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TECHNICAL NOTE

ODONTOLOGY

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Bite Marks: Physical Properties of Ring Adhesion to Skin—Phase 2*

ABSTRACT: Bite Marks: This study demonstrated that surface wetness was the most influential factor affecting ring adhesion to skin. Also, chemical depilatories and shaving creams were to be avoided when cleaning the skin. The second phase of this research examines the tensile stress needed to rupture the bond between TAK® hydroplastic, three new cyanoacrylates, and pigskin with particular consideration for temperature variations. This study also considers solubility issues of different cyanoacrylates in 10% formalin. Finally, the Dorion Type V bitemark excision technique could significantly reduce the risks of tissue distortion when used in conjunction with the following methods and materials. The skin should be devoid of moisture, razor shaved, and cleaned with dishwashing detergent and 98.9% ethanol while avoiding the use of shaving creams and/or chemical depilatories where ring placement is anticipated. The use of unopened cyanoacrylate is encouraged with Permabond® as the cyanoacrylate of choice.

KEYWORDS: forensic science, bite mark, bite mark research, bitemark, bitemark research, ring adhesion to skin, skin excision

A recent article suggests that 87.5% of diplomates of the American Board of Forensic Odontology excise the bite site on cadavers (1). Unsupported excised skin may shrink by as much as 50% or more (2). In 1981, a method was developed for ring adhesion to skin prior to excision with the goal of minimizing tissue distortion (3–5). This was the first of five modified versions of the technique bearing the author's name (Dorion Types I, II, III, IV, and V) and reported over the years at various forensic conferences/meetings (Dorion RBJ, personal communication, April 14, 1993; Dorion RBJ, personal communication, May 16, 1997; Dorion RBJ, personal communication, September 11, 1998; Dorion RBJ, personal communication, May 21, 1999; Dorion RBJ, March 26, 1999; Dorion RBJ, June 8, 1999; Dorion RBJ, February 28, 2002; Dorion RBJ, personal communication, February 5, 2007) (6–13) and textbooks (2,13–16). A search of the literature reveals only one article (17), one thesis (18), and one alternate method (19) peripherally dealing with this topic.

Phase 1 of this project (20) indicated that surface wetness was the most influential factor affecting ring adhesion to skin, followed by the type of bonding material, its "freshness," and the cleaning agent used to prepare the skin. The use of a depilatory or shaving cream was to be avoided.

This study evaluated the amount of tensile stress needed to rupture the bond between TAK® hydroplastic (Pearson Dental Supply Co., Sylmar, CA) excision ring, three different cyanoacrylates (Permabond® [Permabond, Pottstown, PA], Threebond® [Threebond International Inc., Hachioji-Shi, Tokyo], and Krazy Glue® gel [Krazy Glue, Columbus, OH]), and shaved, cleaned pigskin. Dishwashing detergent and ethanol were used as cleaning agents, and particular emphasis on temperature variations was analyzed. Second, the differences in the histologic appearance of pigskin when untreated/treated, cleaned with various agents and a depilatory were analyzed. Third, the solubility of different cyanoacrylates in 10% formalin was studied, and last, the structural change of the TAK® hydroplastic and the introduction of new cyanoacrylates were evaluated with respect to the aforementioned factors.

Materials and Methods

Instrumentation and materials included the following: a digital thermometer to record pigskin and room temperatures, a butane torch, a nail file, a spatula, a scalpel, and mosquito fiberglass netting (Phifer Wire Products Inc., Tuscaloosa, AL).

Dishwashing detergent (Palmolive® Original scent dishwashing liquid ™ [Colgate-Palmolive Company, Toronto, ON, Canada]) and 98.9% ethanol were used for cleaning and/or treating the pigskin. Three different cyanoacrylates used were as follows: Permabond®, Threebond®, and Krazy Glue® gel.

The controlled climatic conditions integrated temperature variations from 21 to 25°C; the room humidity varied from 20% in winter to a maximum of 60% in summer; ventilation was <0.15 m/s at 21°C and <0.25 m/s at 25°C; and CO_2 was inferior to 1000 ppm.

