THE JOURNAL OF INVESTIGATIVE DERMATOLOGY
Vol. 49, No. 2

METABOLICALLY ACTIVE SKIN SLICES

FURTHER IMPROVEMENT IN THE DISSECTION OF METABOLICALLY ACTIVE UNIFORMLY THIN SKIN SLICES*

WM. D. STEWART, M.D. AND J. O. RUNIKIS, PH.D.

Modification of existing equipment often enables the completion of tasks that would not otherwise be possible, and thus details of the newer equipment design may be of value, published in short report form. We report here on improvements in the technique of obtaining very thin but metabolically functional skin slices through modification of the Castroviejo Electro-Keratotome.† The instrument has been used successfully by us to dissect over 300 human and animal skin slices to meet varying size and thickness requirements for epidermal respiration, superficial wound healing and analytical chemical studies.‡ The design and operation of the instrument has been adequately described (1, 2) but little has been published on ways of extending the usefulness of this valuable instrument.

The Electro-Keratotome, developed for lamellar keratoplasty (1), was introduced for use as a dermatome by Blank et al. (2). Subsequently it was used by Santoianni and Ayala, Halprin and Ohkawara, and other investigators (3, 4). The dermatome represents an advance for obtaining thin, intact skin slices over free hand dissection techniques such as the Deutch technique (5), and other presently available electric dermatomes such as the more bulky Brown Electrodermatome.§ It obviates the inconvenience of preliminary whole skin removal as in the Van Scott skin stretching method (6), but does not attain as clean a separation. We confirm, however, the experience of Ogura et al. (7) who concluded, after considering twenty-six epidermal separation methods, that, when biochemical determinations are to be made, skin tissues isolated by mechanical separation provide truer values than those obtained by enzyme digestion, heat or ionic change methods even when morphological separation is less than complete.

The main limitation of the Castroviejo instrument is that, developed for the needs of the eye surgeon, it lacks the necessary adaptability to the more varied requirements of the dermatological investigator. The original design claims the ability to dissect 0.5 mm thick lamellar and 0.2 mm thick buccal grafts (1). Within this range the instrument performs well for skin dissections generally. It fails when thinner skin slices are desirable as is the case, for instance, for the study of the biological activities of the epidermis. Only very small pieces of human skin can be removed when the instrument is set to cut at a depth of 0.1 mm (4), and is inadequate for 'tougher' and less resilient animal skin (i.e. of guinea pigs, rabbits, pigs, mice, etc.). The original design also has other inadequacies. The number of oscillations of the blade per minute, and hence the cutting speed, is too slow. In our hands the motor often stops when little more than routine pressure is applied thus producing 'ridges and valleys' in the specimen and in the wound. The instrument produces skin slices of varying thickness when there is a substantial age difference between patients.

In order to circumvent these limitations, we introduced the following innovations. We replaced the original motor with an equally convenient but variable and higher speed dental drill motor (Fig. 1-A)¶ and attached it through a two-ball bearing adaptor (Fig. 1-B) to the headpiece of the instrument (Fig. 1-C).

* Faculty of Medicine, Division of Dermatology and Faculty of Pharmacy, The University of British Columbia, Vancouver, B. C., Canada. Supported by the Medical Research Council and the Canadian Foundation for the Advancement of Therapeutics.
The authors wish to thank Mr. Carl Thumand for his advice and craftsmanship in the innovations of the equipment.

† Storz Instrument Company, 4750 Audubon Avenue, St. Louis, Missouri.

‡ To be published

§ Zimmer Manufacturing Company, Box 111, Warsaw, Indiana.

¶ The Kerr Electro-Torque Model A motor. The Storz Instrument Company is prepared to supply the dermatome with the Kerr motor.

