2

Physical Properties of Skin

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Introduction

Human skin is the largest organ of the body, which protects the organism from mechanical trauma. Skin acts as an interface between body and environment. The characteristic of physical properties of the skin is its extreme variability. It differs in different locations on the same individual and differs at the same location in different individuals.[1]

The skin possesses unique physical properties, and knowledge of it is therefore appropriate. For plastic surgeons placing of incisions, use of skin flaps and application of tissue expansion techniques are influenced by its special characteristics. It is also important to demonstrate variation in physical properties of skin in aging, menopause, and various disease states. Skin exhibits four basic physical properties: nonlinearity, viscoelasticity, skin tension, and anisotropy.[2]

Nonlinearity

Physical property of the skin is due to its heterogeneous nature. The skin is composed of various interrelated networks. Important constituents of the skin include collagen fibers, elastic fibers, ground substance, capillaries, lymphatics, and nerve fibers. The main fibrous constituents, collagen and elastin provide structural stiffness and elasticity to the skin. The proteoglycan-rich matrix provides the skin its viscous nature at low load.

Collagen is an important component of the skin. In young adults, collagen in the papillary dermis appears as a network of randomly oriented fibers while the reticular dermis consists of loosely interwoven large, wavy, and randomly oriented collagen bundles.[3] Collagen fibers form the bulk of dermis. As they reach the epidermis, the fibers become finer. Collagen fibers network of dermis varies with the state of the skin. In the relaxed state, collagen fibers are convoluted and haphazardly dispersed. As skin is stretched, collagen fibers will become parallel along the line of stretch. Older skin is thinner than younger skin because amount of collagen and ground substance are less in dermis. This decline in skin thickness progresses approximately 6% per decade.[4] Skin thickness is greater in males for any anatomical location because it has greater collagen content.

Elastic fibers in the skin consist of superficial thin bundles of microfibrils that become associated with progressively larger amount of amorphous elastin and increase in size from papillary to reticular dermis.[5] Elastic fibers are responsible for ability of the skin to recoil after deforming forces have been applied. Elastic fibers are important to provide elasticity to the skin but do not contribute to overall tensile strength of the skin.[6] The volume fraction of elastic tissue increases with age to approximately 1 year and then appears to plateau. The density of elastic fibers in the papillary dermis decreases from approximately 2.5 to 2% for individual older than 10 years.[7]

Ground substance comprises glycosaminoglycans, hyaluronic acid, keratan sulfate, heparan sulfate, and chondroitin sulfate.[8] It is found between collagen and elastic fibers and acts as a lubricant during movements. The glycosaminoglycans content is found to decrease with respect to amount of protein with increasing age.[9] Ground substance helps direct collagen fibers formation. Its contribution to the elasticity and tensile strength of the skin are thought to be minimal.[10]

Stress–Strain Curve

Stress–strain curve is essential to know the strength and limits of skin. Stress–strain relationship is a physical property of the skin. The stress–strain curve measures the relationship between load and the length of strain (**Fig. 2.1**).[11–13]

The stress–strain curve of skin is composed of three phases. During the first phase of low loading, collagen network offers little resistance to deformation and behavior is dominated by the elastic fibers. During this phase skin dissipates elastic energy stored in the fibrous network via viscous means. The stress–strain curve is nearly linear and elastic. It is a flat phase, highly extensible considerable extension occurs with little force.

The second phase is of rapid transition. As skin load continues, it will not completely return to its original shape upon removal of stress. In this phase, additional collagen fibrils begin to offer resistance to deformation and the elastic component dominates the deformation.

The third phase with high stress load, almost all dermal collagen fibers are aligned in the direction of applied force. In this phase, little extension is possible despite great

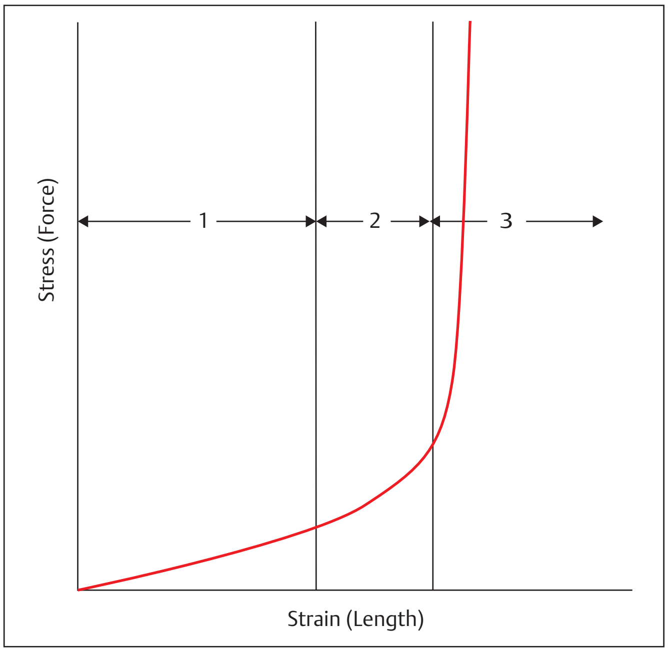

Fig. 2.1 Stress–strain curve for skin. (From Larrabee WF Jr. Immediate repair of facial defects. Dermatol Clin 1989;7:662.)

increase in force. At this point, no further deformation is possible because of the inextensible nature of fully oriented collagen.

Viscoelastic Properties of Skin

Skin is viscoelastic and as a result of mechanical response to stress applied and quickly removed, the deformation is temporary (elasticity), but when stress is maintained for a prolonged period of time, permanent deformation occurs (viscosity).[14] Energy applied to the skin is partially dissipated through viscous sliding of collagen fibrils during alignment with the force direction while elastic behavior of skin is important in ensuring shape recovery after deformation.[15]

Two time-dependent properties of the skin routinely exploited by the surgeons are creep and stress relaxation. Creep occurs when a portion of skin is stretched with stretching force kept constant; the skin continues to expand depending on force applied. In skin creep causes increase in length of skin as collagen fibers of the dermis become straightened and aligned, tissue fluid and ground substance are progressively displaced from the network. The more the fluid in the dermis, the greater is the amount of creep obtained.[16]

Stress relaxation is a corollary of creep and occurs when a portion of skin is stretched for a given distance and that distance is held constant. The force required to keep it stretched is gradually decreased. Stress relaxation clinically explains the flaps that appear to be sutured too tightly in the immediate postoperative period is often viable a few hours later.

