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Age-Related Changes in the Cutaneous Basal Lamina: Scanning Electron Microscopic Study

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Scanning electron microscopy of human epidermal-dermal basal lamina demonstrated striking age-related changes. The basal lamina from abdominal skin was exposed in specimens from 26 humans by separation of epidermis and dermis after treatment with sodium bromide solutions. Transmission electron micrographs demonstrated the split to be in the lamina lucida. Scanning electron microscopy of mature epidermal-dermal junction and basal lamina showed distinct dermal valleys; tall, dome-shaped dermal papillae; and basal lamina arranged in prominent corrugations that tended to be oriented vertically on papillae and irregularly on interpapillary zones. Skin from subjects in their 7th through 10th decades demonstrated progressive loss of dermal valleys, flattening and widening of dermal papillae, and loss of basal lamina corrugations.

Skin undergoes dramatic age-related structural and functional changes, many of which may be associated with alterations in the epidermal-dermal basal lamina. The basal lamina serves a variety of functions, including physical support for the epidermis, adhesion of epidermis and dermis, scaffolding for epidermal repair, modulation of epidermal differentiation, and proliferation and control of movement of some macromolecules [1–3]. Light microscopic and transmission electron microscopic studies [4–8] have indicated that this basal lamina has a complex profile, which may vary with development and aging; however, current concepts about its topography based on transmission electron micrographs have been incomplete or inaccurate [5,6,8]. Because of the intimate relationship between the cutaneous basal lamina and a variety of other skin structures and functions which may show age-related changes, we studied by scanning electron microscopy the epidermal-dermal basal lamina in humans 16–92 years of age.

MATERIALS AND METHODS

Skin in 1 cm^2 sections was excised from the abdominal midlines, equidistance between the umbilicus and xyphoid, from 26 humans at autopsy. This population included 18 men and 8 women with an age range of 16–92 years. Two were in the 2nd, 3 in the 3rd, 5 in the 4th, 2 in the 5th, 4 in the 6th, 3 in the 7th, 1 in the 8th, 4 in the 9th, and 2 in the 10th decades. None of the patients had a history of dermatologic disease, and excised skin was free of disease by gross inspection. Subcutaneous fat was removed, and blocks of skin were immersed in 2 N sodium bromide at 4°C for 14 h. Under the dissecting microscope, epidermis was gently lifted from the dermis. The latter was fixed in 3% glutaraldehyde in phosphate buffer, treated with osmium-thiocarbohydrazide-osmium (OTO), dehydrated in graded ethanols, critical point dried, and coated with gold-palladium. Representative sections were studied by transmission electron microscopy to document the level of the epidermal-dermal separation, and preservation of the basal lamina and subbasal lamina connective tissue. Specimens were examined on a Philips 500 scanning electron microscope and a Philips 300 transmission electron microscope.

RESULTS

The transmission electron micrograph in Fig 1 demonstrates that the epidermal-dermal split following treatment with sodium bromide was in the lamina lucida, leaving the basal lamina attached normally to the subbasal lamina connective tissue. Thus scanning electron micrographs presented in this report show the epidermal surface of the basal lamina. Fig 2*A* shows the appearance of the epidermal-dermal junction of mature skin from the 2nd through the 6th decades. It was characterized by a complex pattern of dermal valleys and papillae. The valleys were distinct, and the papillae were tall and mostly dome-shaped. Peak-shaped papillae were uncommon. Fig 3*A* shows how the basal lamina covering the papillae and interpapillary

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Abbreviations:
OTO: osmium-thiocarbohydrazide-osmium

