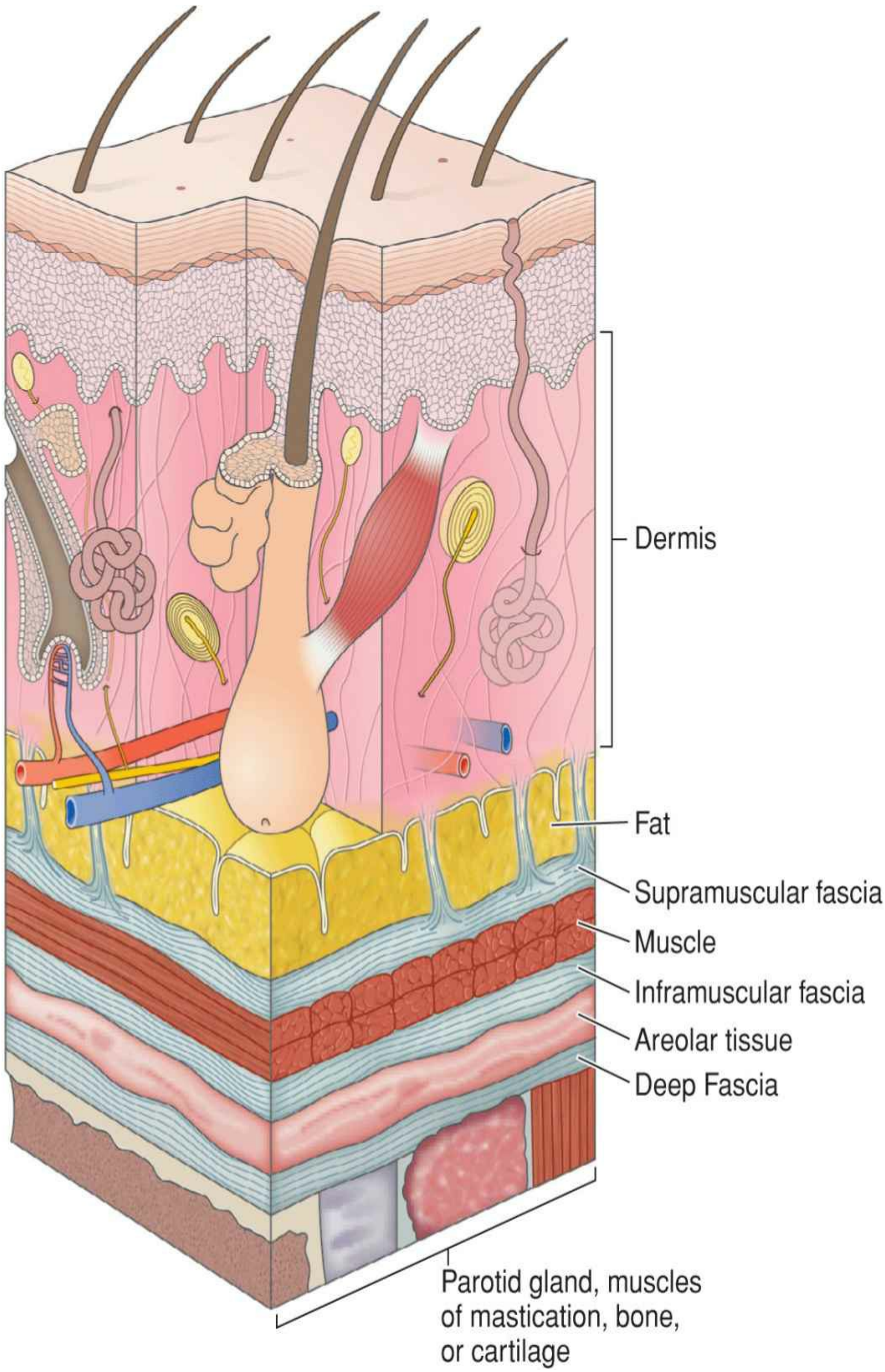

Dermis
Fat
Supramuscular fascia
Muscle
Inframuscular fascia
Areolar tissue
Deep Fascia
Parotid gland, muscles of mastication, bone, or cartilage

Figure 1.2 *The fibrous portion of superficial fascia envelopes the muscles of facial expression. The supramuscular fascia is thin while the deep fascia is thick and inelastic*

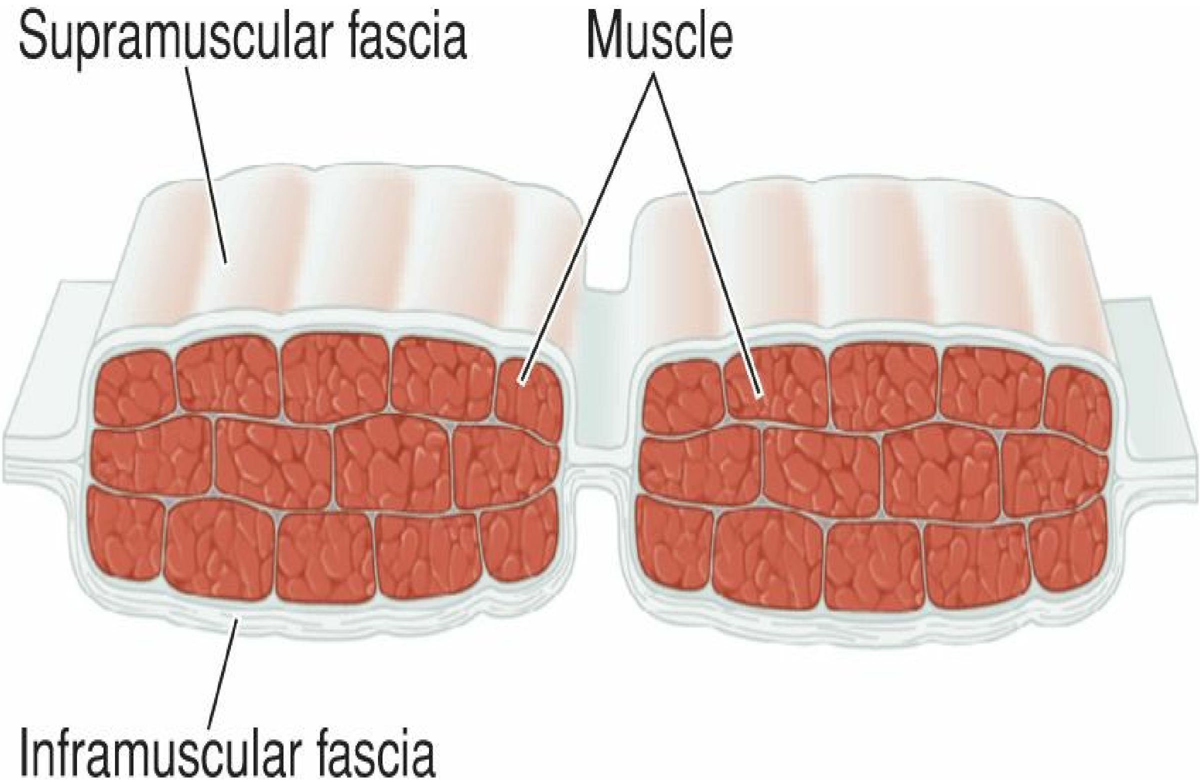


Figure 1.3 *The fibrous portion of superficial fascia envelopes the muscles of facial expression, interconnecting them for coordination of complex movements*

The deep fascia of the face is separated from the superficial fascia by loose, relatively avascular areolar tissue. Facial deep fascia covers cartilage, bone, muscles of mastication, and visceral structures. Similar to the superficial fascia, the deep fascia is a continuous sheet. The nomenclature is altered as it involves various structures, and therefore, deep fascia encompasses the perichondrium, periosteum, temporalis muscle fascia, and parotid-masseteric fascia.

Significant biomechanical consequences result from the incorporation of fascia into mobilized tissues. Mechanically, the fibrous component of the superficia fascial inhibits tissue mobility and prevents the normal elasticity of the skin from contributing to the closure process. Clinically, this situation is exemplified on the scalp and forehead. Undermining is readily accomplished in the deep avascular plane beneath the galea.

However, despite extensive undermining, little tissue mobility is gained. The fascia in this area simply does not stretch.

Fascia may be used mechanically for benefit. Plication of the fibrous component of the superficial fascia can be used to relieve closure tension on the dermis. The fascia of the cheek and neck is frequently plicated in rhytidectomies and reconstructive cheek closures to minimize skin closure tensions[13] (Fig. 1.4). Because of the attachment of the dermis to fascia through interlobular septae, skin is moved without being under tension itself. As an avascular structure with few nutritional requirements, the fibrous component of the superficial fascia is able to bare significant force without vascular compromise. Similarly, the superficial fascia can be anchored to the deeper fascia, thus preventing tension on a free margin such as the eyelid.[14]

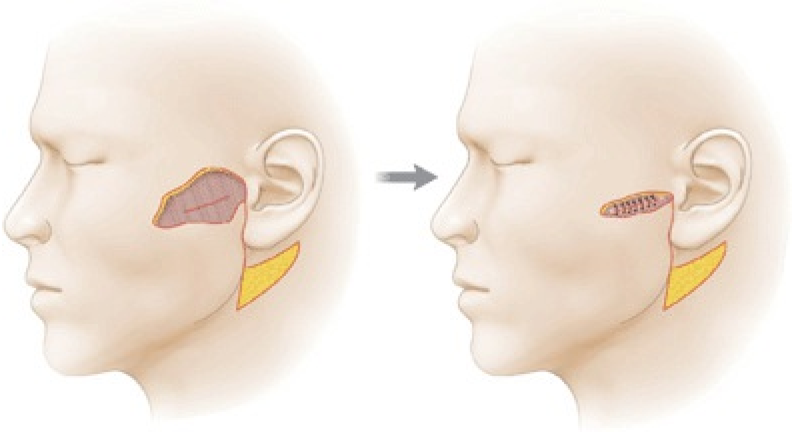


Figure 1.4 *The SMAS may be plicated to achieve reduction in surface (dermal) wound closure tension*

Tension redistribution is also relevant when using the deep fascia in a repair. As noted earlier, deep fascia may be used as an immobilizing structure or anchor to which tissue may be fixed to prevent pull and distortion. Suspension sutures may be placed between mobilized tissue and deep fascia, especially the periosteum, to prevent tension on anatomic landmarks and moveable structures. In the malar area, for example, tissue may be suspended to the infraorbital rim periosteum to prevent vertical tension and ectropion. Flaps from the temple and cheek may be tacked to the lateral orbital rim periosteum to prevent tension on the lateral canthus and lateral ectropion. Therefore, although fascia may mechanically inhibit tissue elasticity, it may be selectively used to relieve skin tension and guide wound closure.

Vasculature

The axial vasculature of the face consists of named branches and their associated angiosomes. An angiosome is a three-dimensional tissue block consisting of muscle, fascia, subcutaneous fat, and skin that is supplied by a particular source artery. On the face there are 13 angiosomes corresponding to larger arterial branches.[15] The named axial arteries such as the facial artery, superficial temporal artery, infraorbital artery, supratrochlear artery, and supraorbital artery branch widely and anastomose broadly to provide a rich arterial supply to the face.