Creep has a clinical importance. Mechanical creep is the elongation of skin with constant load over time beyond the extensibility as seen in wound closure with presuturing, intraoperative tissue expansion,[17] and skin stretching devices.[18] Similarly tension-relief system (TRS) is an innovative method that enables the use of both mechanisms of stress-relaxation and mechanical creep for skin stretching and primary wound closure. Its use has been previously reported to enable the primary closure of medium to large soft tissue defects.[18,19]

Biological creep plays a crucial role in conventional tissue expansion. In tissue expansion there is increased mitotic activity responsible for true gain in the tissues. Physical properties of skin involved in the process of tissue expansion are biological creep and stress relaxation. Stress relaxation is the cause of initial tissue stretching before onset of mitotic activity.

Skin Tension Properties

Skin tension varies widely in different individuals and at different sites. It plays an important role in the outcome of surgical repair and varies between different sites of body. The assessment of skin tension of a particular individual at a particular site is important to evaluate the nature of the resultant scar. On the face, it is less around the eyes and more on the forehead. In each location there is a directional consideration of skin movement. The ultimate width and shape of scar are largely determined by tension at a particular site and likely to become hypertrophic when tension across the scar is maximum. Based on skin tension properties, plastic surgeons plan the direction of incision so that tension across it is minimum, resulting in a fine linear scar. Crease only forms if tension at right angle is minimal. Scars that are aligned with crease lines have a better aesthetic outcome, whereas scars that cross crease lines have a greater tendency to hypertrophy. Crease scar angle then becomes a vital factor, and the closer it is to 90 degrees, the greater are chances of hypertrophy. Conversely, the lesser the angle is or the closer it is to 0 degree, the lesser are chances of hypertrophy.

Effect of Increased Tension on Skin

Because of increased tension on the skin, it can produce three effects depending on the force applied: stretching, blanching, and rupture.

Stretching of Skin

Permanent stretching of the skin occurs when it is stretched gradually. This stretching is commonly observed in slowly increasing adiposity and lymphedema. Skin and subcutaneous tissue grow over gravid abdomen. This type of stretching usually depends on growth and biological activity and differs from creep that is physical in nature. Conventional skin expansion with expanders is now popular for a variety of reconstructive purposes. In this technique, there is a contribution of creep and biologic stretch.

Blanching

When increasing tension is applied to a skin, there reaches a state where dermal blood flow is obstructed. If allowed to persist, it produces necrosis. If skin flap is sutured into a defect under tension or if skin is advanced too far after wide undermining, even a small amount of increased tension may compromise blood flow. If tension is not relieved, it will produce necrosis. Undermining of a wound edge is frequently performed to facilitate a tension-free closure. Undermining beyond a particular distance causes injury to the surrounding structures and compromises the blood flow.[20,21] Similarly, when primary closure of wound is not possible due to skin tension, skin flaps are used. Increased tension of wound margins can occur with large defect or low skin extensibility. Usually skin flaps are planned from a lax adjacent area and move in a favorable direction to achieve wound closure. Blood flow to the flap depends on tension and distance. Flaps with adequate blood flow can withstand tension, but with insufficient blood flow even small tension skin flap may necrose.

If there is excessive and prolonged pressure on the skin, which causes obliteration of dermal blood vessels, blood flow is obstructed and tissue perfusion will be impaired leading to ischemia and then begins pressure sores formation. Dinsdale conducted pressure studies and concluded that constant pressure equal to twice the end capillary arterial pressure (70 mm Hg) applied for 2 hours produces irreversible tissue ischemia.[22]

Rupture of Dermis

Tension in skin is not enough to cause blanching but results in rupture of dermis causing striae. Striae is often noted in abdominal skin of females during pregnancy, increasing fat deposit in the buttocks, thigh, and shoulder of the patient suffering from Cushing's disease.[23]

Sometimes increased tension on normal skin has no effect on normal skin, which means tension is not adequate to produce stretching or any other effects. Normal skin adjacent to a postburn flexion contracture does not stretch and correct defect in spite of recurrent tension.

Anisotropy

Skin extensibility varies in different direction in different parts of the body. There are various individual variations such as difference between the slim and obese, young and old, male and female. Throughout life, the skin is stretched and relaxed. The property of elastic fibers to return the skin from its extended state to its fully relaxed state is gradually lost. Later, skin extensibility is replaced by skin laxity. Plastic surgeons do various procedures based on skin extensibility and laxity, particularly the complete closure of skin defects without importing tissues from other site.

The surgeon can assess skin extensibility by picking up a fold of skin between thumb and finger known as the "pinch test." Greater extensibility predicts greater ease of closure on any given area. Thicker skin is less distensible and difficult to move.[24]

Directional variation in skin tension and extensibility properties is important. Skin has a degree of elasticity due to presence of elastic fibers in dermis. Property of elasticity maintains state of constant tension. In aging there is degeneration of elastic fibers in the skin causing relaxation of skin and formation of skin folds. Ability of the elastic tissue from extended state to its fully relaxed state is gradually lost and skin extensibility is replaced by skin laxity.

Dupuytren first described existence of lines of tension in skin. He noticed a cobbler who committed suicide by stabbing himself with an awl with a circular cross section, but the wounds were elliptical in shape depending on the tension across the wound.

Langer made notable observation of Dupuytren's work. He was an anatomist, famous for his lines called "Langer's lines." Langer's four articles on skin are titled as "Cleavability," "Tension," "Elasticity," and "Swelling Capability." Thomas Gibson has translated these four papers into English in 1978.[25]

Langer made the pattern of cleft by punching circular holes in the skin of cadavers and noting the orientation of long axis of the resultant ellipse,[26–28] when he established the direction of cleft and possibly that they were arranged in a linear fashion, followed the hypothetical pattern lines (**Figs. 2.2, 2.3**). Langer's lines run parallel to the fibers in dermis and appear to originate from the ultrastructural organization of the dermis.[29] Langer's lines are described as cleavage lines, normal tension lines, retraction lines, and minimal extensibility lines. Langer's lines should not be confused with the crease lines of the face and relaxed skin tension lines.