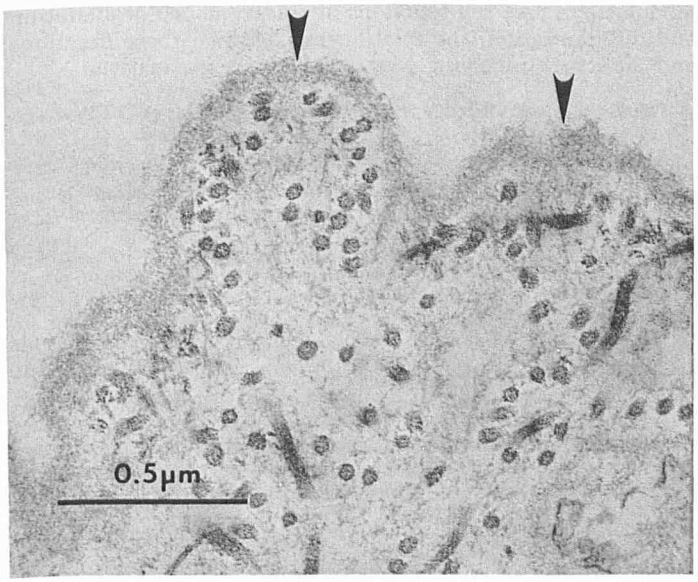


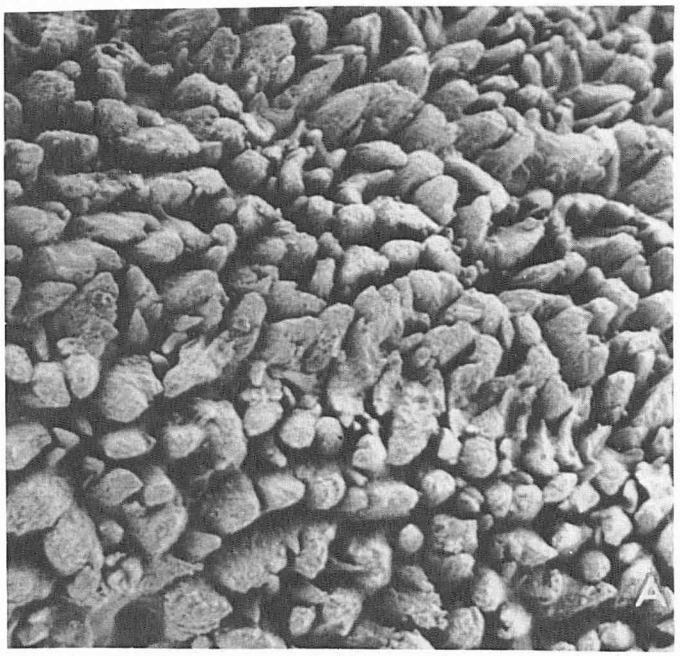
FIG 1. Transmission electron micrograph of basal lamina (*arrows*) following removal of epidermis. Note that the split is immediately above the basal lamina in the lamina lucida zone. The dermal connective tissue including collagen fibers and anchoring fibrils remain well preserved and attached normally to the basal lamina.

troughs produced a complex pattern of corrugations. The corrugations were mainly oriented vertically on the papillae and oriented irregularly on the interpapillary surfaces. Fig 2*B* and 3*B* show skin changes representative of those in the 6th through the 10th decades. There was a progressive loss of definition of dermal valleys with flattening, widening, and apparent fusion of dermal papillae. Loss of basal lamina corrugations resulted in a relatively smooth to slightly undulating surface.

DISCUSSION

Utilizing sodium bromide solutions [9] to separate epidermis and dermis at the level of the lamina lucida, this study characterizes the external surface of the basal lamina at the epidermal-dermal junction in mature and aging human skin. The use of scanning electron microscopy to examine these specimens has clarified and corrected conclusions from previous studies that used other types of microscopy. Light microscopy demonstrates progressive flattening of rete pegs with aging [10]. Stereoscopic light microscopes used to visualize the epidermal-dermal junction [4] lack the magnification and depth of field necessary to demonstrate the complexity of this basal lamina. Studies based on transmission electron micrographs [5,6] have led to an incomplete, inaccurate understanding of this junctional surface. Such studies have characterized the surface as being covered by numerous pseudopodia or microvilli, but scanning electron micrographs show that the basal lamina in nonsenescent adult skin is characterized by a complex pattern of corrugations. Montagna and Carlisle [11] used scanning electron microscopy in similar split-skin specimens, but they studied the bottom of the basal cell layer of the epidermis rather than the top of the basal lamina. They found microvilli that were reduced with aging. Such data should be viewed cautiously since the technique used to separate epidermis and dermis can produce considerable damage to the delicate plasma membranes of the basal cells. Because of the potential for inducing significant artifacts in the basal cells as compared to the much more resistant collagen of the dermis and basal lamina, we believe that the surface of the basal lamina as viewed here gives a much more reliable image of this epithelial-mesenchymal junction.