Facial vascular patterns may be organized by vessel caliber, depth, and orientation[16-22] (Fig. 1.5). The named arteries branch and ascend to run in within the superficial fibrous fascia, from which point they give off numerous vertically oriented vessels, which then ascend into the adipose tissue where they branch and interconnect to form a subcutaneous vascular plexus. The subcutaneous plexus is in turn connected to the deep dermal vascular plexus which is then connected to the superficial dermal plexus. The superficial and deep intradermal plexi are composed of a microvascular network that is usually unable to support tissue viability when a flap is performed. The shallowest substantial vascular supply that can support an adjacent tissue transfer is the subdermal vascular plexus. The vessels of the subdermal plexus run horizontally within the superficial subcutaneous tissues. They are preserved by leaving a layer of adipose on the undersur-face of any adjacent tissue transfer.

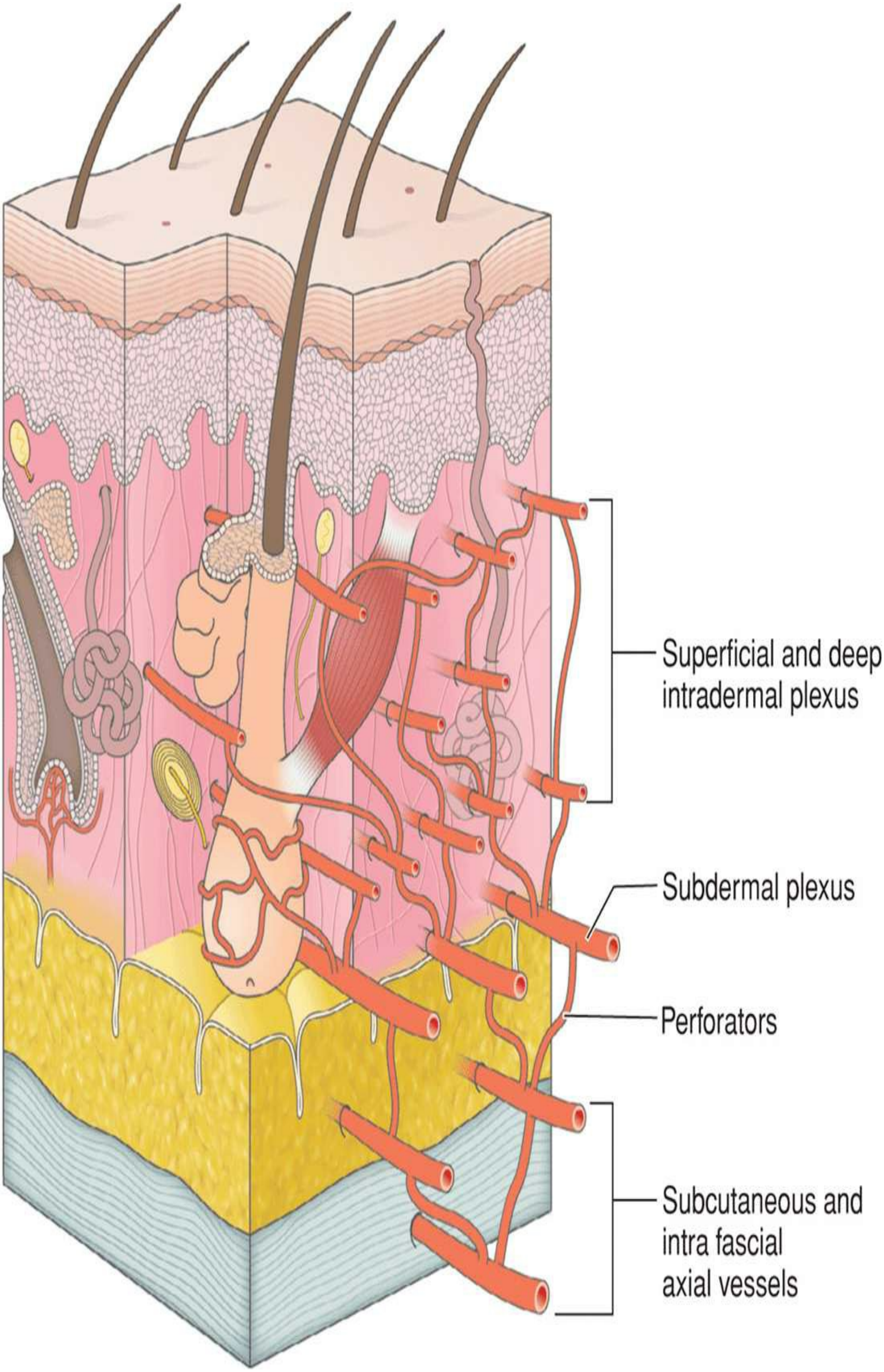

Superficial and deep
intradermal plexus
Subdermal plexus
Perforators
Subcutaneous and
intra fascial
axial vessels

Figure 1.5 *Cutaneous and subcutaneous vasculature is composed of horizontally and vertically oriented networks with the caliber of vessels largest where they run within or just deep to the fascia*

In most facial reconstructions, the redundancy of the subdermal plexus allows for a reliable blood flow; however, incorporation of vessels from the deep plexus can be needed in certain instances due to flap design, flap tension, or underlying host factors such as heavy smoking. Mechanical planning must always be coupled with an awareness of how tissue viability is to be maintained.

Nerves

Neural input is unimportant to flap survival, but flap design and actuation should take into consideration the underlying nerves, as neural function is of crucial importance to host biology and function.

Two patterns of neural organization apply: sensory innervation and motor innervation. Sensory innervation of the face is derived primarily from branches of the trigemina nerve and the first several cervical nerves. After leaving their foramina of origin, the trigeminal nerve branches ascend to the level of the superficial fascia where they run just above the fibrous component of the superficial fascia or within the subcutaneous tissues (Fig. 1.6). In areas where the SMAS envelopes facial musculature, the sensory nerves are within the thin supramuscular component and are often accompanied by small axial vascular branches creating neurovascular bundles. Small branches of these nerves intermittently ascend to innervate portions of the overlying skin. Therefore, undermining at any level is capable of causing sensory denervation.

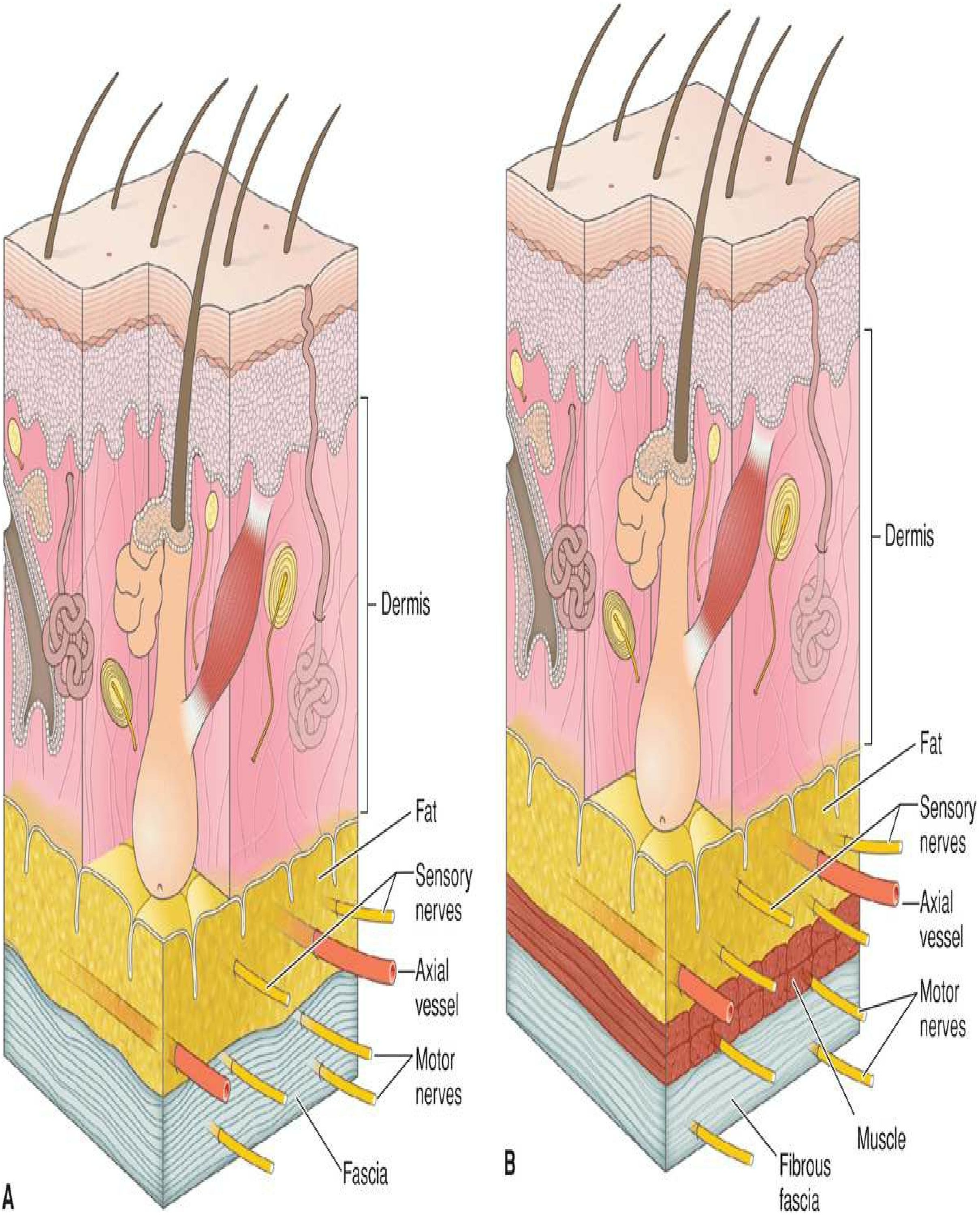


Figure 1.6 (A) *Sensory nerves are usually paired with axial vessels where they run as neurovascular bundles within the thin superficial fascia. Motor nerves run within the deeper fibrous component. (B) Where facial muscle exists, sensory nerves run superficial to the muscle, whereas motor nerves run deep to muscle*

Several areas are particularly prone to sensory disruption. The forehead is richly innervated by the supratrochlear and supraorbital nerves. While these nerves emerge deeply from bony foramina, they ascend quickly to run over the surface of the frontalis muscle. Incisions on the forehead, especially those that are horizontal, risk disruption of these nerve branches. While the most common eventuality of such disruption is a band of numbness on the forehead and anterior scalp, permanent numbness and neuralgia can result. Another area in which sensory disruption is common is in the periauricular region, where the large greater auricular nerve lies above the fascia just behind and beneath the earlobe. The auriculotemporal nerve is vulnerable just superior to and anterior to the tragus. Other sensory nerves tend to lie more deeply beneath fascial layers.

More important to host function is the integrity of the motor nerves supplying the muscles of facial expression. Motor innervation is derived primarily from the branches of the facial nerve.[23-26] The facial nerve is protected by the parotid gland on the lateral face. After leaving the parotid fascia, the branches of the facial nerve ascend to the level of the superficial fascia where they travel within the fibrous component. For that reason, undermining above the fibrous component of the superficial fascia and within the subcutaneous fat will rarely lead to motor nerve injury. However, careless incisions and/or undermining can easily damage these nerves. As the fibrous component envelopes the facial muscles, the nerves stay within the thick deep portion to produce appropriate innervation.