Langer's concept was not applicable practically as Langer's lines were produced as a result of experiments on cadavers and has no relationship to many of natural flexion creases. Langer's lines are not always parallel to skin creases, often seen obliquely or even perpendicular to most of skin creases like forehead, cheek, and lateral aspect of the eyes (**Fig. 2.3**). It extends vertically across the antecubital region, wrist, thigh, and tibia region.[30]

Pinkus,[31] a dermatologist, was first to question the use of Langer's lines in planning of surgical incisions. Later, he

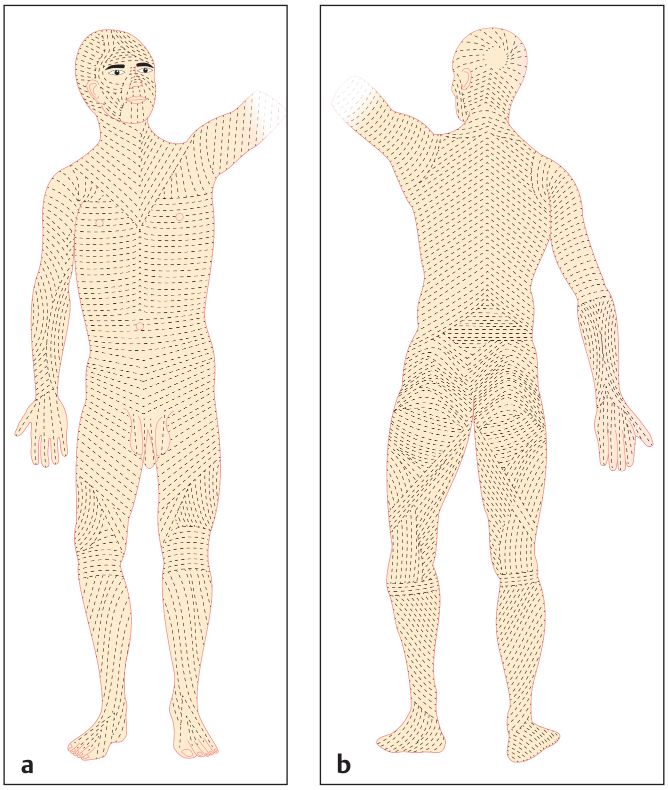

Fig. 2.2 (a,b) Langer's "cleavage lines" run obliquely or perpendiculars to the recommended "main folding lines" of the forehead, cheek, lower abdomen, upper back, and extremities. (Reprinted from Langer K. On the anatomy and physiology of the skin. I. The cleavability of the cutis. Br J Plast Surg 1978;31:3–8.)

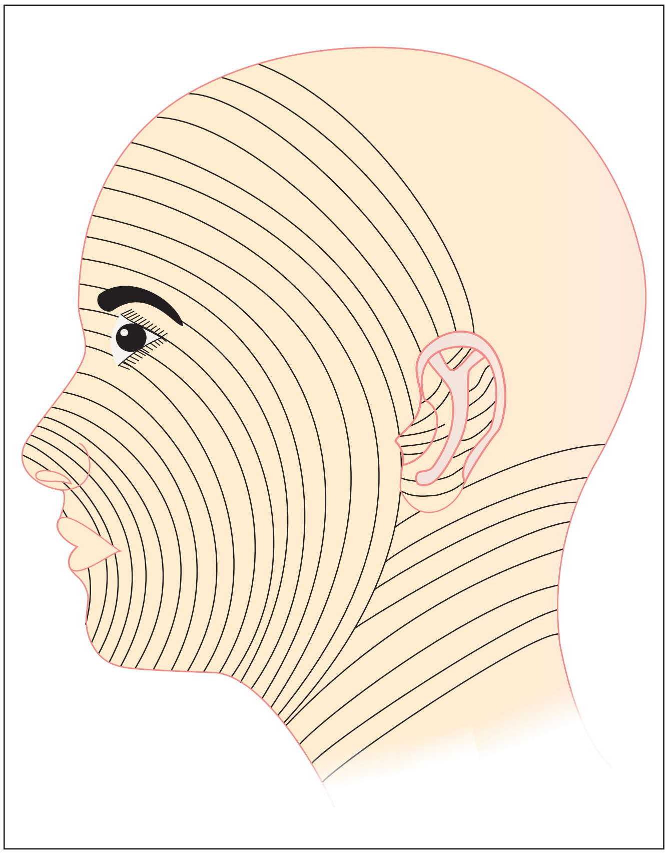

Fig. 2.3 Langer's lines on face.

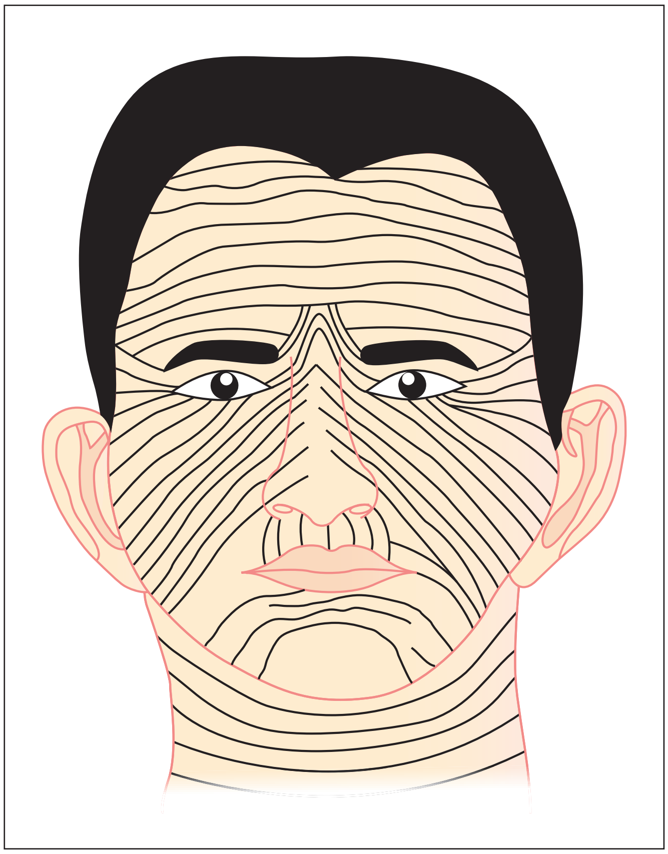

Fig. 2.4 Kraissl's lines run "perpendicular to the direction of the underlying musculature." The facial folds lines show long-accepted incision lines advocated for use in facial surgery. (Reprinted from Borges AF, Alexander JE. Relaxed skin tension lines, Z-plasties on scars, and fusiform excision of lesions. Br J Plast Surg 1962;15:242–254.)

described main folding lines of skin. Kraissl[32] described the antimuscular lines, which are usually perpendicular to the underlying muscles (**Fig. 2.4**). Kraissl's lines correspond to normal wrinkles of old age.