The first experiment involved a simple test to evaluate pigskin adhesion to variations in pigskin temperature with Permabond®. The shaved pigskin was cleaned with liquid detergent, and 98.9% ethanol and ring mounted uncovered (Fig. 1) in a refrigerator for an hour. The same was performed with vacuum-packed pigskin to

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FIG. 1—*Mounted and uncovered pigskin placed in the refrigerator.*

FIG. 2—*A vacuumed-packed mounted pigskin placed in the refrigerator.*

FIG. 3—*DigiSense® digital thermometer.*

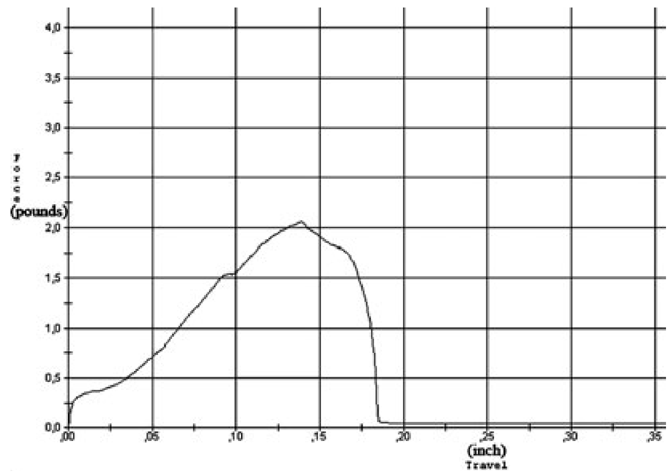

FIG. 4—*Graphic illustration of the resulting force to displacement curve on the TriggerScan™ 2.0 instrument.*

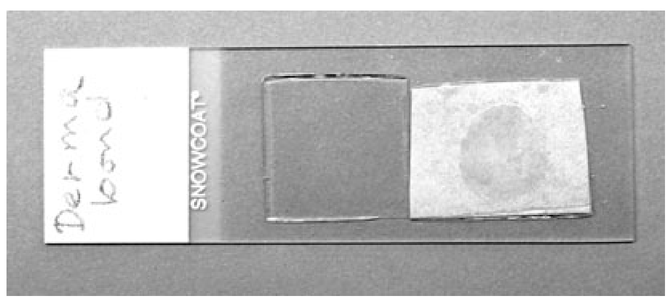

FIG. 5—*Surgipath® microslide used to test the solubility of different cyanoacrylates in 10% formalin.*

minimize dehydration (Fig. 2). The air and pigskin temperatures were taken with an electronic DigiSense® thermometer (Oakton Instruments, Vernon Hills, IL) (Fig. 3).

The second experiment compared the tensile strength of three ethyl cyanoacrylate gels such as Permabond®, Threebond®, and Krazy Glue® gel. As in phase 1, the pigskin was cut octagonally and cleaned with dishwashing detergent and 98.9% ethanol. Tests were performed on a modified TriggerScan™ 2.0 (Dvorak Instruments Inc., Tulsa, OK) used in phase 1, producing a force to displacement curve (Fig. 4). The resultant tensile strength of the different cyanoacrylates was compared.

The third experiment compared the stratum corneum histology visualized through a Leica® stereomicroscope (Leica Microsystems Inc., Concord, ON, Canada) at 400×. The pigskin variables included untreated, cleaned (shaving cream), and treated with Veet® (Reckitt Benckiser Group, Slough Berkshire, England, and Wales).

The fourth series of tests gauged the solubility of the six cyanoacrylates used in phases 1 and 2 in 10% formalin. In other words, it gauged, in part, the adhesion of the bonding agents to TAK® and skin. Clean Surgipath® glass slides (Surgipath Medical Ind. Inc., Richmond, IL), glass cover slips 18×18 mm, and white paper were used. A drop of cyanoacrylate was laid under the cover glass and under a piece of white paper on each slide (Fig. 5). The slides were left uncovered at room temperature for 1 week and then placed in 10% formalin for 2 weeks. Each cover glass and paper was evaluated for adherence. Its presence indicated that the cyanoacrylate had not dissolved.

The last experiment used the modified TriggerScan™ 2.0, a mosquito fiberglass netting, and melted TAK® hydroplastic (Fig. 6). Two trials (A and B) were evaluated. In trial A, the set TAK® hydroplastic was slightly peripherally heated with a butane torch, and the mosquito fiberglass netting was pressed into the TAK® against a hard surface backing (Fig. 7, right); then, the hardened TAK® and mosquito fiberglass netting were glued with Loctite Super Glue gel® (Henkel Corporation, Westlake, OH) to the pigskin as described in phase 1 of the study. For trial B, Loctite Super Glue gel® is spread with a cotton roll in a very thin layer over the mosquito fiberglass netting onto the pigskin (Fig. 8); then, the surface of the TAK® hydroplastic material is melted with the butane torch and pressed onto the pigskin on the TriggerScan™ 2.0 prototype setup (Fig. 9).