As a general rule, undermining at a level to include the subdermal plexus in mobilized tissue is without risk. Inclusion of deeper axial vessels may prove hazardous over zones where branches of the facial nerve traverse. The frontal and marginal mandibular divisions are at particular risk, because of their shallow locations and the paucity of interconnecting anastomoses.[27,28]

Particular attention must be paid to the frontal branch of the facial nerve.[29,30] As the nerve ascends over the zygomatic arch, the superficial fascial complex is elevated closer to the surface and the fatty layer thins. Thus, although the pattern relationship is constant, the nerve is more exposed. While some texts have listed the nerve as running above the fascia, the nerve does lie within the innominate fascia just deep to the SMAS over the zygomatic arch and then ascends just slightly more superficially to lie within the superficial temporal fascia. This relationship has been exquisitely demonstrated by cadaver dissection.[31] (Fig. 1.7). Incisions and undermining in this area, which stay above the fascia, are safe (Fig. 1.8). Coincidentally, this area harbors the temporal artery and large branches thereof (Fig. 1.9). They can serve as a marker for the depth at which excision and undermining expose the nerve to injury.

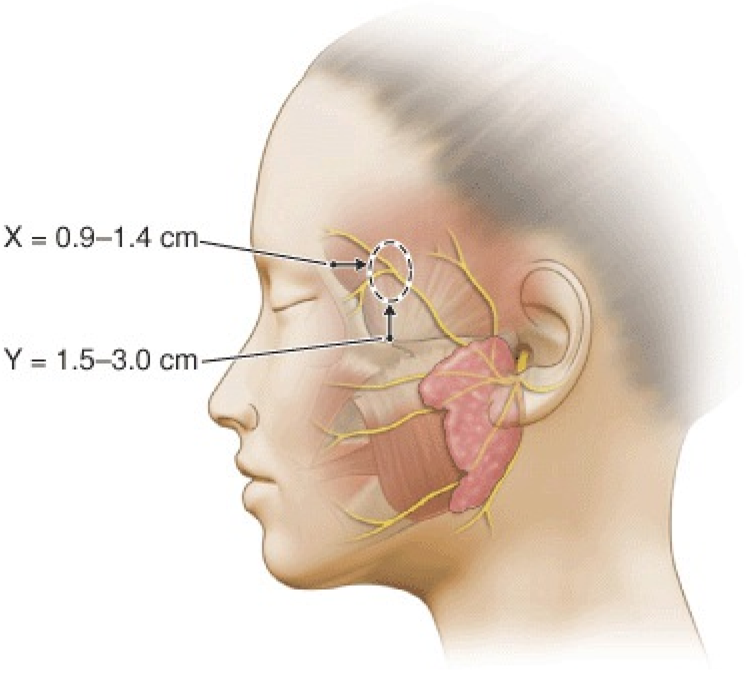


Figure 1.7 *Illustration depicting the fascial transition zone (dotted circle) where the frontal branches transition from the innominate fascia to the superficial temporal fascia. The x-axis measurement was the distance posterior to the lateral orbital rim and the y-axis measurement was the distance superior to the upper border of the zygomatic arch (Reproduced with permission from Agarwall CA, Mendenhall SD, Foreman KB, et al. The course of the frontal branch of the facial nerve in relation to fascial planes: An anatomic study. Plast Reconstr Surg 2010;125:532-537. Copyright Wolters Kluwer Health.)*

Figure 1.8 *The frontal branch of the facial nerve is seen as it courses just beneath the nick created in the superficial fascia*

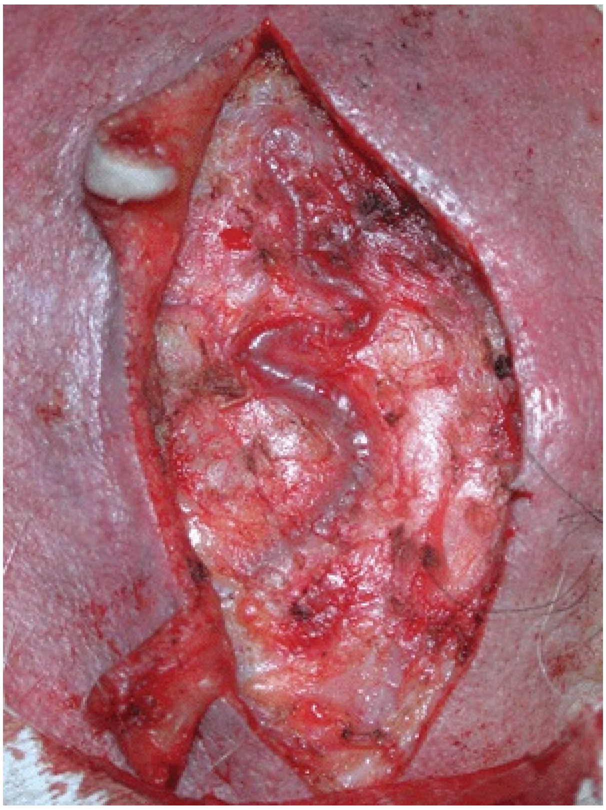


Figure 1.9 *The temporal vessels run just beneath the subcutis in the superficial fascia. The vessels run shallow to the frontal branch of the facial nerve. They are readily identified and staying above them when undermining provides a measure of safety*

Bioanatomy is therefore used to facilitate successful tissue movement while preventing host morbidity. Fascial structure is an organizing framework for conceptualizing vascular and neural relationships. Fascia may be used mechanically to decrease tension forces in the skin and to immobilize critical structures. Knowledge of vascular and neural anatomy is important in the design of adjacent tissue movement in order to maintain viability and avoid morbidity.

MECHANICS OF TISSUE MOVEMENT

Adjacent tissue transfer involves the planned manipulation of closure force vectors to minimize the tension of wound closure and prevent anatomic distortion. This goal is accomplished by considering three variables: (1) tension reduction, (2) tension redistribution, and (3) dog-ear manipulation.

Tension Reduction

Low closure tension is the desirable choice to prevent tissue ischemia and necrosis, to avoid anatomic distortion, to minimize the spread of a scar, and to avoid wound dehiscence.[32, 33] Increased closure tension reproducibly reduces blood flow, alters repair viabilty, and may lead to flap necrosis.[34] Appropriate undermining can substantially reduce closure tensions;[35, 36] however, a common misconception is that progressive undermining uniformly diminishes closure tension.[37-39] In order to truly increase skin mobility, the tissue to be moved must be effectively separated from whichever structures are imposing the restriction. Effective undermining is more important than extensive undermining. Skin stretchability may be inhibited by direct or indirect attachment to the fascia, muscle, and bone. The mechanism of restriction is site specific and dependent on the particular anatomic organization.[40]

The scalp, for example, is tightly bound to the inelastic fibrous superficial fascial component termed *galea*, through the interlobular septae of the fat.[41] The fascia is then attached to the bony supraorbital ridge, anteriorly, and occiput, posteriorly. This further inhibits mobility. If undermining is performed in the typical subgaleal avascular plane, the major restrictive component persists and significant laxity is not achieved. Movement may be partially gained by carrying undermining over the supraorbital ridge or nuchal crest, detaching the tissue from the bony restriction. Adverse consequences include eyebrow elevation anteriorly (desirable in the forehead lift) and potential damage to neurovascular bundles anteriorly and posteriorly. Scalp flaps may also be raised (with care) above fascia, thus diminishing the effect of galeal restraint (Fig. 1.10).

Figure 1.10 *A scalp flap raised above galea has much more elasticity than one containing the deep fascia. Care must be taken, however, not to compromise flap viability*

Substantial movement may be achieved by interrupting the continuity of the rigid fascial sheath. For example, side-to-side closure of donor defects from wide scalp flaps can be facilitated by shifting undermining levels from the subgaleal to the suprafascial plane. This allows for a greater degree of stretch by allowing for the natural elasticity of the skin to be unencumbered by the rigid galeal fascia. Interruption of the fascia may also be created by surgical incision. On the scalp, fascial discontinuity may be percutaneous or subcutaneous. A percutaneous galeotomy is achieved by the creation of a bipedicle advancement flap[42, 43] (Fig. 1.11). The galea is incised inferior and superior to the bipedicle flap. When the wound edges are apposed, the galea is left unclosed. The skin fat complex achieves a degree of stretch via the galeal incisions. If mechanically feasible, galeal incisions, or scoring, may be purely subcutaneous. If subcutaneous galeotomies are created, attention must be directed toward avoiding major vessels and nerves as injury to large, deep vessels can cause copious bleeding.

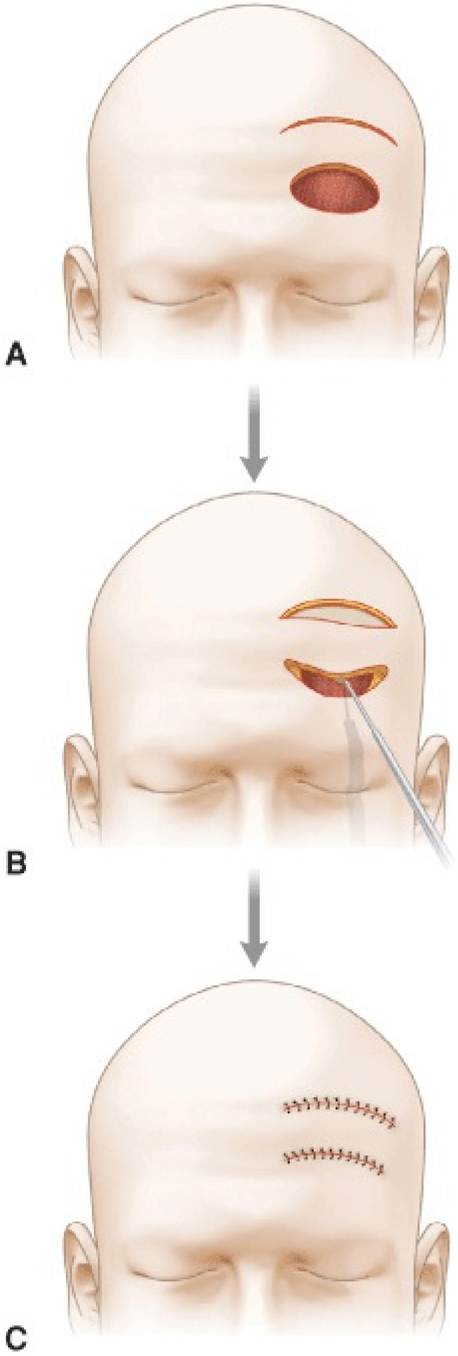


Figure 1.11 *A bipedicled advancement flap increases cutaneous mobility by interrupting the continuity of the galea. (A) Operative wound and planned repair. (B) An incision is made to periosteum within the hair-bearing scalp. (C) The skin and fat are closed. The galea is not sutured (Adapted with permission from Flint ID, Siegle RJ. The bipedicle flap revisited. J Dermatol Surg Oncol 1994;20:394-400. John Wiley & Sons, Ltd.)*

Theoretically, the skin of the scalp may be totally separated from fascial restriction by undermining in the subcutaneous plane above the galea.

Although this provides good mobility, it may be associated with morbidity. Since major vessels and sensory nerves reside within this plane, such undermining risks vascular compromise, bleeding, and sensory denervation, as well as hair bulb injury.

Tissue movement in the forehead region is restricted similar to the scalp. The same bony attachments are relevant. The subcutaneous tissue is thin, providing little innate elasticity. The fibrous fascia and frontalis muscle, both inelastic structures, are tightly bound to the skin via the interlobular septae. Undermining in the subcutaneous level above fascia and muscle is a suitable alternative; however, it must be done with direct visualization to avoid vascular and neural injury.

Over the temple, the fat is somewhat thicker, providing some baseline stretch. Detachment of the interlobular septae from the fascia clearly increases mobility. However, since the frontal branch of the facial nerve lies just below the superficial temporal fascia, it is important to maintain a uniform, careful undermining plane just above the fascia (Fig. 1.12). Extensive undermining at this superficial level may create vascular compromise at the distal portion of the flap edges.