Later, Borges[33,34] referred to skin lines as relaxed skin tension lines (**Fig. 2.5**). Collagen and elastic fibers are arranged with long axis parallel to the minimal skin tension lines. Lines refer to orientation of the furrows produced by pinching skin in a relaxed position in between different directions. However, this pinching technique is difficult to perform in certain areas of the body such as thick back skin of an adult. Difficulty encountered by this technique is variability as it is evident when applied to the extremities. Pinching of skin forms a pattern of furrows, which depends on the direction of force and position of extremity, in supination or pronation.[35,36] Kraissl's lines are not always parallel to relaxed skin tension lines on the face. They are oblique on the side of the nose, horizontal below the vermilion on the lower lip, and radiate outward from lateral canthus of the eye.

A scar present along the relaxed tension lines is least noticeable, so offer a suitable location for surgical incision with aesthetic scar (**Fig. 2.6**). A scar that traverses the lines of skin tension at right angle is subjected to constant changes in tension due to the activity of underlying musculature. Therefore, hypertrophy of scar usually occurs.

Clinical Relevance

Understanding of unique physical properties of the skin is necessary to obtain best outcome in wound closure. When wound is closed tightly or a flap seems too small but the defect is closed, the physical properties of creep and stress relaxation act, and the skin elongates. However, there is certain limit to this mechanism, and blood supply must be considered. Plastic surgeons can use the physical properties of the skin for designing and execution of various flaps. The nonlinear stress–strain curve for skin determines wound closure tension, blood flow, and flap survival. Time-dependent properties of the skin, such as creep and stress relaxation, are a clinically useful phenomenon that permits tissue expansion.

Primary Closure and Undermining

Primary closure is a preferred reconstructive option if excessive tension and distortion of surrounding tissue

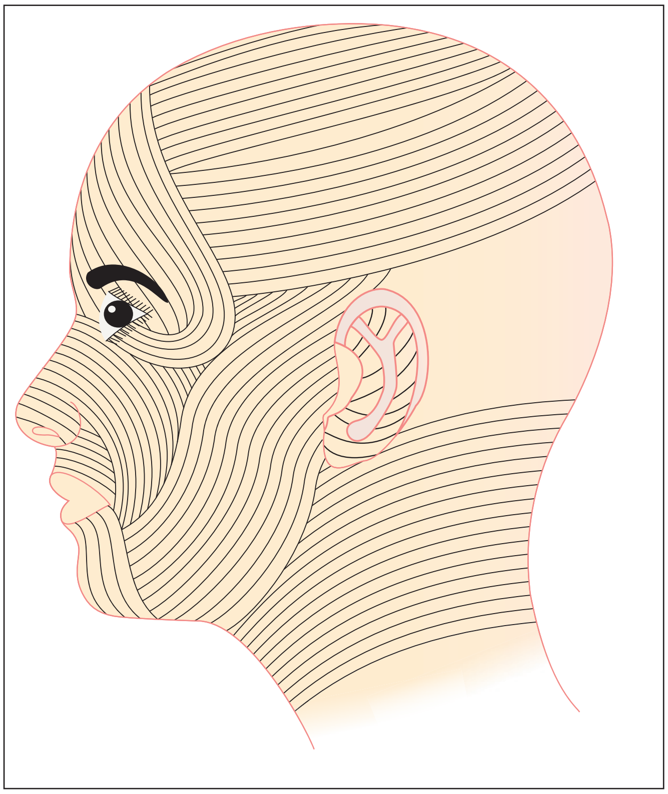

Fig. 2.5 Borges "relaxed skin tension lines."

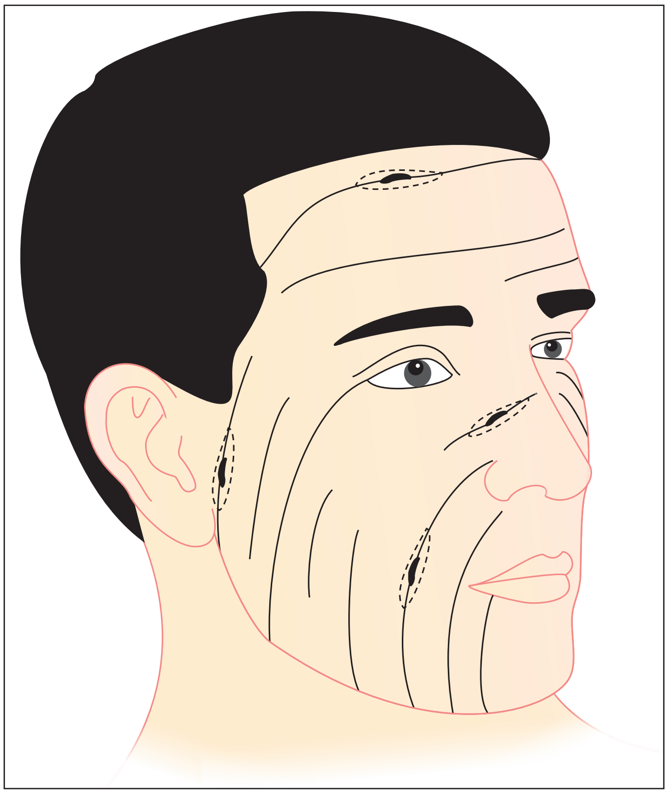

Fig. 2.6 Suitable locations of incisions along resting skin tension lines.

is avoided. The size of defect that is suitable for primary closure depends on site, skin tension, and skin extensibility. The scars are ideally placed along minimal skin tension lines on natural skin crease to produce a fine aesthetic scar. Skin tension is important for wound healing. Wound closed under tension is likely to produce stretched hypertrophic scar. Some area of high skin tension also produces stretched or hypertrophic scars as in shoulder and sternum (**Fig. 2.7**). The constant state of tension in skin is maintained mainly by the collagen, which does not contribute to elastic recoil of skin. This elastic recoil fiber is a property due to elastic fibers. Therefore, orientation of scar in respect to relaxed skin tension lines is essential. Example includes bridle scar crossing alar facial groove and vertical scar on the back of the neck or forehead (**Fig. 2.8**).