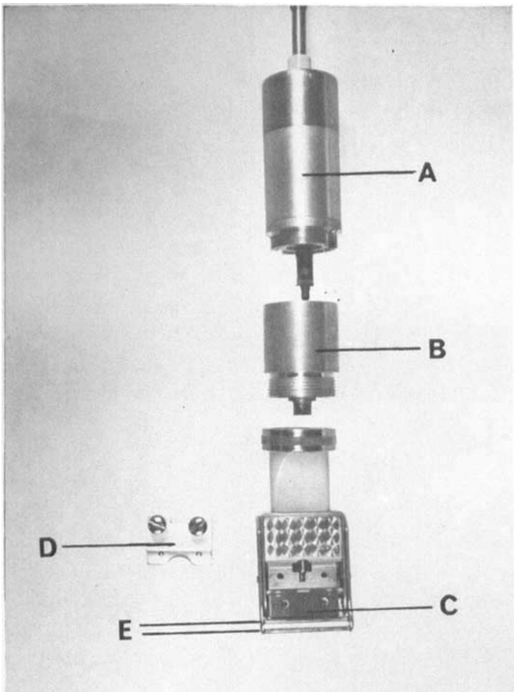

FIG. 1. Exploded view of the dermatome showing the Kerr Electro-Torque motor (A), ball bearing containing adaptor (B), the dermatome headpiece showing the blade and its locking holes in position as cut with the blade press described in text (C), the blade holder of the new design (D) and the two bar guards (E).

The speed of the motor can be varied up to 20,000 rpm. with a corresponding increase in the cutting oscillations of the blade. We find the variable speed feature a distinct improvement. At low and medium speeds the motor operates with sufficiently high torque to eliminate stopping of the motor.

The original design of the headpiece was found to be satisfactory, but the straight edge type blade holder was replaced with one having a concave edge (Fig. 1-D). The free space inside the concave edge facilitates the movement of the cut skin slice and the guidance of the movement with the aid of forceps. This can be seen in the operation of the dermatome (Fig. 2).

We have constructed a convenient manual punch press to fit stainless steel safety razor blades to the locking holes of the Castroviejo headpiece.* The razor blade is simply placed in the slot and the lever (Fig. 3-A) pressed down. The blade may then be fashioned to the desired width with tin snips. The value of the press is threefold. It makes the blades inexpensive enough to allow them to be changed after each cut, a requirement for uniformity. It obviates the mechanical uncertainties en-

* Blueprints available from the authors on request.

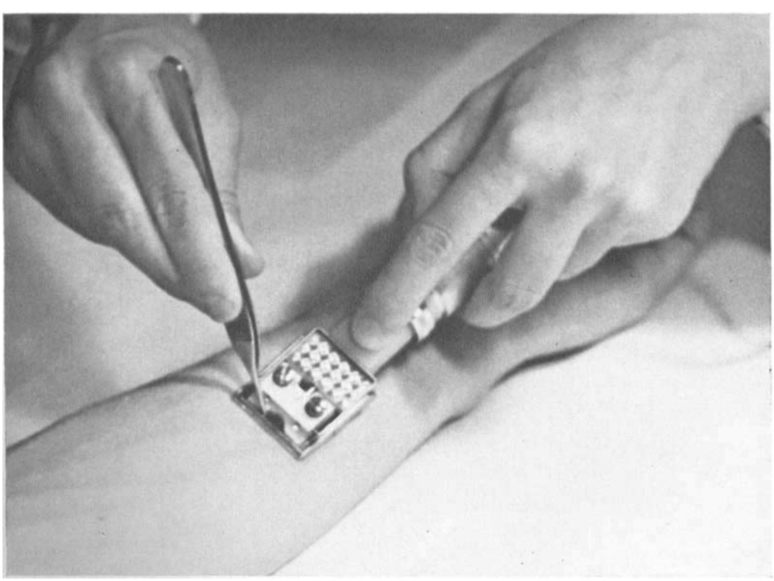

FIG. 2. The assembled dermatome in operation

countered in ordering small demand, highly specialized blades from commercial sources.

A useful attachment to the punch press is, however, a screw type microadjustment (Fig. 3-B) which permits, in 0.0014 mm increments, punching of the locking holes (seen in Fig. 1-C) closer to or further away from the cutting edge of the blade. This is important for the dissection of skin slices thinner than 0.2 mm. With the standard blade, the gap width can be adjusted only crudely in 0.1 mm increments by insertion of appropriate spacers (Fig. 4-A). The standard blade designed to cut 0.5 mm corneal slices has its cutting edge partially blocked by the bar guard and only barely reaches the skin when the cutting depth is decreased to less than 0.2 mm. The result is that the blade tends to glide over the tissue rather than to cut. We found that when lack of flexibility of the skin did not permit the dermatome head to be pressed deep enough in the skin to compensate for an inadequate protrusion of the blade, the situation was remedied by advancing the blade a little. These situations occur frequently with animal work but are encountered also with human skin. This method of altering the position of the locking holes in the blade, gives one the ability to use the dermatome at settings of less than 0.2 mm, and results in much greater uniformity of the