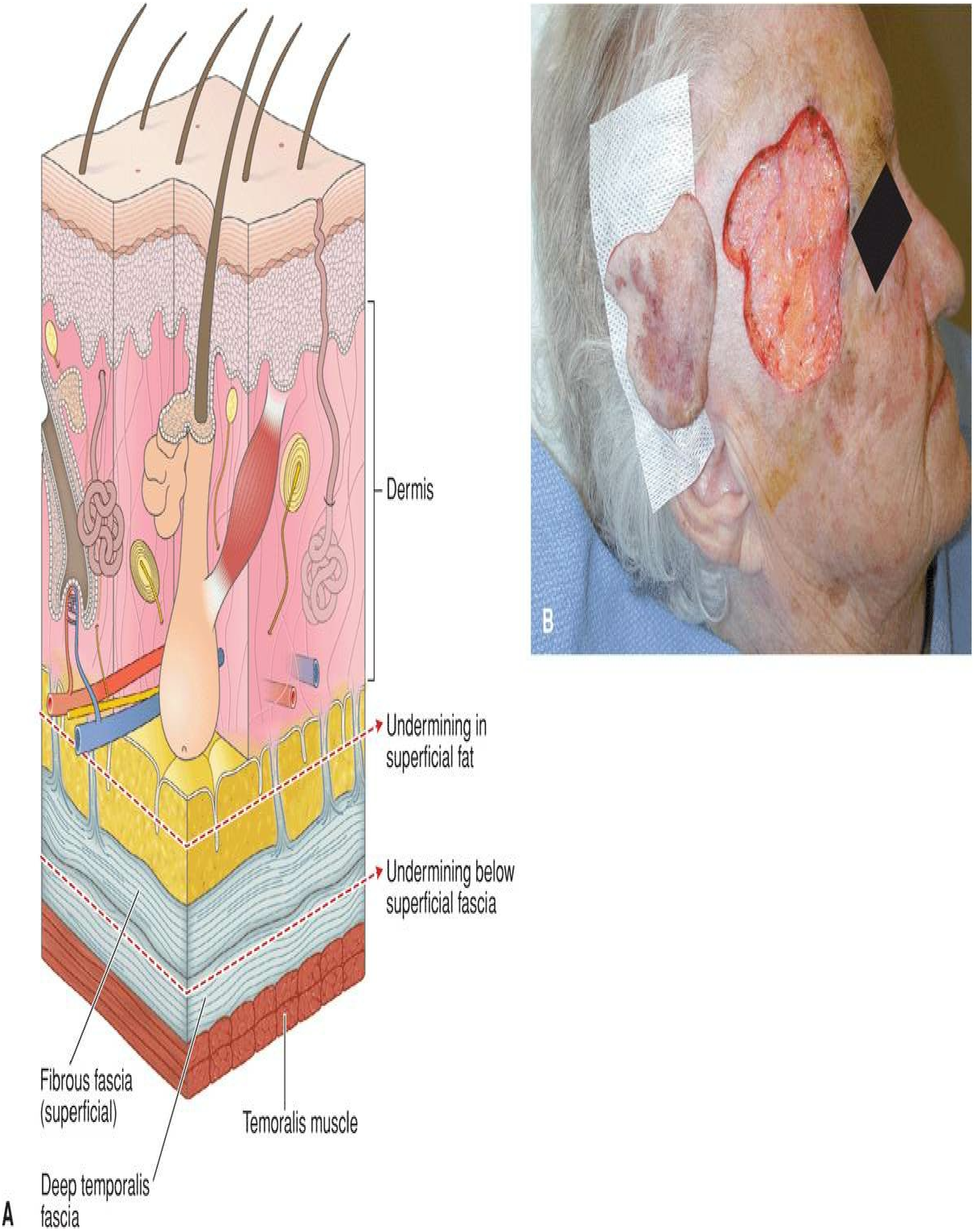


Figure 1.12 *(A) On the temple, undermining is safest in the loose adipose just above the superficial fascia. As long as undermining is above fascia, the motor nerve fibers will not be disrupted. (B) A broad superficial squamous carcinoma has been removed just above fascia, thus preserving function of the frontal branch of the facial nerve*

The cheek has a thick layer of subcutaneous fat. Therefore, sufficient mobility is often available, even without extensive undermining. Due to a predictable vasculature, extensive flaps may be elevated just above the SMAS and will maintain reliable viability unless placed under substantial tension. Over the lateral cheek, undermining at any depth within the fat is safe, since the facial nerve branches are well protected within the parotid gland (Fig. 1.13). Undermining in the lateral cheek releases restrictive forces by separating the fibrous component of the superficial fascia or SMAS from the interconnecting links of the interlobular septae.[44] Medially on the cheek, there is a less defined fascial layer, and the neurovascular bundles lie in the deep to the loose subcutaneous fat where they intermingle with the muscles of facial expression (Fig. 1.14). Undermining in this area should be within the adipose and should involve direct visualization.

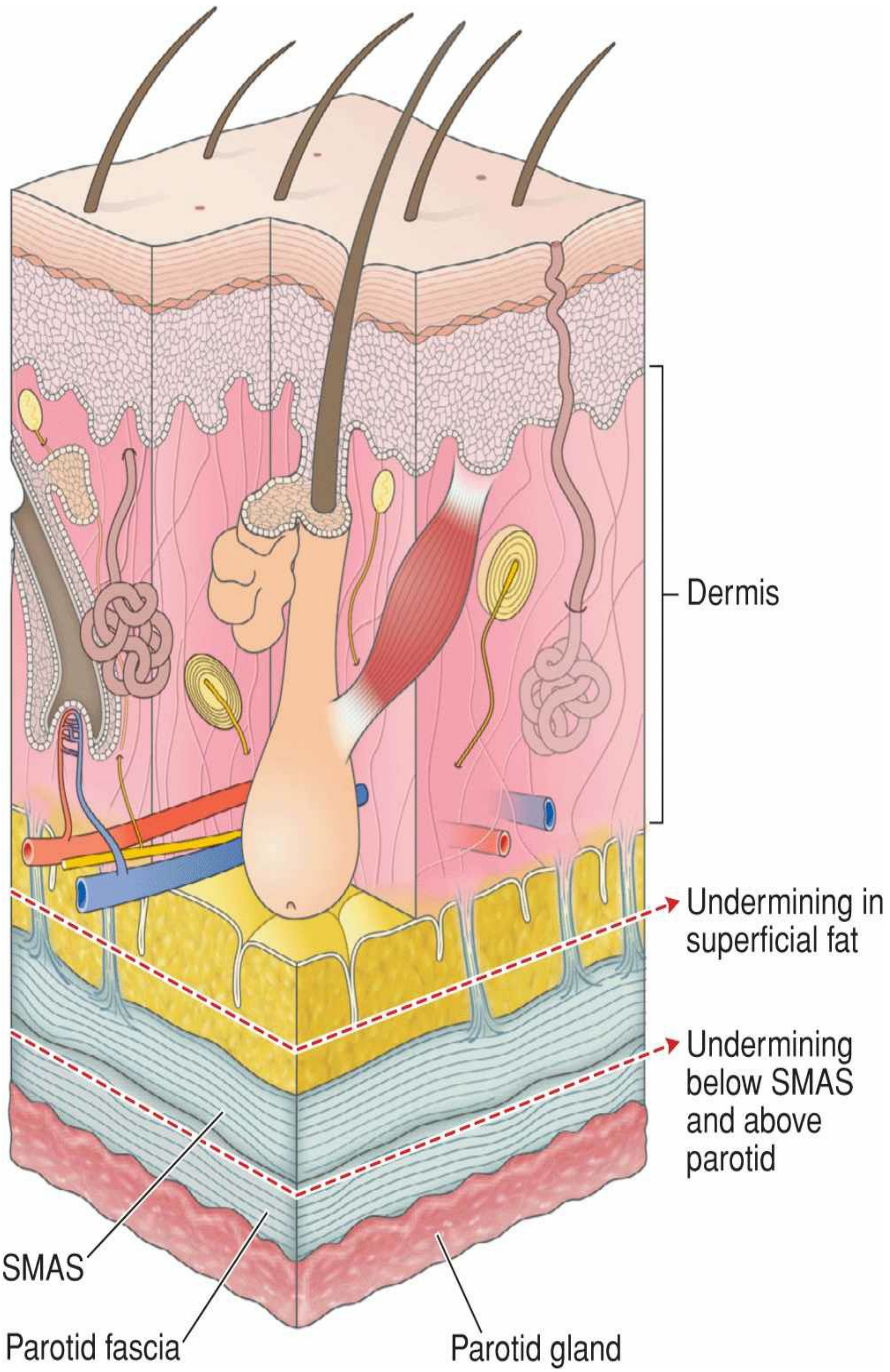

Dermis
Undermining in superficial fat
Undermining below SMAS and above parotid
SMAS
Parotid fascia
Parotid gland

Figure 1.13 *Neurovascular structures on the lateral cheek are protected by adipose, SMAS, and parotid fascia. Undermining within the deep subcutaneous plane just above the SMAS is safe and achieves substantial laxity*

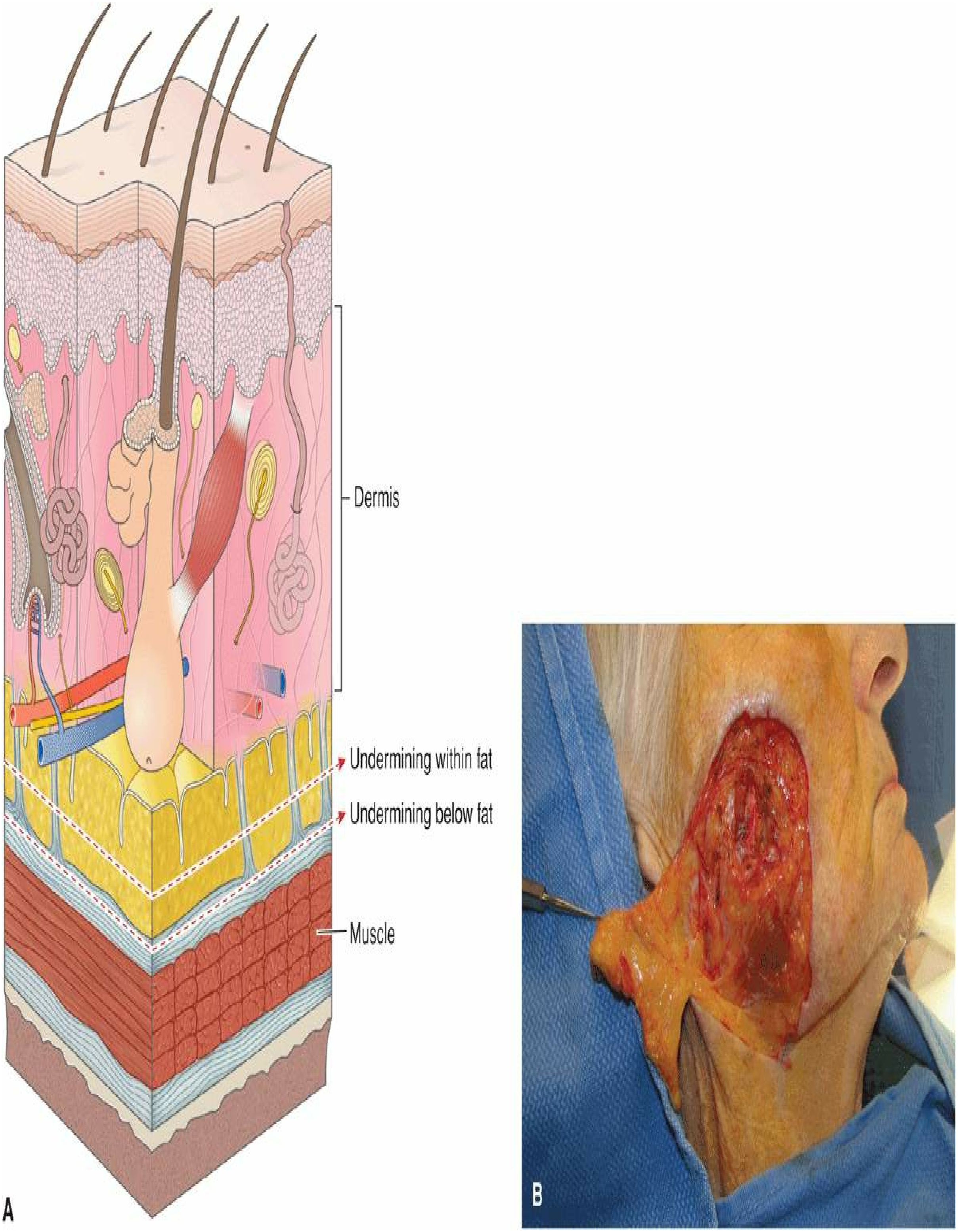


Figure 1.14 *On the medial cheek, a well-defined fascial plane is not visualized. Undermining within the deeper adipose is safe, although the large caliber facial/angular artery runs above musculature as it courses along the nasolabial fold.* **(B)** *In this flap elevated on the lateral and mid cheek, two planes are visualized. Laterally, the flap is elevated above SMAS which is white. Medially, the excision has been deeper, exposing the buccal branches of the facial nerve along their course*