Borges suggested three scar revision technique: fusiform excision if scar is in the relaxed skin tension lines, Z-plasty for scars at an acute angle to the relaxed skin tension line, and W-plasty for scars more than 60 degrees to relaxed skin tension lines (**Fig. 2.9**). When wound is wide enough and difficult to close primarily, undermining of wound edge is usually performed to facilitate a tension-free closure. The edge of wound is advanced both to stretch the skin and to overcome the resistance (**Fig. 2.10**). Undermining is possible to a certain limit; otherwise, it may compromise the blood flow. However, in old-aged patients, comparatively larger defects can be closed due to excessive skin extensibility.

Fig. 2.7 A 10-year-old child with postburn hypertrophic scar over lower sternum.

Skin Flap Design

Primary closure of wound is not possible in certain conditions due to excessive tension, so role of skin flaps arises. The study of skin biomechanics has increased precision and reliability of flaps. A minor variation in flap design can alter the mechanical property of the skin and change the force necessary for advancement and wound closure. Proper flap design will minimize wound closure tension and maintain

Fig. 2.8 Vertical hypertrophic scar on the back of neck. (Courtesy: Dr R. K. Mishra, Head of Plastic Surgery, SIPS Super Specialty Hospital, Lucknow, India.)

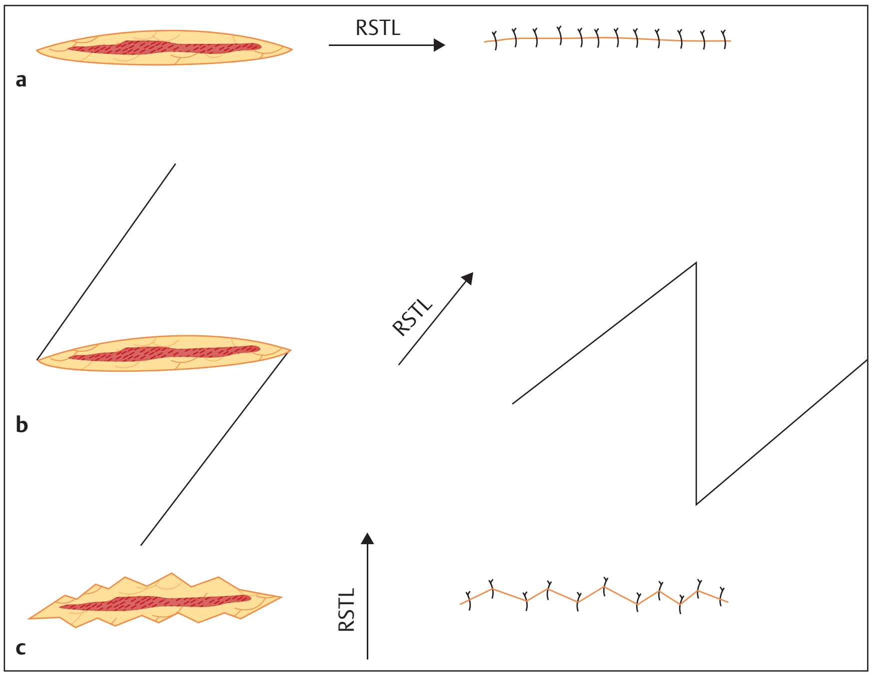

Fig. 2.9 **(a)** Elliptical excision in resting skin tension lines. **(b)** Z-plasty for scars at an acute angle to the resting skin tension lines. **(c)** W-plasty for scars more than 60 degrees to resting skin tension lines.

Fig. 2.10 Primary closure with undermining **(a)** Pre-op view of patient with vascular malformation face. **(b)** Post-op view after excision and primary closure of the defect. **(c)** Two weeks post-op result.

adequate blood flow. Excessive tension usually occurs with large defects or low skin extensibility. Flaps are usually designed to place a donor site incision within the lines of minimal tension. This can be determined by identifying the area of the skin with maximum extensibility. Then loose surrounding skin is transferred to the defect. Blood supply to the skin flap and tension to the flap are important for survival. There is increased tension in the flap when skin flaps are sutured into the defects slightly too large or the skin is advanced too far after wide undermining. This results in blanching of skin due to obstruction of blood flow. If not relieved, necrosis follows. However, flap with ample blood flow can withstand the extremes of tension.

On the face transposition and rotation flaps are frequently used to cover medium to large defects. Rhomboid flap, a type of transposition flap, is versatile and used to cover the defects on the lower and lateral cheek and temporal area on the face. Lesion is excised in rhomboid shape consisting of parallelogram with opposing angle of 60 and 120 degrees. The donor flap bisects the 120-degree angle. Depending on the skin extensibility, donor site incision is placed along the lines of minimal tension and flap is transposed to the defect with primary closure of donor site (**Figs. 2.11, 2.12**). Another commonly used flap for facial defects is rotation flap. This includes cervicofacial rotation flap for repair of moderate to large defects of upper medial region. These flaps include loose preauricular and neck skin. Wide subcutaneous undermining of skin flaps is required. This flap is designed such that incision starts at the superior aspect of defect and extend to the outer canthus and along the zygomatic arch. The incision is then brought along preauricular area and extended below the ear, and retroauricular hairline then brought down. Flap is advanced and rotated to cover the defect (**Fig. 2.13**).

Tissue Expansion

Physiologic tissue expansion occurs during rapid growth at puberty, pregnancy, and rapid weight gain. During pregnancy, time interval is relatively short and skin thinning occurs and sometimes results in striae formation. Obesity causes an overall increase in skin surface area and maintains a normal thickness in both the epidermis and dermis with normal collagen content.[37]

Tissue expansion is used to close large surgical wounds that could not otherwise be closed (**Fig. 2.14**). In tissue expansion, dermis decreases rapidly in thickness during expansion over the implant. The underlying mechanism for the overall increase in skin surface area without thinning of epidermis is increased epidermal mitotic activity and keratinocyte proliferation. Dermal thinning persists at least 36 weeks after expansion is completed.[38] Expanded tissue demonstrates quantitative increase in collagen content of the dermis. Relative proportion of types I and II collagen are not significantly changed after expansion in dermal epidermal interface.[39] Expanded skin has increased vascularity. Angiogenesis is probably secondary to ischemia of expanded tissue. There is significant increase in number of cells expressing vascular growth factor when compared with nonexpanded tissue.[40] Expanded tissues with increased vascularity have significant vascular benefits.[41,42] Requirement of this technique is that there be sufficient normal skin adjacent to the defect so that silicone tissue expander can be placed. Expander is filled with saline on weekly basis for a period of 8 to 10 weeks or more depending on the requirement. Then expanded flap is advanced or rotated to cover the defect (**Fig. 2.15**).