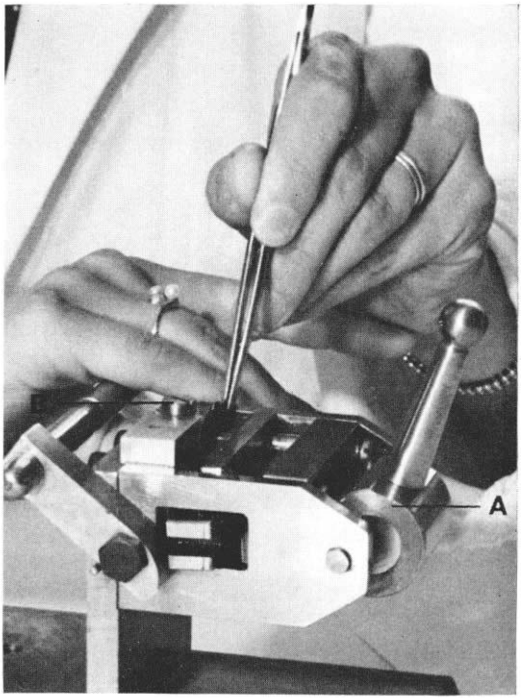

FIG. 3. Manual blade punch press. (A) lever, (B) microadjustment for obtaining blades of desired cutting length.

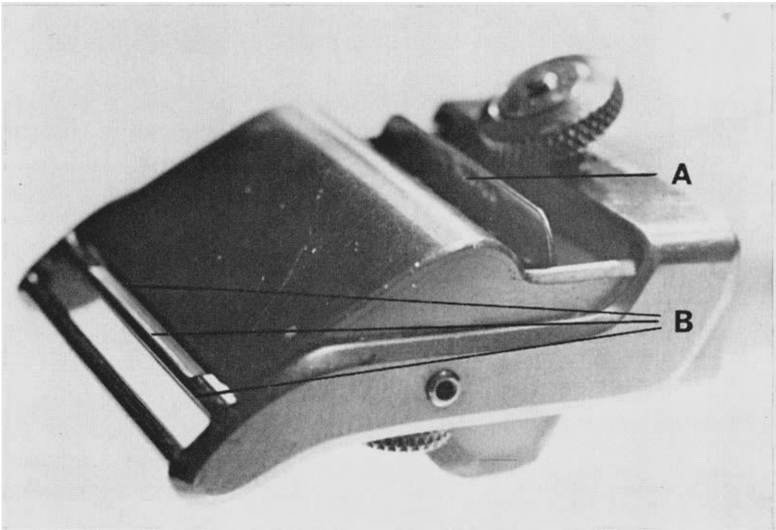

FIG. 4. Illustration of the cutting features which determine the thickness of the skin slices. (A) spacer, (B) protrusion of the blade in relation to its gap width and the angle the edge of the blade forms with the bar guards.

