



Skin tape stripping: Which layers of the epidermis are removed?

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Skin biopsies represent the gold standard for investigating skin immunology and biomarkers.¹ However, biopsies cause discomfort, bleeding, minor scarring, and, rarely, skin infections. Accordingly, non-invasive techniques are becoming increasingly popular in dermatological research.^{2,3} Among these, the tape-stripping method is commonly used for obtaining skin cells, but validation showing how many cell layers are removed with this sampling method has not yet been adequately performed. In this study, we determined the number of epidermal cell layers that are removed when skin is tape-stripped with two different adhesive materials.

METHODS

Ten young volunteers with white skin and with no known history of dermatitis on the hands or arms were included in the study (6/10 males, median age 23 years [25-75th percentiles, 22-24 years]). Oral and written consent was obtained before inclusion. The study was conducted according to the Declaration of Helsinki principles, and after permission had been given by the Ethics Committee of Copenhagen (H-16050507) and the Danish Data Protection Agency (HGH-2017-018). Tape stripping was performed with either D-squame sampling discs (Monaderm, Monaco, France) or Barrier tape (Mölnlycke, Allerød, Denmark).

In detail, 0-30 consecutive tapes were applied on the same skin area, with a new tape being used for each application. Custom numbers of tapes were used for the two tape types, as they have different tensile strengths. Each trial participant had three skin areas tape-stripped, and one skin area left intact as a control site. Both tape types were applied with a D-squame pressure applicator applying a standardized pressure (225 g/cm²) (Monaderm). Pressure was applied for ~10 seconds, and the tape was then removed with a tweezer in a quick uniform movement, following the longitudinal axis of the arm. From each tape-stripped

area and the control skin area, a 4-mm punch biopsy was obtained. The biopsy specimens were haematoxylin and eosin-stained, and two blinded assessors independently counted the remaining numbers of keratin layers in the thinnest area of the stratum corneum (SC) for each biopsy to assess how much of the epidermis the tape-stripping method removed.

RESULTS

We found that both tape types completely removed the SC. Overall, complete removal of the SC required at least 30 consecutive tapes when D-squame tape was used, whereas 15 consecutive tapes were sufficient when Barrier tape was used (Figure 1). Notably, the median number of tape strippings needed to remove the SC with Barrier tape was eight (Figure 2). Complete removal was not successful for some trial participants, who had some remaining cell layers after tape stripping. Histology did not show that cells from the stratum granulosum, or deeper layers of the epidermis, were collected. However, it cannot be ruled out that the tape-stripping method collects cells from any of the deeper layers of the epidermis, especially when an increased number of consecutive tapes or alternative tape types are used.

DISCUSSION

Although the included trial participants were age-matched white-skinned persons with no history of skin disease, we observed large interindividual variation in the thickness of the SC and the number of tapes required to strip the SC (8-15 for Barrier tape, and 30 for D-squame tape). In addition, visual examination of the skin immediately after tape stripping, with both tape types, showed no signs of severe erythema, although mild erythema with interindividual variability was observed. Notably, in trial