A variation on tissue expansion is serial excision. Serial excision is a multistep procedure in which lesion in inelastic

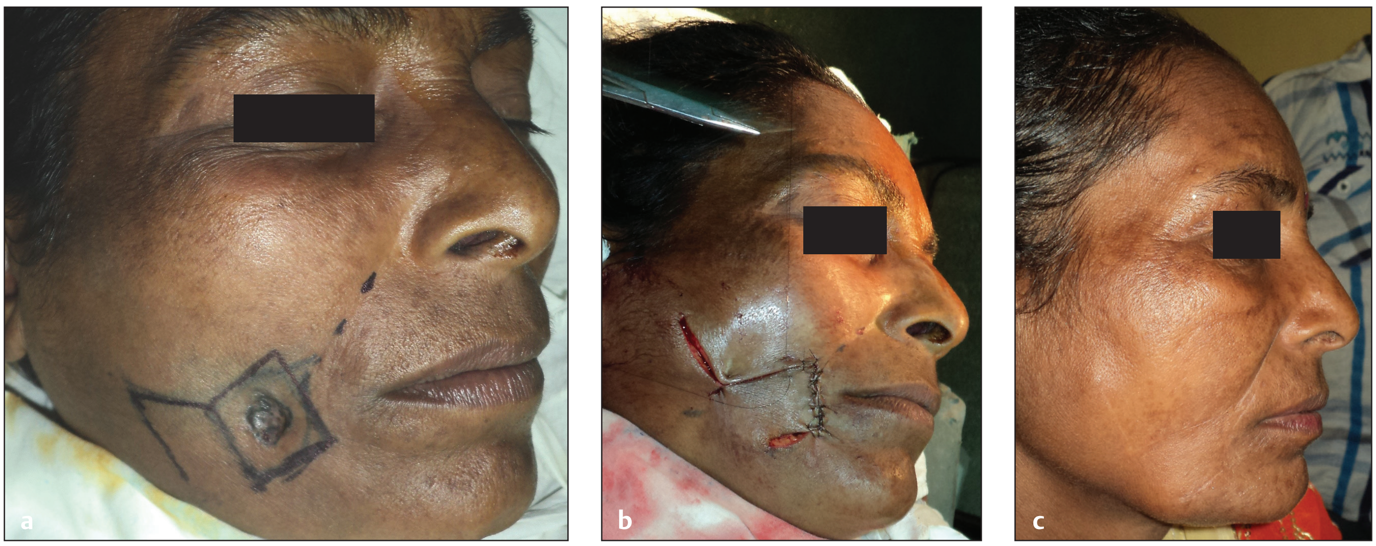

Fig. 2.11 Rhomboid flap for cheek defect. **(a)** Basal cell carcinoma of the lower face, rhomboid flap marked. **(b)** Defect after excision of lesion is covered by rhomboid flap. **(c)** Post-op result. (Courtesy: Dr Brijesh Mishra, Prof., Dept. of Plastic Surgery, KGMU, Lucknow, India.)

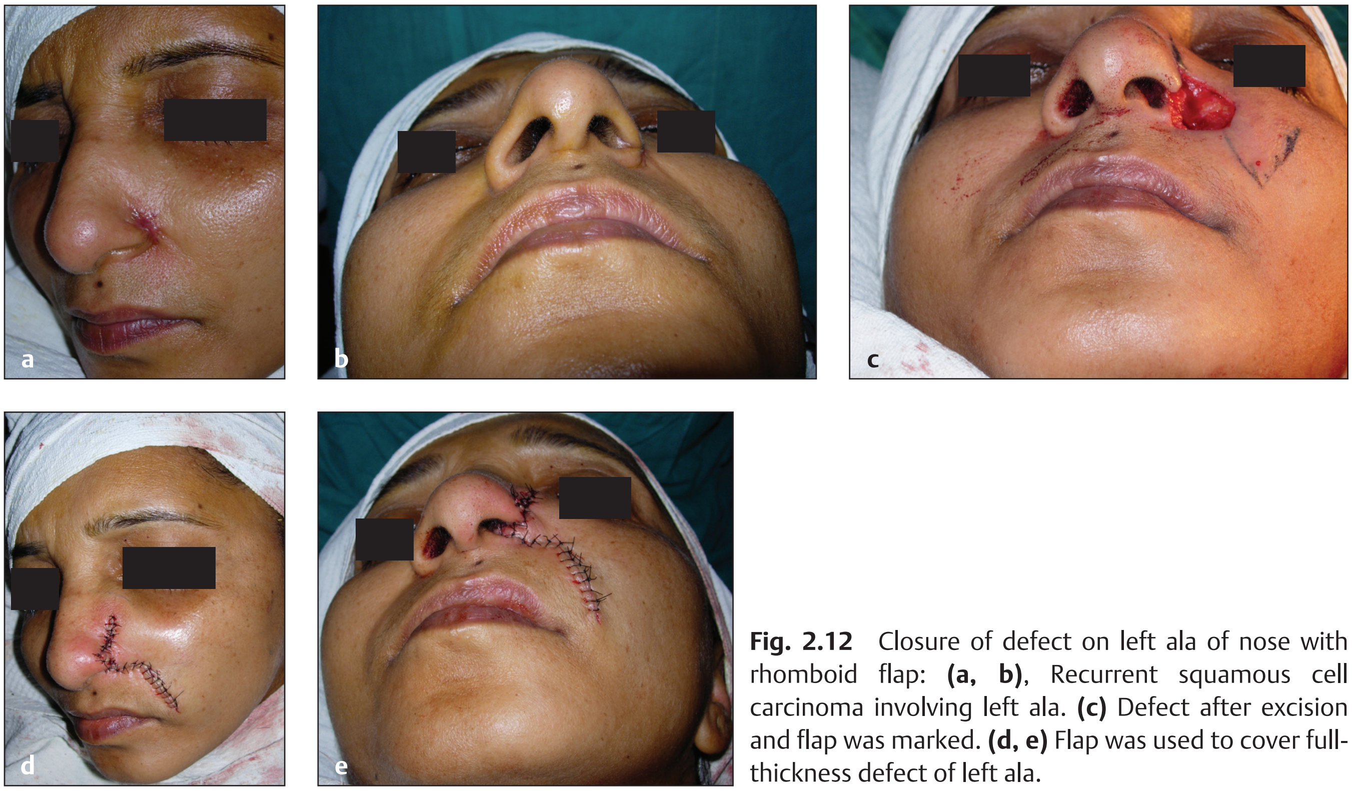

Fig. 2.12 Closure of defect on left ala of nose with rhomboid flap: **(a, b)**, Recurrent squamous cell carcinoma involving left ala. **(c)** Defect after excision and flap was marked. **(d, e)** Flap was used to cover full-thickness defect of left ala.