Undermining in adipose tissue has historically been done bluntly and many texts advocate undermining at a relatively shallow level. On the cheek in particular, two patterns of adipose exist. The shallow adipose, just beneath the dermis, is somewhat adherent to dermis, is composed of small lobules, and is richly vascularized with small arte-rioles. The deeper adipose is composed of large, oblong fascicles, which are traversed by many fewer, larger vessels (Fig. 1.15). Blunt, shallow undermining can lead to profuse bleeding and postoperative edema. It may also fail to release deep restraint. Sharp undermining with an undermining scissors under direct visualization and at a level within the deep, loose, minimally vascularized adipose is less traumatic and achieves a greater degree of tension release and flap mobility.[40]

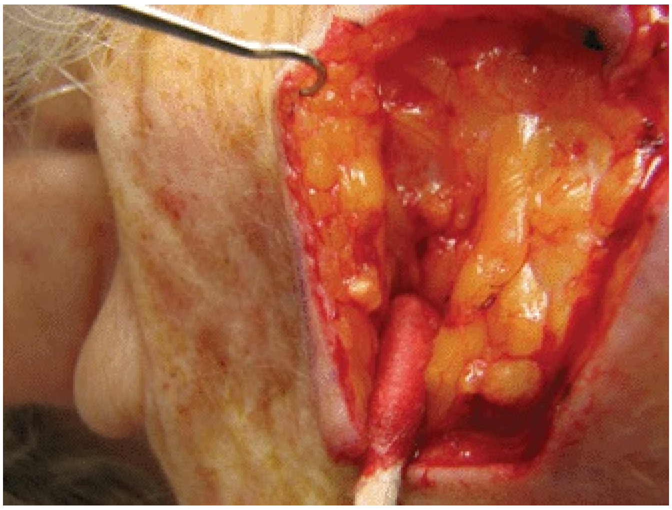


Figure 1.15 *Two types of adipose are seen. At left is the denser superficial adipose tissue that can be challenging to undermine. At right is the deeper adipose tissue made up of minimally vascularized large lobules. Undermining in the latter tissue, with care to avoid larger vessels, achieves substantial laxity with little bleeding and minimal resultant edema*

On the nose, the effect of undermining is limited by the thickness and inelasticity of sebaceous skin as well as the deep attachment of nasalis muscle. Undermining below fascia and muscle, and above perichondrium, is safe and relatively avascular. If restricted to the nose only, this does not lead to substantial mobility. However, this level of undermining is usually appropriate for flap creation used to redistribute tension vectors including rotation or transposition flaps. Undermining in the subcutaneous plane often causes substantial bleeding and risks vascular compromise. Tension on the nose may be markedly diminished by separating the attachment of the cheek to the maxilla, and this can be of particular importance when flaps are expected to have a significant component tissue advancement.

The perioral and chin units are conceptually similar to the medial cheek. The fat is ample and provides some innate stretch. Undermining in the subcutaneous plane is safe and separates skin from ascending oral muscle fibers that derive from orbicularis and the elevator and depressor musculature. Mobility is usually not as great a concern as is pull and distortion of the lip, and tension vectors on the chin must uniformly be oriented medially to laterally.

The periocular area is similar to the perioral region, except for the absence of significant subcutaneous fat. Skin is intimately attached to orbicularis muscle and fascia. Separation of the skin from the underlying muscle may cause vascular trauma and must be done with care; however, it can provide substantial mobility. The submus-cular plane above deep fascia (the orbital septum) is sometimes an appropriate level for tension redistribution during reconstruction. This is, in fact, the most used plane for lower lid blepharoplasty, such as the “skin muscle flap.”

There are circumstances when undermining is used not to decrease tension but to promote eversion, decrease dog-ear visibility, or to separate tissue from its underlying bed for the purposes of redraping. This redraping allows for the creation of novel secondary defects whose closure is dictated by different, more favorable tension vectors, thereby redistributing tension rather than releasing it per se.

Tension Redistribution

Mechanically manipulating tissue for the purposes of simple side-to-side closure is not always feasible or appropriate. In some instances, a linear closure may breach a cosmetic unit or cross a free margin where a flap would fall along normal cosmetic boundaries. In other circumstances, a linear repair fails to recruit adequate laxity for closure. In these circumstances, the vectors of closure tension must be altered and redistributed. Tension redistribution is achieved via the redraping of tissue using the creation of flaps. Depending on design, both rotation and transposition flaps are capable of either partial or total tension redistribution.

Rotation flap

A classical rotation flap, through tissue redraping, creates a redistribution of tension vectors by transforming a primary defect into a crescent-shaped, newly oriented secondary defect[45, 46] (Fig. 1.16). Closure of the secondary defect involves tension vector orientations perpendicular to or nearly perpendicular to the original forces. This maneuver is useful when side-to-side closure would be anticipated to require excessive tension or produce distortion of critical anatomic structures. Often, tissue that is perpendicular to the vector of primary defect closure can be made to assume partial or total responsibility for wound apposition.[47-49] It is not possible to totally eliminate closure tension of the original defect unless the tissue can be so effectively mobilized as to permit redraping without pull from the flap pivot point. This is sometimes, but not always, achievable with extensive undermining beneath the flap pedicle or by the creation of a backcut at the point of greatest tension. Both maneuvers, however, risk compromise of flap viability by decreasing vascular input to the pedicle.

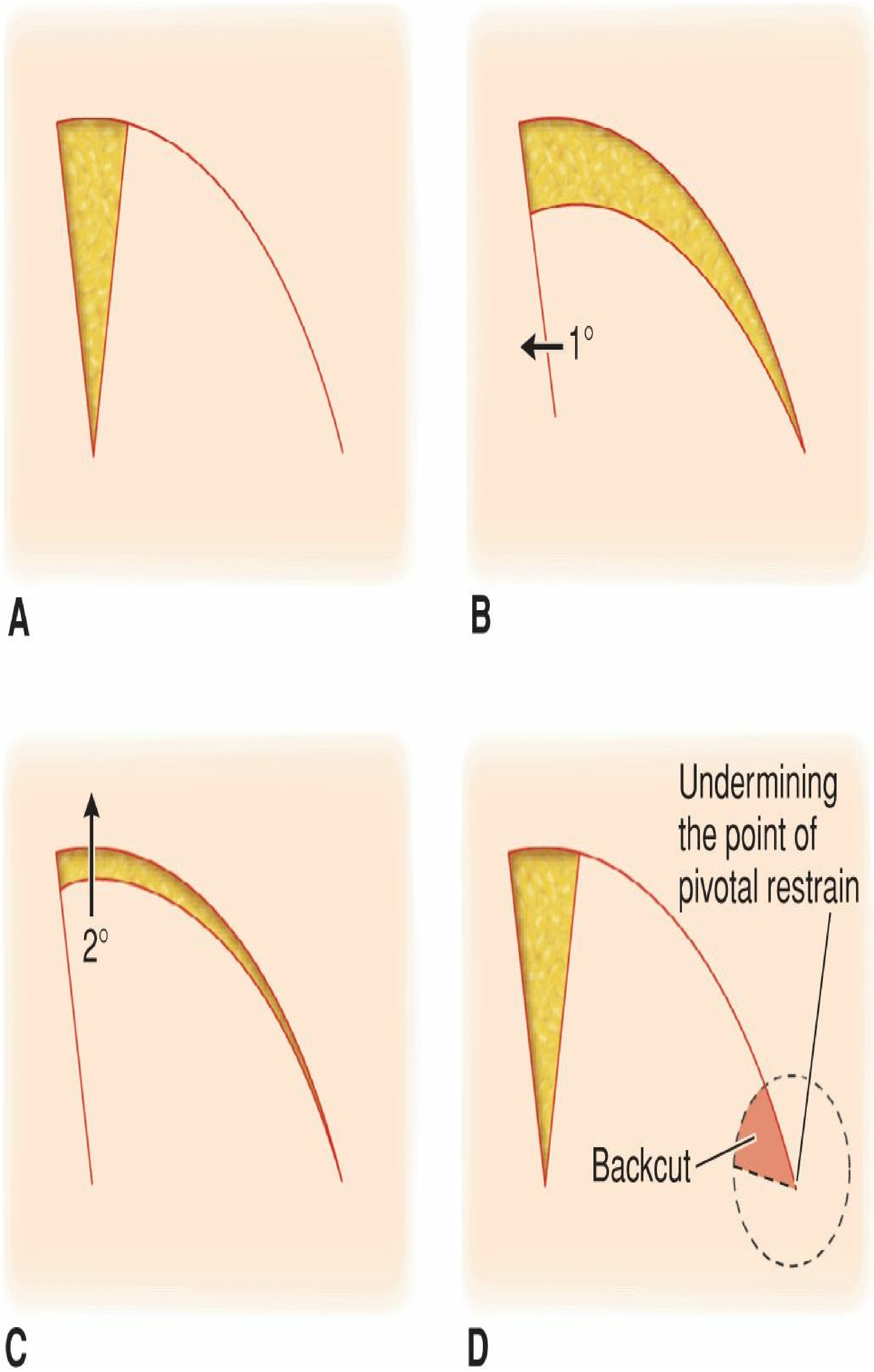
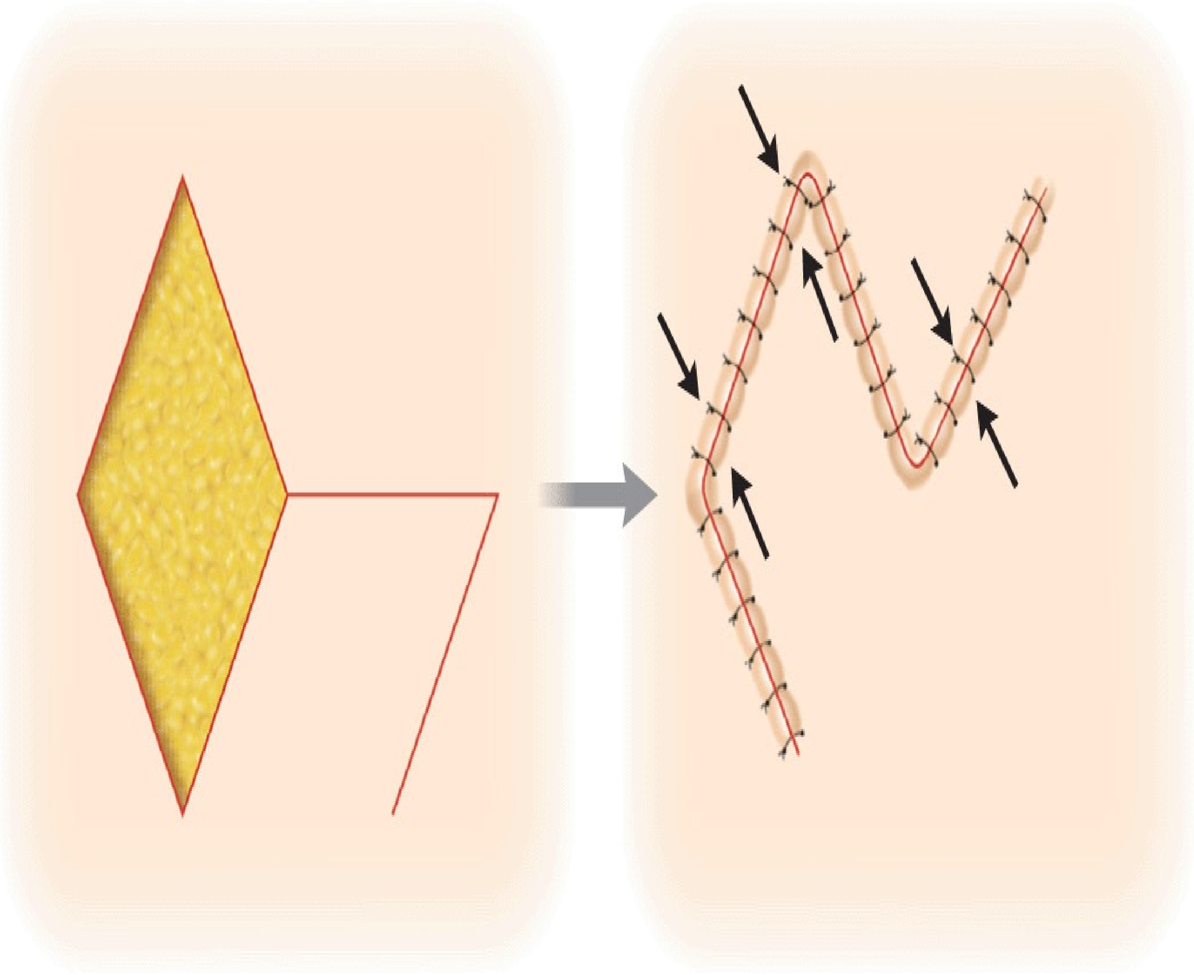