Results

Effects of Skin Temperature and Humidity on Adhesion

When the specimens were placed uncovered in a refrigerator for an hour, the pigskin temperature dropped from 18.6 to 9.7°C with a resultant increase in tensile strength with a mean adhesion from 16.8 PSI to 27.1 PSI (Table 1).

The vacuum-packed counterpart had a temperature drop from 17.5 to 8.8°C and with a resultant mean decrease tensile strength of adhesion from 18.5 PSI to 12.3 PSI. This can be explainable by dehydration in the former versus humidity retention in the latter.

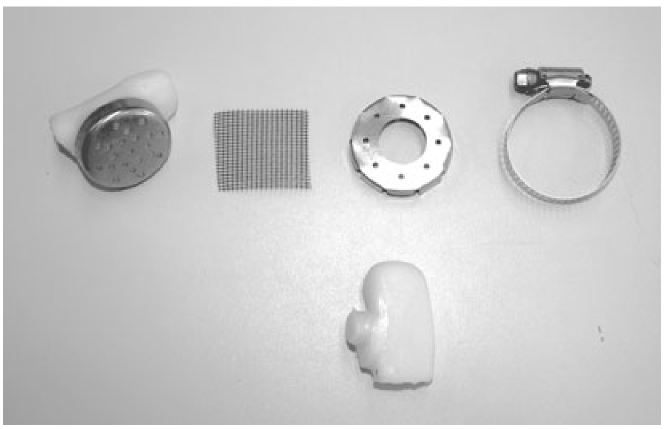

FIG. 6—*Materials used in trials A and B using a modified TriggerScan™ 2.0 instrument.*

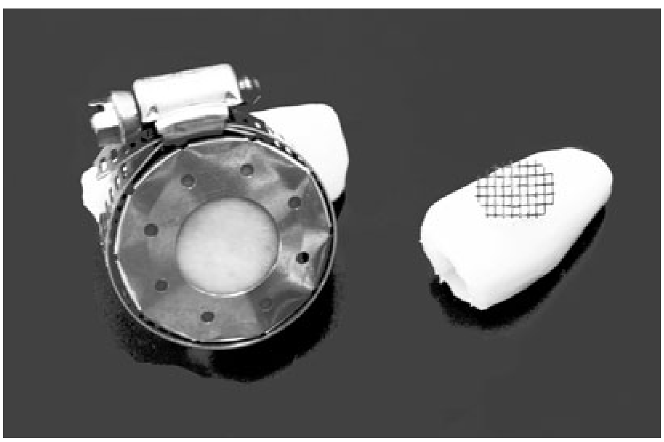

FIG. 7—*Trial A materials.*

Effects of the Type of Cyanoacrylates on Adhesion

The following three ethyl cyanoacrylate gels were compared: Permabond®, Threebond® and Krazy Glue®. Threebond produced a mean tensile strength of 14.7 ± 3.8 PSI; when TAK® was slightly melted with a butane torch, the mean tensile strength was augmented to 15.5 ± 2.5 PSI. With Krazy Glue, it was 15.8 ± 3.4 PSI, and with Permabond the highest at 17.1 ± 1.4 PSI (Table 2).

Skin Histology and Adhesion

The stratum corneum (Fig. 10) was modified by the use of shaving cream (Fig. 11) and Veet® (Fig. 12). Thus, surface condition and adhesion are intimately linked and further confirms results obtained in phase 1; in that, shaving cream and/or a depilatory such as Veet® should not be used in the area of ring placement.

Solubility of Cyanoacrylates

This experiment confirms that Loctite Super Glue gel®, Threebond®, Krazy Glue®, and Permabond® are insoluble and became brittle in 10% formalin. Dermabond™ (Ethicon [Johnson and Johnson Company], San Angelo, TX), on the other hand, is insoluble