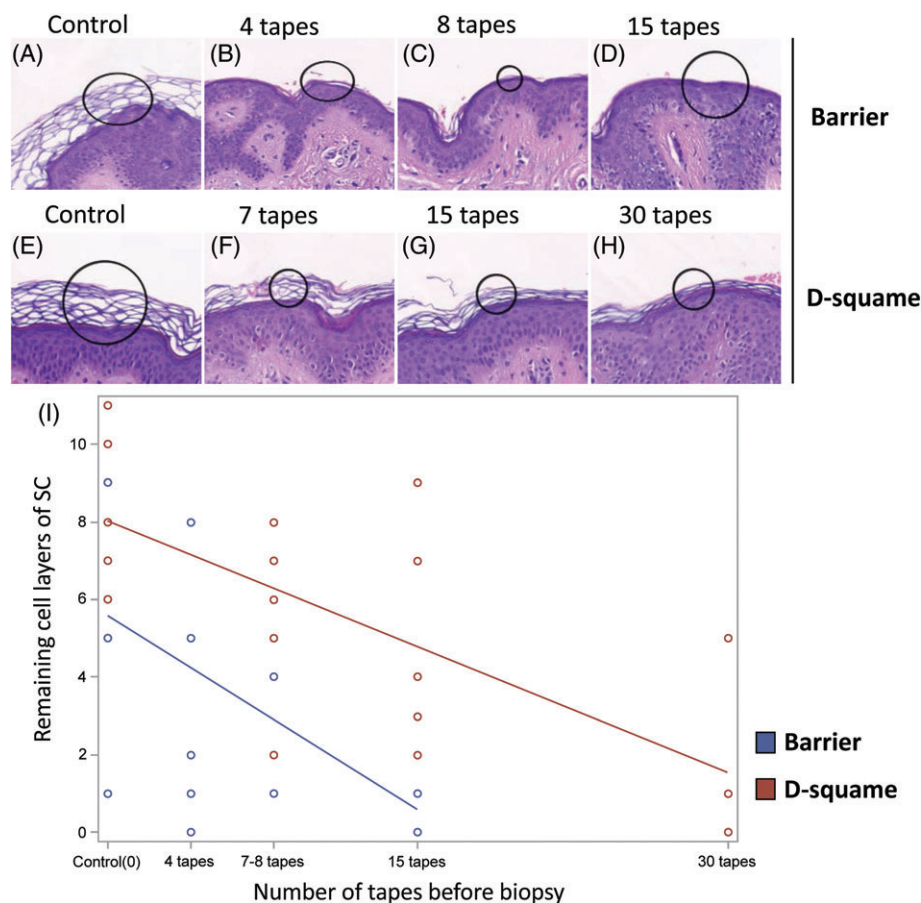


FIGURE 1 (A-D), Histology images from a 22-year-old male who was tape-stripped with Barrier tape. The circles indicate the areas in which the remaining layers of the stratum corneum (SC) were counted after (A) 0, (B) 4, (C) 8 and (D) 15 consecutive tape strippings. (E-H), Histology images from a 25-year-old male who was tape-stripped with D-squame tape. The circles indicate the areas in which the remaining layers of the SC were counted after (A) 0, (B) 7, (C) 15 and (D) 30 consecutive tape strippings. (I) Count of the remaining layers of the SC by tape type. Circles represent the individual observations (some data points overlap). Barrier tape is in blue, and D-squame is in red. No sex difference was observed ($P = 0.57$)

participants in whom the skin became moist during the tape-stripping procedure, additional tape strips did not adhere well on the skin, and, by visual examination of the tape strips, it appeared that tape stripping of moist skin did not remove a significant amount of skin cells. In line with this, Dickel et al (2010) investigated epidermal mRNA expression induced by a standardized tape-stripping protocol with 3M Blenderm surgical tape.⁴ The authors described the stratum lucidum as a visual endpoint of tape stripping, indicating almost complete removal of the SC, and

used 24 (median) tape strips down to the stratum lucidum with 3M Blenderm surgical tape. However, the minimum and maximum values on used tape strips (15-35 tapes) indicates, as in this study, large variability among the 31 participants.⁴ In addition, Dickel et al showed significant changes in epidermal expression profiles, based on curettage biopsies, 6 hours after standardized tape stripping. As curettage biopsies were taken 6 hours after tape stripping, keratinocytes were thought to be the major sources of the immunostimulatory response.⁴

Interestingly, studies have successfully retrieved RNA and proteins from this outermost layer of the skin by using the tape-stripping method;^{3,5-7} however, it is still to be determined whether the cells obtained with the tape-stripping method contain molecular markers that represent the cell responses in the deeper, living layers of the epidermis. Therefore, studies that compare findings of cells from tape strips with those obtained from skin biopsies are needed. In line with this, a study from 2018 compared the RNA transcripts from cells obtained by tape stripping with cells from skin biopsies in patients with atopic dermatitis, and showed that the expression profiles from cells obtained by tape stripping were different from those found in skin biopsies, and can be used to identify novel endotypes of atopic dermatitis.⁸ The methodology, however, needs to be further developed. Moreover, the large interindividual variation that we observed

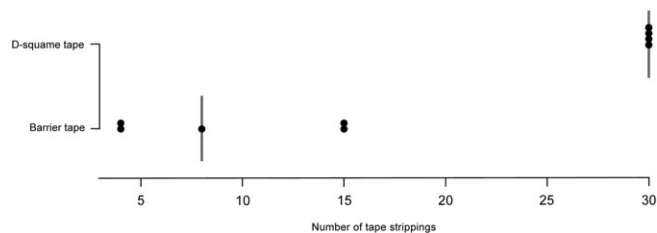


FIGURE 2 Black dots represent the number of tape strippings until complete removal of the stratum corneum (SC). Complete removal was defined as no remaining layer or one remaining layer of the SC. The grey line shows the median number of tape strippings used until complete removal. One individual is missing in the D-squame group, because complete removal was not obtained with 30 consecutive tape strippings

in healthy skin must be expected to be even greater in dermatitis patients with an impaired skin barrier.⁹

In conclusion, our study shows that only skin cells from the SC are removed by the tape-stripping method applied to healthy skin. Moreover, large intraindividual variation was observed in relation to the number of layers of the SC and the number of consecutive tape strippings needed to completely strip the SC. The fact that the tape-stripping method primarily obtains cells from the SC, when used on individuals with healthy skin, is important to take into consideration when results from skin cells obtained with this non-invasive technique are interpreted.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to report.

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