1°
2°
Undermining
the point of
pivotal restrain
Backcut
A
B
C
D

Figure 1.16 *Rotation flaps redistribute some or all tension from a primary defect to a secondary defect. (A) Classic rotation flap arc design. (B) Closure of the primary defect with creation of a secondary defect. (C) Secondary motion of the rotation flap. (D) Tension vectors may be reduced by release of pivotal restraint through undermining or by creating a backcut*

Transposition flap

A transposition flap is capable of partially or totally eliminating tension vectors from the primary defect by the creation of a secondary defect in distant anatomic sites with altered closure directions.[50, 51] Tissue is effectively "jumped" via redraping from areas of laxity to the primary defect. The defect can be totally or partially filled by the transposed flap, depending on whether the goal is tension sharing or tension elimination. Transposition flaps include simple banner flaps, rhombic flaps and rhomboid modifications, and multilobed flaps[52, 53] (Fig. 1.17). Tension is effectively manipulated and redistributed by altering closure directions.



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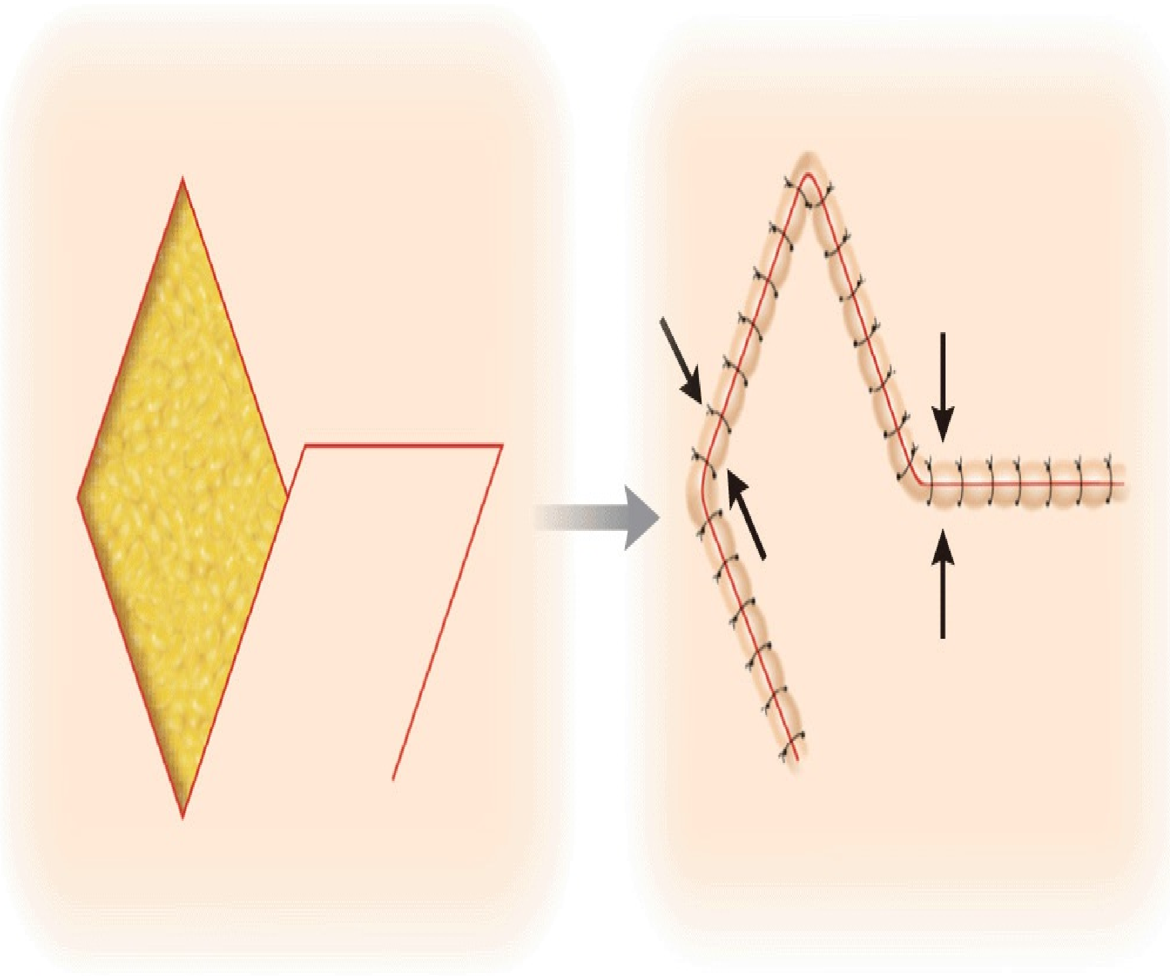

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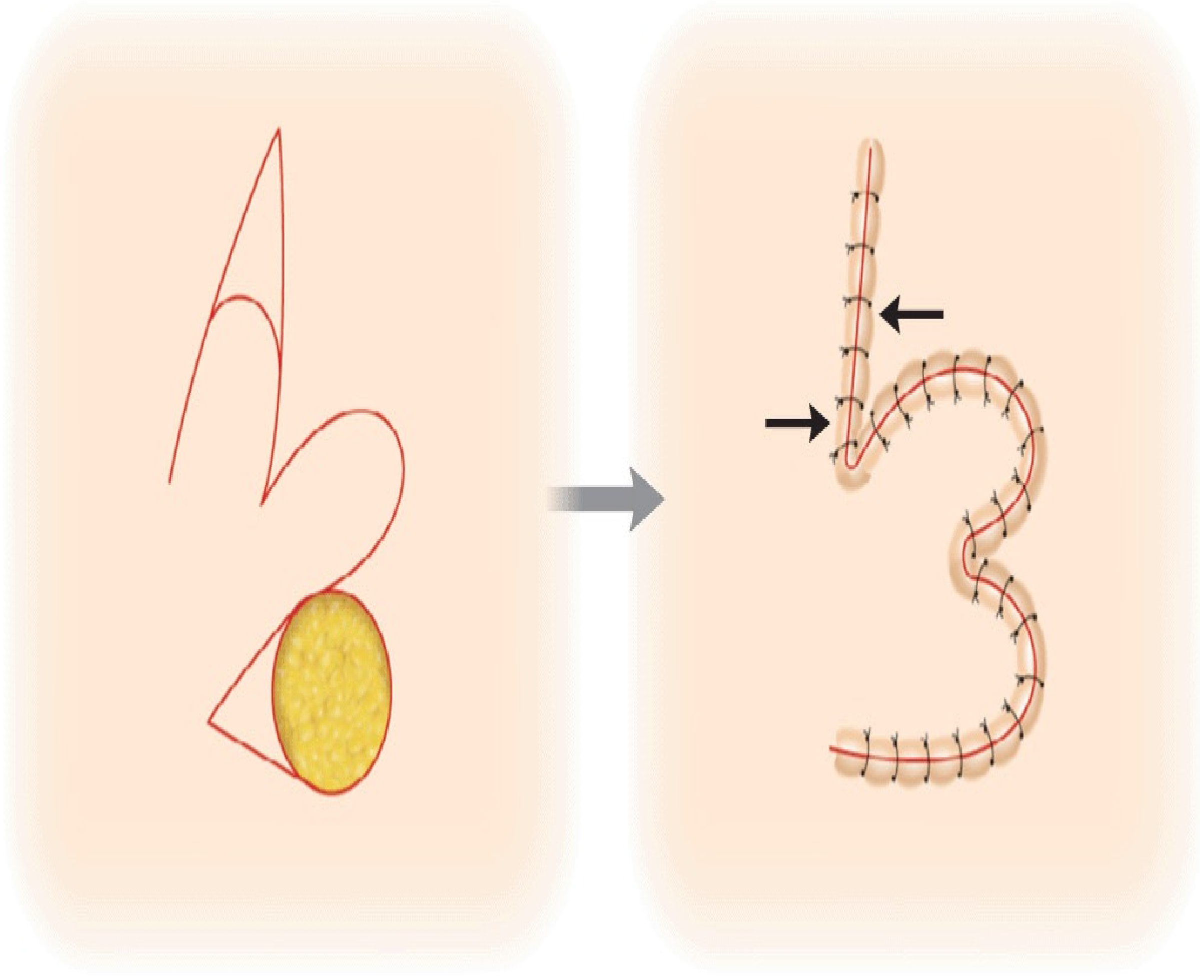
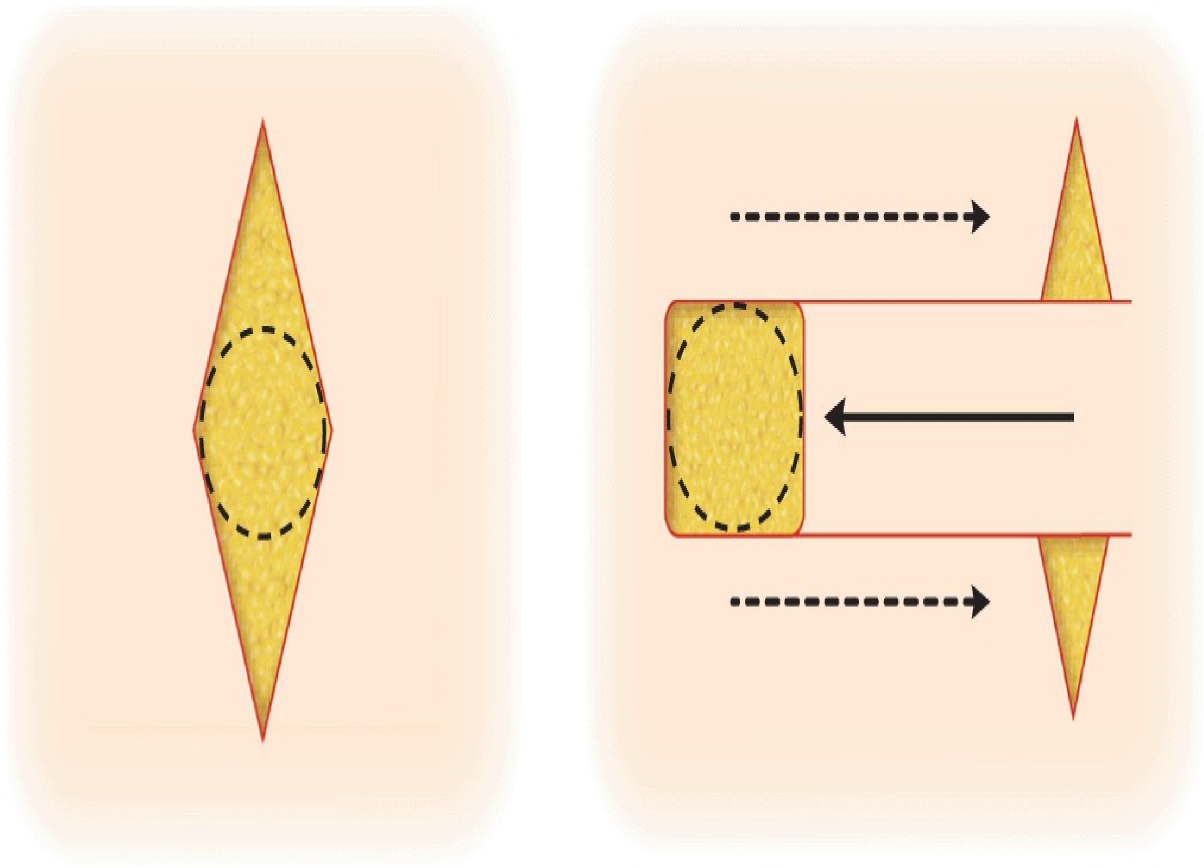