Beyond the 6th decade of life in both men and women, there



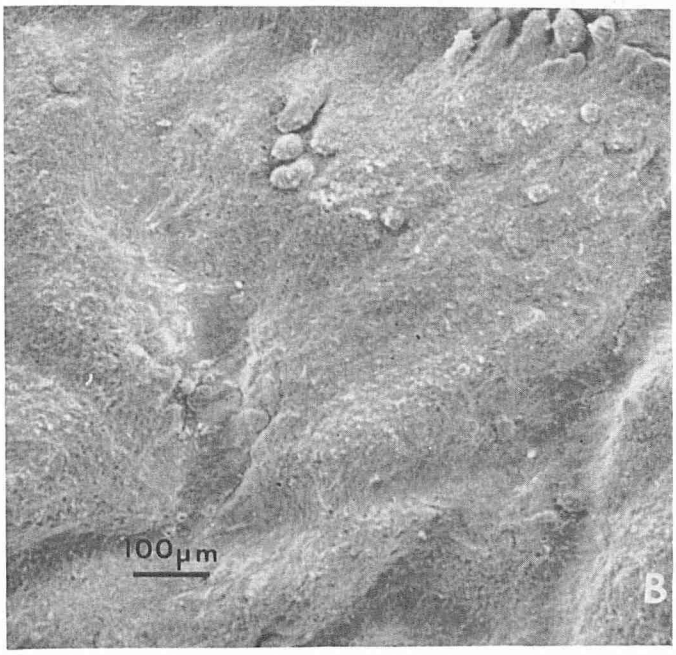


FIG 2. *A*, Low-power scanning electron micrograph of dermal-epidermal junction and basal lamina from a 33-year-old man. Note the abundant, tall, dome-shaped papillae and deep dermal valleys. To facilitate comparison, both *A* and *B* are the same magnification and the *bar scale* is also applicable to both. *B*, Low-power scanning electron micrograph of dermal-epidermal junction and basal lamina from a 90-year-old man. Note the striking decrease in the number of papillae and the flattening of papillae, which result in an overall effacement of the surface.

is progressive flattening of the epidermal-dermal surface and a dramatic loss of basal lamina corrugations. These differences in morphology may reflect differences in both structural support and differentiation modulation functions of the basal lamina and dermal connective tissue that are operational at various stages of skin development and aging. For example, the loss of both well-formed dermal papillae and basal lamina corrugations results in a decreased surface area for epidermal-basal lamina contact and adhesion. These morphologic changes correlate well with the decreased adherence of epidermis and dermis in senescent skin. While the cutaneous basal lamina

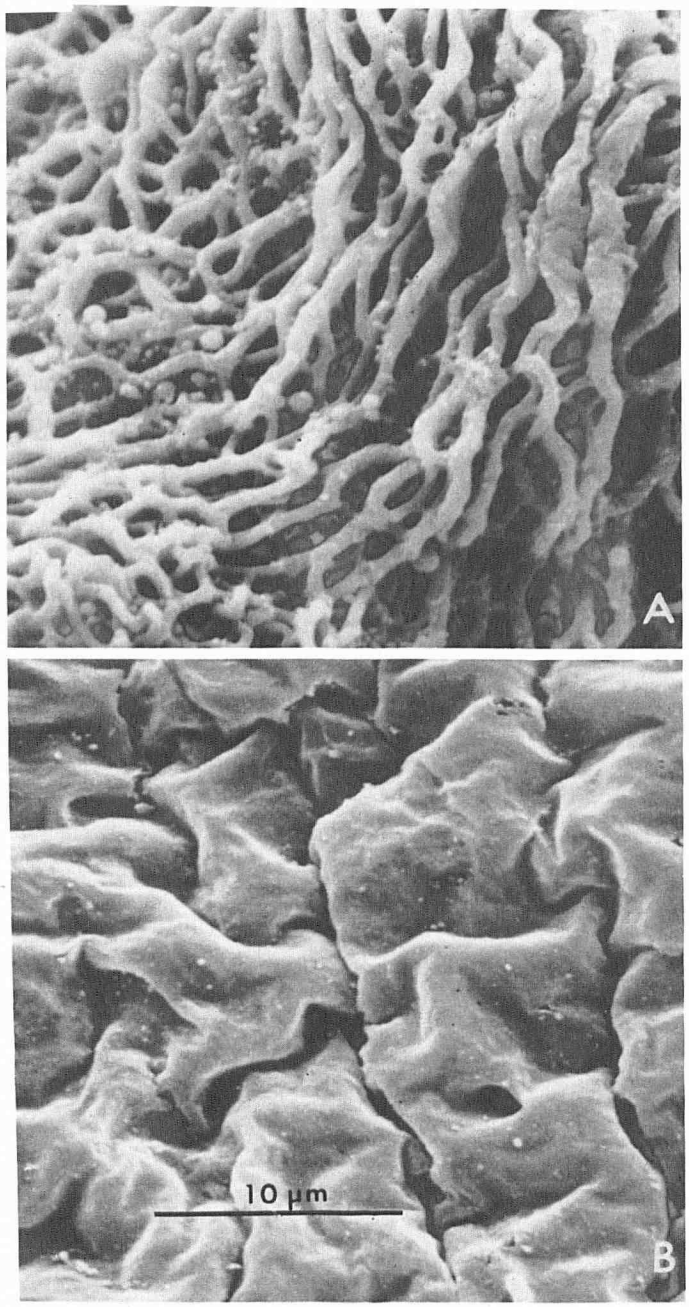


FIG 3. *A*, High-power scanning electron micrograph of basal lamina from a 33-year-old man. The surface is characterized by deep corrugations. To facilitate comparison, both *A* and *B* are the same magnification and the *bar scale* is also applicable to both. *B*, High-power scanning electron micrograph of senescent basal lamina from a 90-year-old man. The basal lamina has lost the pattern of complex corrugations which have been replaced by a relatively smooth, undulating surface.

modulates in part the functions of epidermal cell proliferation and differentiation, the relationship between these functions and the structural changes reported here is speculative.

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