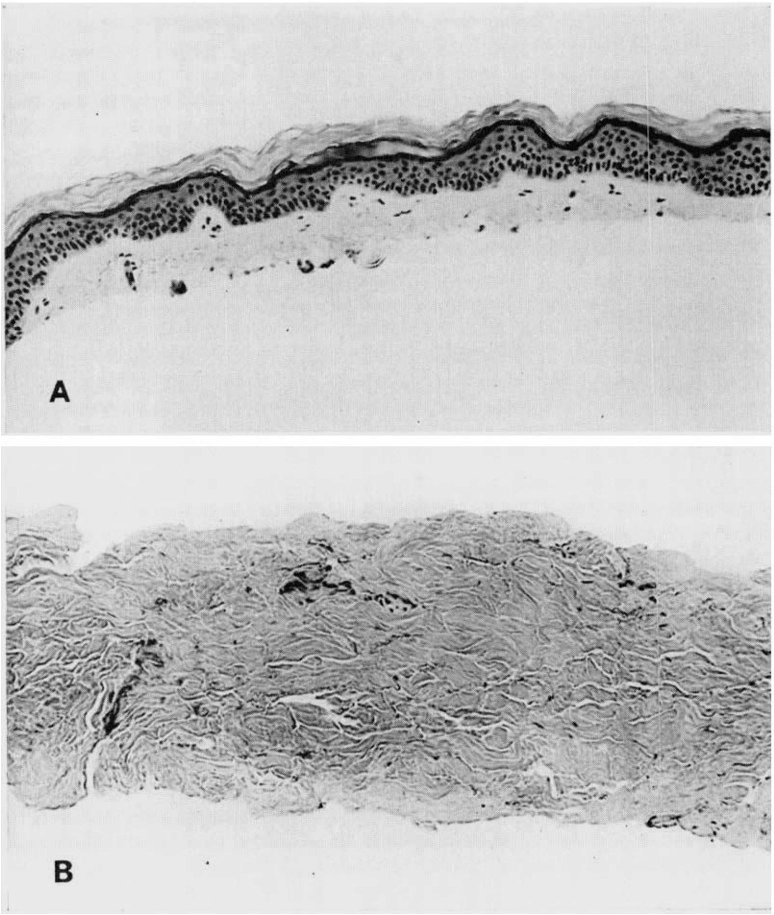

FIG. 5. (A) Human epidermis, approximately 150 microns thick (0.1 mm setting), (B) human dermis, approximately 300 microns thick (0.2 mm setting). × 140, H. and E. Stain.

skin slices, and a reduced frequency failure to obtain satisfactory specimens.

The following demonstrations of applications should be of interest. The human epidermis (Fig. 5-A) is approximately 150 microns thick, and is obtained with a 0.1 mm setting and appropriate blade positioning. Skin slices of this type are useful in studies of the metabolism of the epidermis. The dermal tissue present contains only a small fraction of the metabolically active cells of the slice as may be inferred from the relative scarcity of the nuclei in the dermis. This view is supported by others (4). The dermal cut (Fig. 5-B) was taken at a depth of 0.3 mm and is approximately 300 microns thick. It was obtained by doubling the blade—bar guard gap. The ability to remove reproducibly uniform slices of viable dermis at a predetermined depth provides new possibilities for time-controlled studies of drug penetration.*

The three slices of hairless mouse skin (Fig. 6), obtained by successive serial cuts, represent samples taken at selected levels through the entire thickness of mouse skin. The epidermal slice and the slice of pure dermis below it are each approximately 50 μ thick (0.1 mm setting); the third slice (Fig. 6-C) is approximately 100 μ thick (0.2 mm setting). Serial slices of hairless mouse skin apparently have not been demonstrated before. The lack of hair makes this animal convenient for exploratory experiments. The illustrations, however, show certain specific differences between the mouse and human skin. It

* To be published.