Figure 1.17 *Transposition flaps allow for partial or complete redirection of tension vectors. (A) The classic rhombic flap partially redistributes tension. (B) A modified (oversized) rhombic flap more effectively diminishes tension on the closure of the primary defect. (C) A bilobed transposition flap effectively directs tension away from the primary defect to a secondary and tertiary defect*

Dog-Ear Manipulation

To optimize the aesthetic result of wound closure, it is often necessary to mechanically reposition tissue redundancies (dog-ears), which are produced by side-to-side apposition.[54-58] Dog-ears can selectively be moved using advancement flaps (Fig. 1.18). In this way, dog-ears may be translocated away from areas of cosmetic importance. Variations of the advancement flap include the classic unilateral advancement, bilateral advancement, Burrows wedge, and A- to T-plasty (bilateral Burrows wedge).[59-61] Dog-ears may deliberately be placed so that the removal occurs along junctions of cosmetic units, and preexisting creases and wrinkles; therefore, the additional excisions produced by the correction of the tissue redundancies are maximally camouflaged, and transgression of crucial structures such as lid margins or lips can be prevented. Advancement flaps may also be created to redistribute the tissue redundancy over a longer line of incision. In this way, miniature dog-ears are created along the entire edge of the flap. The wound is closed by the process of "halving" so that the entire length of the flap assumes the burden of tissue redundancy. These miniature dog-ears usually fade with time and require no further revision.



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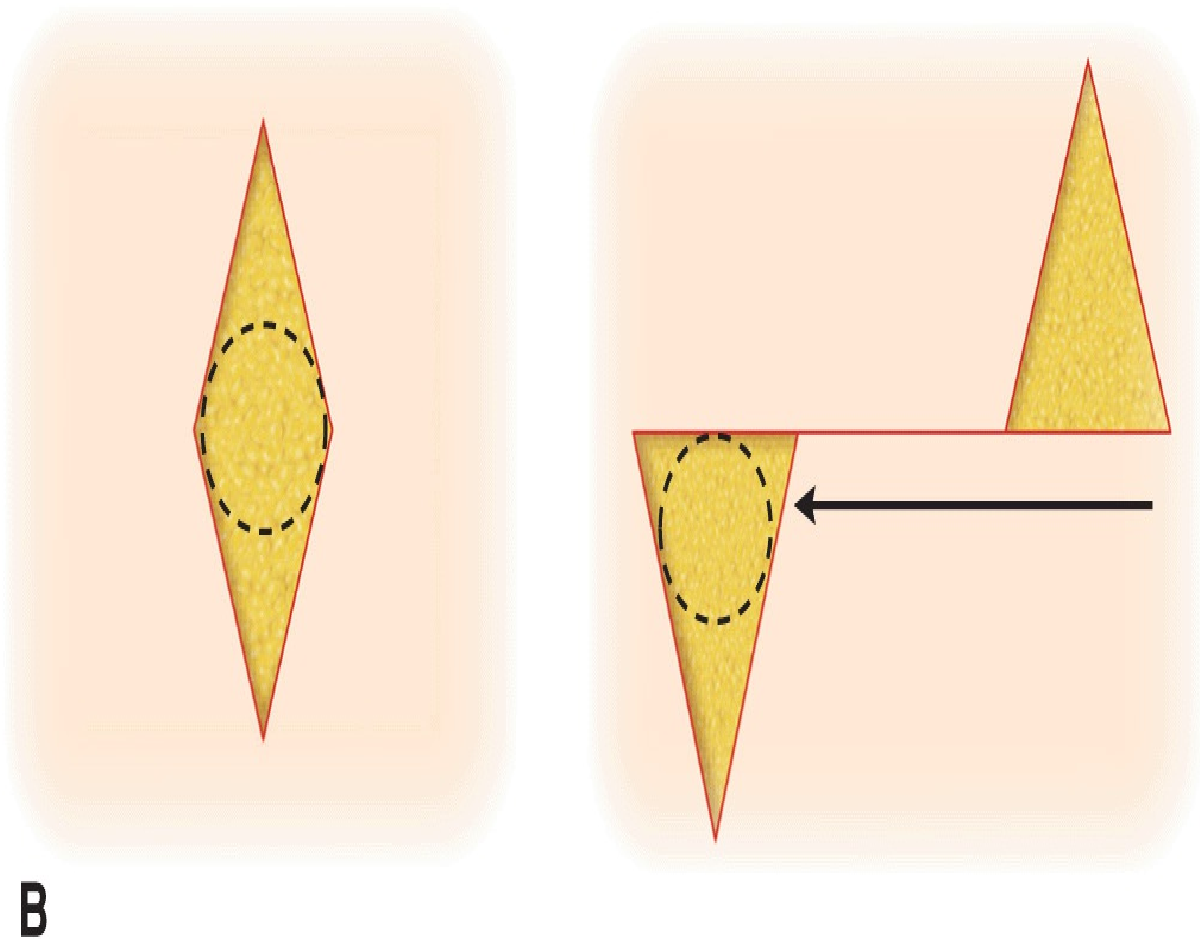


Figure 1.18 *Advancement flaps may be used to alter the positions of tissue redundancies (dog-ears). (A) A classic single advancement flap displaces dog-ears away from the primary closure site. (B) A Burrow's wedge advancement flap leaves one dog-ear adjacent to the primary closure site and translocates the other dog-ear to a distant site*

CLOSURE VECTORS, THE FUSIFORM ELLIPSE, AND THE COMPLEXITY OF DOG-EAR FORMATION

When a rectangular advancement flap or direct laceration repair is effected, the wound is sutured perpendicular to the advancing edge of the flap and all tension is directed straight across to the recipient site. The entire tension vector in this case is unidirectional, and the only motion present is advancement. With a fusiform or elliptical closure, in reality, the tension vectors are not entirely uniform, and each such closure has a component of rotation. While we refer to this as a linear closure, the result is an approximation of linearity, but the closure is more complicated.

The intrinsic design of the elliptical closure forces two opposing curved edges together to meet in the line of ultimate closure, which is geometrically straight. If one were to unravel the curved edge into a straight line, one would observe that the length of the curve to be greater than the length of the final closure line. The two curved edges are ultimately squeezed together into a smaller space that eventuates in the bulges or protuberances affectionately referred to as “dog-ears.” While the majority of tension in the linear closure is side to side, there is an element of end-to-end force as well that tends to create what would be viewed from the side as a set of ski jumps (Fig. 1.19).