Fig. 2.13 Cheek rotation flap for cheek and paranasal defect: **(a)** Preoperative view. **(b)** Defect after excision of basal cell carcinoma. **(c)** Rotation flap to cover the defect. **(d)** Post-op result. (Courtesy: Dr Brijesh Mishra, Prof., Dept. of Plastic Surgery, KGMU, Lucknow, India.)

Fig. 2.14 Tissue expansion for post-burns scar face. **(a)** Burn scar involving lower lip, chin, cheek, and neck. **(b)** Expansion of cheek skin with expander placed in the lower cheek area. **(c)** Per-op marking of scar. **(d)** Burn scar excised and expanded flap advanced anteriorly and inferiorly without distortion of surrounding area. (Courtesy: Dr Brijesh Mishra, Prof., Dept. of Plastic Surgery, KGMU, Lucknow, India.)

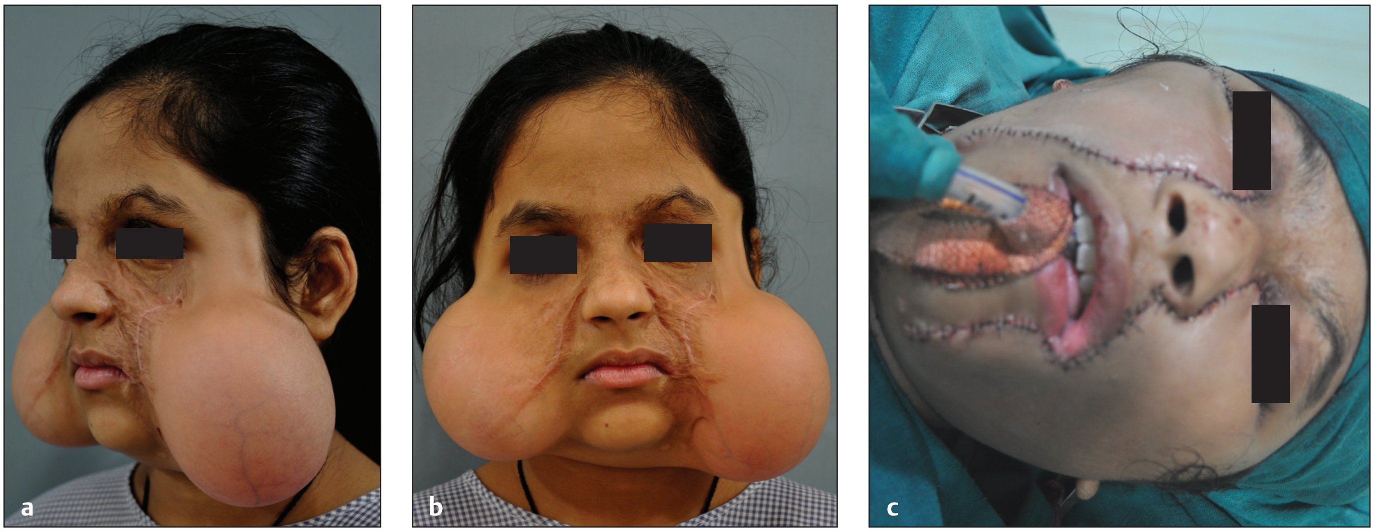

Fig. 2.15 **(a, b)** Bilateral expansion of cheek skin for burn scar. **(c)** Burn scar excised and expanded cheek flap advanced medially to cover the defect. **(d, e)** Post-op result. (Courtesy: Dr R. K. Mishra, Head of Plastic Surgery, SIPS Super Specialty Hospital, Lucknow, India.)

region can be removed by multiple excisions. After first excision, the closure persistently stretches the affected skin. The force upon the skin gradually decreases as the skin undergoes stress relaxation. At next excision, more tissue is removed and the cycle repeats, leading to gradual expansion.[43]

Gibson and Kenedi[44] first suggested that additional tissue for wound closure could be obtained by rapid intraoperative tissue expansion using loading to stretch the skin. Loading with constant force is achieved by placing temporary retention sutures for some time. Applying traction to wound edges using skin hooks can also perform a loading. Intraoperative tissue expansion increases skin compliance with decreased tension.[45] The use of intraoperative loading using retention sutures can greatly increase the ease of closure (**Figs. 2.16, 2.17**). When skin is stretched using these methods, the elastic fibers do not revert to their original state, rather lengthen through the property of creep

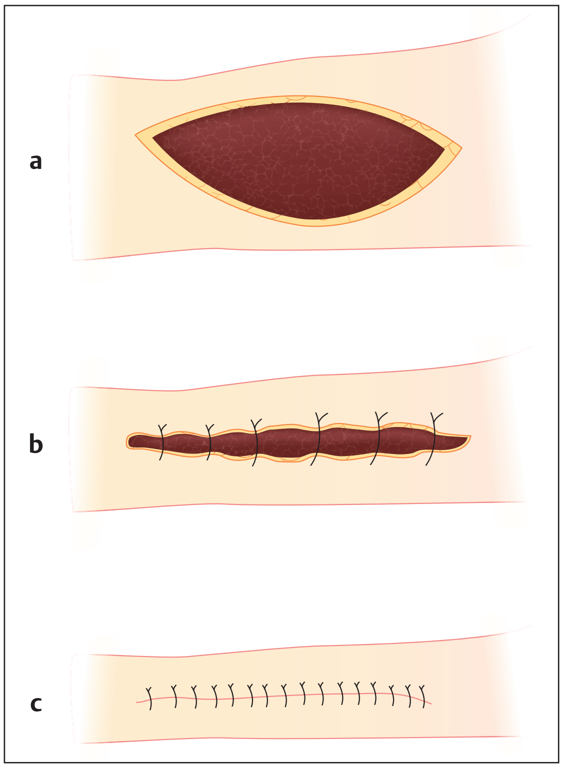

Fig. 2.16 Rapid intraoperative tissue expansion: Skin around the thigh wound defect is loaded with constant force applied with sutures. Because of skin's property of creep, skin expands and results in wound closure.