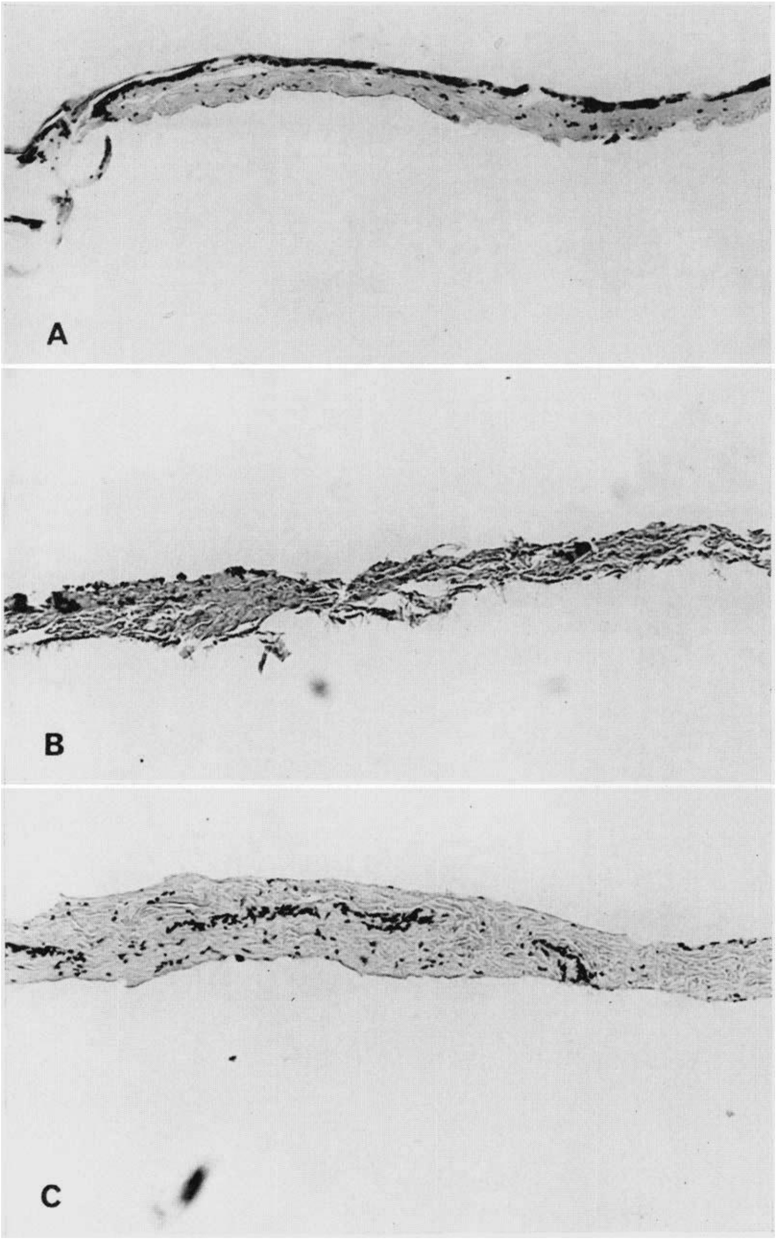

FIG. 6. Serial slices through hairless mouse skin. (A) Epidermis and dermis, approximately 50 microns thick (0.1 mm setting). (B) Dermis, approximately 50 microns thick (0.1 mm setting). (C) Dermis, approximately 100 microns thick (0.2 mm setting). × 140, H. and E. Stain

will be noted that the epidermal layer (Fig. 6-A) is one to three cells thick. This might lead one to expect a proportionately faster drug absorption through mouse than human skin, since cutaneous permeability is thought to be determined by epidermal components (8). Our preliminary experiments seem to support this hypothesis.

SUMMARY

Technical improvements in the dissection of

thin but metabolically functional skin layers at desired depths have been described and some applications of the technique have been demonstrated.

The technical innovations consist essentially of adapting the basic design of the Castroviejo electro-Keratotome to the special requirements of skin dissection. This has been achieved by choosing a more appropriate motor and developing a manual blade punch which enables the investigator to construct his own blades for his particular needs.

The improved dissection technique extends the range in which human and animal skin can be serially sliced 50 to 500 μ in thickness. By adjusting the blade width, the width of the skin slices can be varied from a few mm to slightly more than two cm. The length of the skin slices attainable depends on the thickness of the skin slice but is in the vicinity of several cm for slices less than 200 μ, and greater for thicker slices. No anesthesia is required when the dermatome is set to cut at a depth of 0.2 mm and there is little residual scar formation. There is no scar formation for thinner slices.

REFERENCES

1. Castroviejo, R.: Electro-keratotome for the dissection of lamellar grafts. Am. J. Ophth., *47:* 226, 1959.
2. Blank, H., Rosenberg, E. W. and Sarkany, I.: An improved technic for obtaining uniformly thin sheets of skin. J. Invest. Derm., *34:* 307, 1961.
3. Santoianni, P. and Ayala, M.: Fluorometric ultramicroanalysis of deoxyribonucleic acid in human skin. J. Invest. Derm., *45:* 99, 1965.
4. Halprin, K. M. and Ohkawara, A.: Glucose and glycogen metabolism in the human epidermis. J. Invest. Derm., *46:* 43, 1966.
5. Deutch, W.: An improvement of Warburg's method for cutting tissue slices for respiratory experiments. J. Physiol., *87:* 56P, 1936.
6. Van Scott, E. J.: Mechanical separation of the epidermis from the corium. J. Invest. Derm., *18:* 377, 1952.
7. Ogura, R., Knox, J. M. and Griffin, A. C.: Separation of epidermis for the study of epidermal sulfhydryl. J. Invest. Derm., *33:* 239, 1961.
8. Malkinson, F. D.: Permeability of the stratum corneum in the epidermis, p. 435, Academic Press, New York (1964).