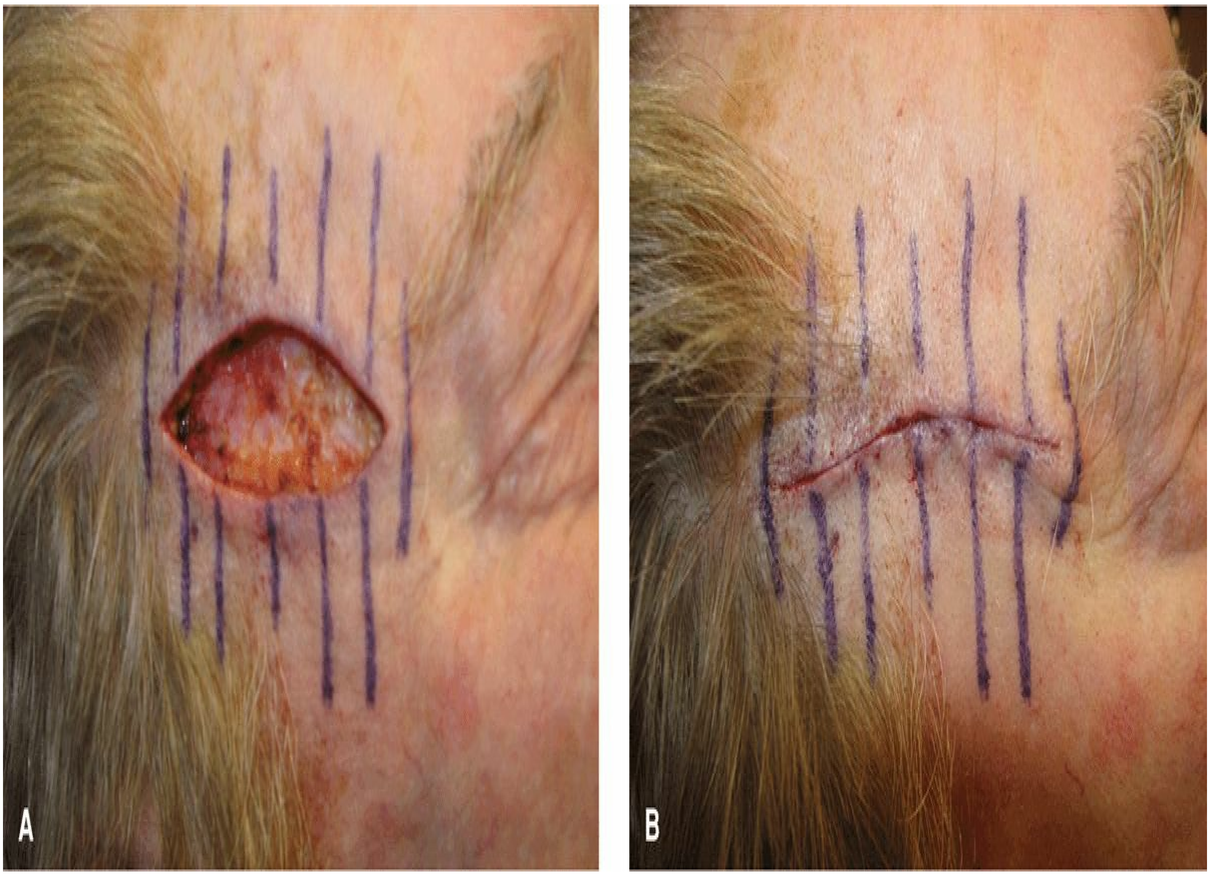


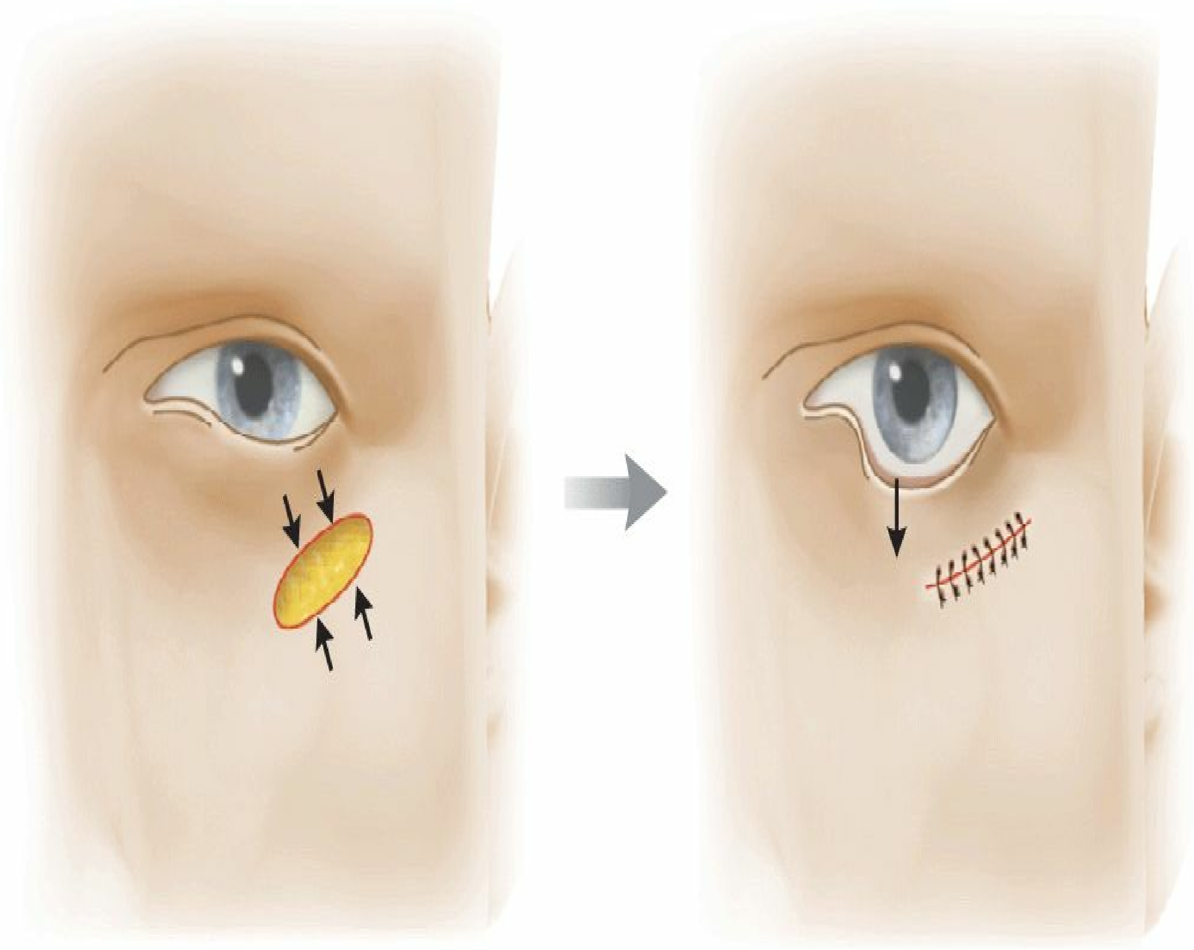
Figure 1.19 *Closure of a fusiform ellipse creates a line that is shorter in one dimension than the original edge lengths. (A) The photos demonstrate a planned ellipse and the effected closure. (B) The lines demonstrate how the apices of the repairs are bowed outward as the wound closes. Note that in the center of the wound, all tension vectors are directly across the wound, but at the ends of the ellipse forces point outward and displace the repair apices*

The aesthetic goal of an ellipse is to create a single line with minimal tissue redundancies. There are several ways to do this. One, not always available, is to appreciably lengthen the closure design to decrease the apical angles and thus minimize the discrepancy between the curved edges and the closure line. Other than this approach, one must accept the length mismatch and decide how to place and distribute the tissue redundancies. The "rule of halves" involves creating equally sized and distributed dog-ears along the length of the closure. Although this may work well, the location of greatest curvature of the elliptical design remains at either end. A subtle approach that can limit the formation of dog-ears is to begin suturing an elliptical wound from the edges with deep sutures placed perpendicular to the curvature of the edge. In this manner, multiple miniature apposing rotation flaps are created. This effectively decreases the discrepancy between the edges at the repair apices, and the protuberance is moved toward the wound center where the visibility may be lower than if located at the wound ends.

Effect of Direction of Closure on Tension Forces

The intention of repair is usually to obtain a symmetric wound closure by matching opposing segments of relatively equal lengths. When operating adjacent to mobile free margins such as the lip and eyelid, this approach may require revision. The priority must be the maintenance of free margin position even at the expense of wound length or dog-ear creation. In these situations, unless unusual laxity is present, closure must be in a direction perpendicular to the force that would cause free margin movement. This situation is encountered frequently when approached with closure of flap donor sites.

Two common examples are closure of an oblong slanted infraorbital wound and repair of the nonvertical donor site from a nasal bilobed flap. In the case of the infraocular wound, a direct side-to-side closure tends to create a lateral ectropion. Suturing in a strict horizontal plane directs all tension to medial-lateral vector and prevents this tendency (Fig. 1.20). In mismatching the edges of the wound, a dog-ear is often created into the eyelid. Fortunately, tissue redundancies in this area frequently become much less noticeable with time, and the excess of lid is preferable to an ectropion.



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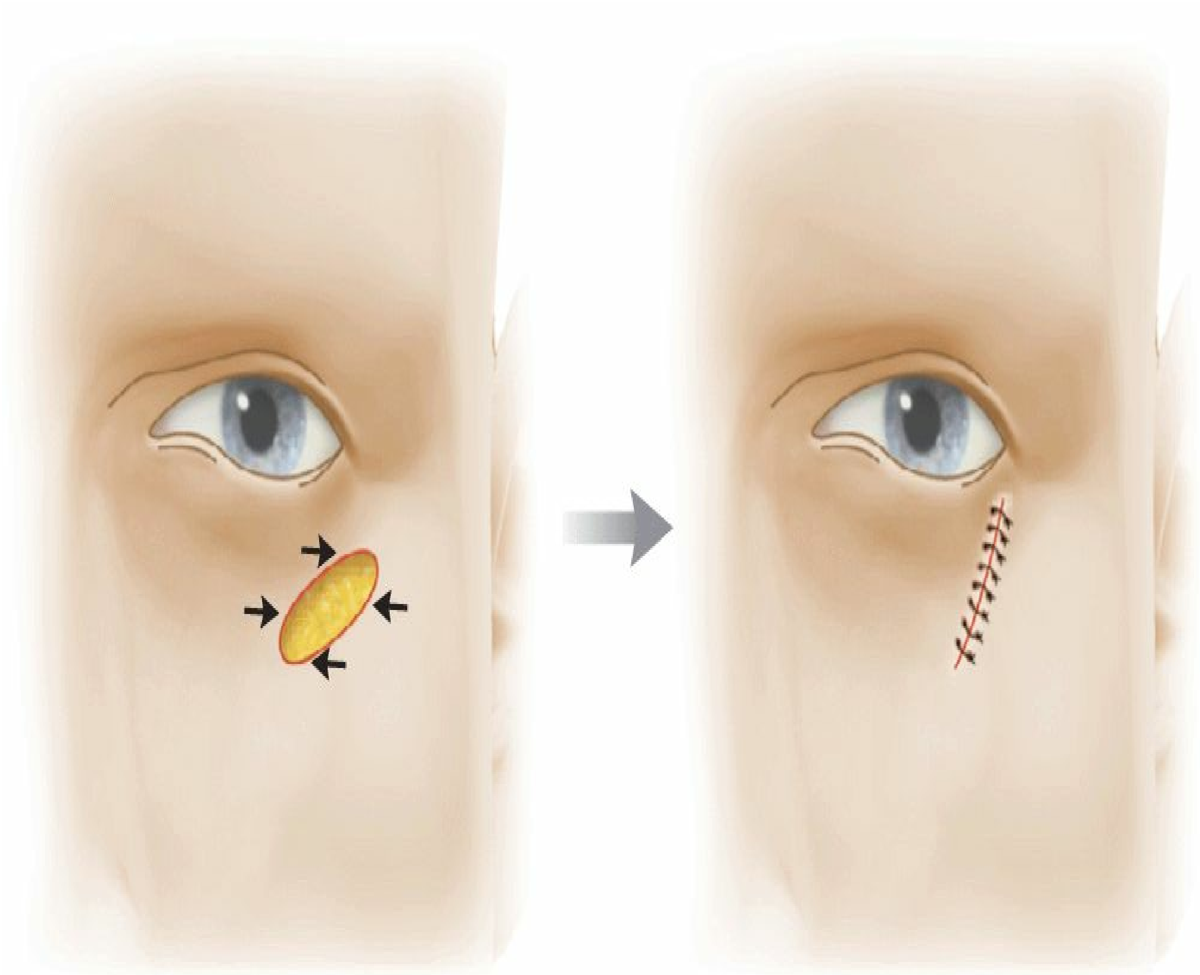

B

Figure 1.20 *Altering the directional closure of a wound may prevent unwanted tension vectors. (A) Direct side-to-side closure of a slanted infraocular wound creates tension on the lateral lower lid and risks ectropion. (B) By suturing in a horizontal axis, there is less vertical (downward) tension on the lateral lower lid margin and ectropion may be avoided*

In the case of the bilobed transposition flap, traditional closure of a transversely oriented donor site places some vertical tension on the contralateral nasal ala. Closure in this manner tends to bulldoze the ipsilateral ala and elevate the contralateral ala. If instead the sutures are placed horizontally across rather than perpendicular to the wound edges, a horizontal tension vector is created, and the ala is not so affected. By definition, this will create a side-to-side length mismatch on the upper nose with resultant tissue redundancies, but these can be dealt with more easily than a displaced nasal ala.