Fig. 2.17 **(a,b,c,d,e)** Rapid Intraoperative tissue expansion: Defect over the dorsum of hand was covered with distal radial artery perforator flap. Donor defect was loaded with multiple sutures. Skin expands intraoperatively and wound closed with less tension.

Specific Conditions: Alteration of Physical Properties of Skin

Aging

There are various changes in physical properties of skin with aging (**Fig. 2.18**). Extrinsic aging is caused by environmental factors; long-term exposure to the sun's ultraviolet radiation is called *photoaging*. Others are due to diet changes, tobacco, and alcohol consumption. In photoaging, cell maturation is altered causing coarse texture and solar keratosis. Melanocyte alteration causes solar lentigines and mottled pigmentation. Decreased collagen number and strength and solar elastosis result in fine wrinkling of the skin.[46] Intrinsic aging occurs due to thinning of dermis that is caused by decrease in collagen and decrease in elasticity of skin because of degeneration of elastic fibers and changes in glycosaminoglycan. With aging, the skin becomes thinner, stiffer, less tense, and less flexible, and lowers its protective function against mechanical injuries.

Body posture and gravitational forces affect the intrinsic tensile strength of the skin because they influence the orientation of dermal fiber networks. They tend to reduce the anisotropic aspect of skin tensile strength.[47]

Systemic Sclerosis

Systemic sclerosis is an autoimmune disease characterized by excessive deposition of connective tissue in the skin, lung, heart, gastrointestinal tract (GIT), and others organs. Edema and inflammatory cell infiltrates around the blood vessels in the dermis are present in early stage of systemic sclerosis. Progression of skin lesion is associated with extensive collagen accumulation of collagen and finally fibrosis. Sclerodermatous skin disturbs normal skin architecture and affects physical properties of skin. Because of deposition of large amount of dermal collagen, there is increase in skin thickness and stiffness. There are reduced extensibility and increased resistance to stress.[48,49] In systemic sclerosis, anomalies of the elastic tissue also exist. Elastic fibers are atrophic and usually absent in few sclerotic areas. Therefore, elasticity of the skin is decreased.[50]

Menopause

Menopause significantly affects physical properties of the skin as estrogen increases the production of collagen and elastin responsible for viscoelastic properties of the skin. Estrogens are C-18 synthesized from cholesterol in the ovary premenopausal and in the peripheral tissue of postmenopausal women. Estrogen exerts its action through receptors in the skin.

During menopause, estrogen production diminishes significantly. Dermal thickness, skin tensile strength, and elasticity too decrease. Thinning of dermis often accompanies aging. Most studies suggest that loss of collagen is more closely related to postmenopausal age than chronologic age, thus reflecting hormonal effects.[51] There is an average decline of 1 to 2% per year in dermal collagen content after menopause.[52]

Estrogen increases production of glycosaminoglycan such as hyaluronic acid, which helps maintain fluid balance. A lack of glycosaminoglycan contributes to diminished skin moisture levels causing dryness, wrinkles, and atrophy.[53] Menopause causes skin aging with loss of skin elasticity leading to laxity, sagging, and wrinkling. Postmenopausal flushing occurs due to vasodilation of dermal papilla. Hair growth is also affected by estrogen and consequently hair loss has been associated with menopause. Aging is also

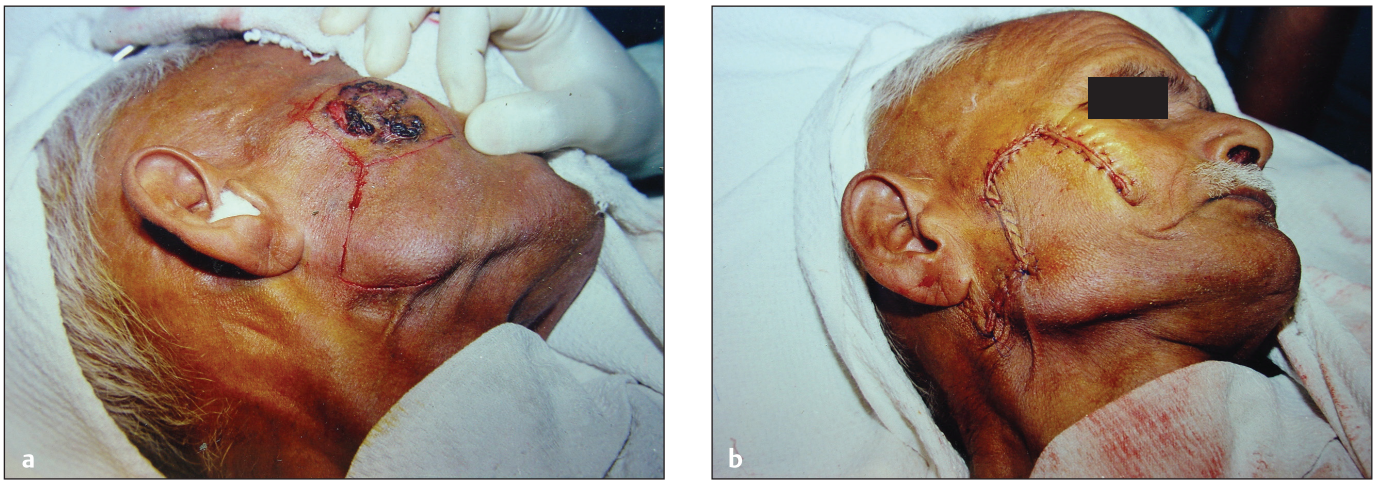

Fig. 2.18 **(a,b)** Old patient with basal cell carcinoma of the cheek covered with rhomboid flap: Because of more extensibility and laxity, skin from jowl and neck area was transposed to the large defect without distortion of surrounding skin. (Courtesy: Dr R. K. Mishra, Head of Plastic Surgery, SIPS Super Specialty Hospital, Lucknow, India.)

associated with reduction in sweat and sebaceous gland. Treatment with hormone replacement therapy has shown to increase collagen content, dermal thickness, and elasticity.

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