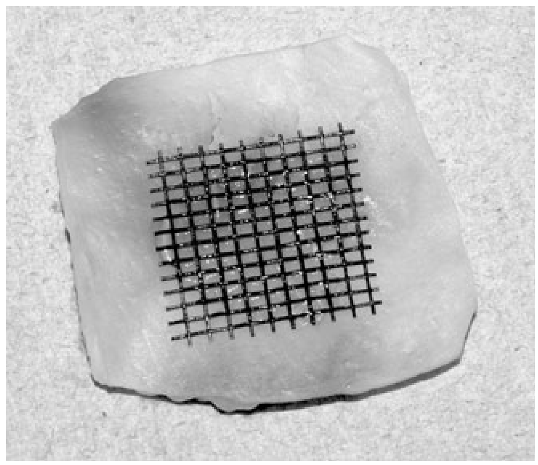

FIG. 8—*Trial B materials.*

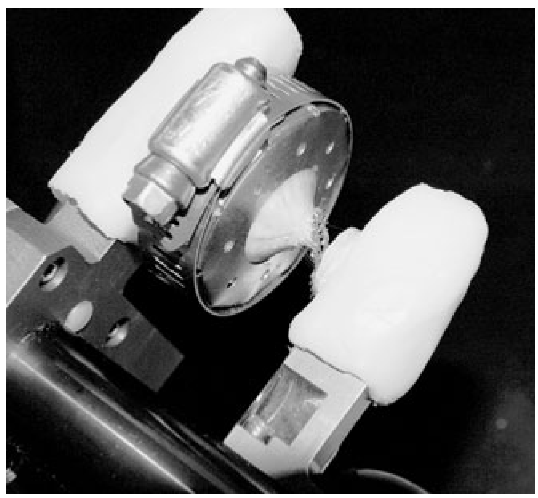

FIG. 9—*Illustration of TAK® hydroplastic, Loctite Super Glue gel®, the mosquito fiberglass netting, and the pigskin mounted on the modified TriggerScan™ 2.0 instrument.*

TABLE 1—*Temperature versus tensile strength.*

Cyanoacrylate	Condition	Temperature	Tensile Strength	Number of Tests Performed
Permabond	Uncovered	18.6 > 9.7°C	16.8PSI > 27.1 PSI	3
Permabond	Vacuumed packed	17.5 > 8.8°C	18.5PSI > 12.3 PSI	3

TABLE 2—*Tensile strength of different cyanoacrylates.*

Cyanoacrylate	Tensile Strength	Number of Tests Performed
Threebond	14.7 ± 3.8 PSI	11
	15.5 ± 2.5 PSI*	3
Krazy glue	15.8 ± 3.4 PSI	4
Permabond	17.1 ± 1.4 PSI	4

*Melted TAK hydroplastic by butane torch.

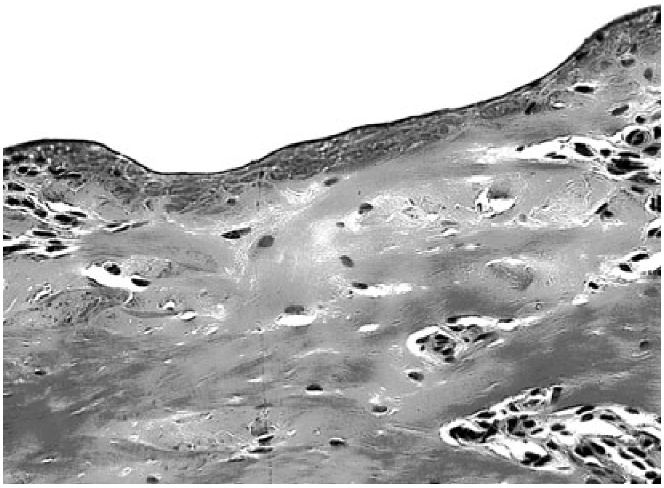

FIG. 10—*Stratum corneum histology of untreated pigskin.*

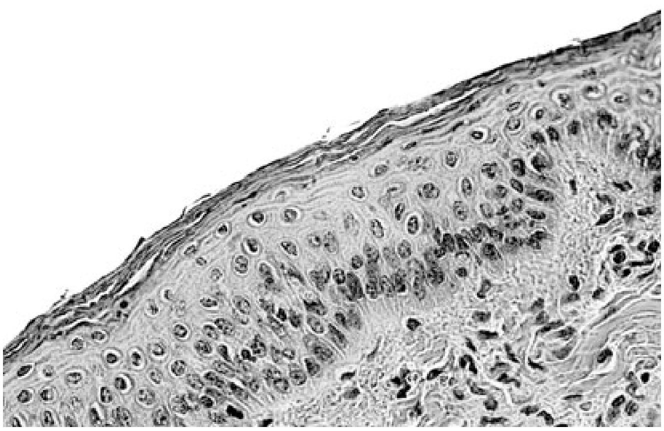

FIG. 11—*Stratum corneum histology of pigskin treated with shaving cream.*

but becomes flexible in 10% formalin. Vetbond™ (3M Corporate Headquarters, St. Paul, MN) retained the same properties as Dermabond™ but is volatile when exposed.

The Mosquito Fiberglass Netting and Melted TAK® Hydroplastic

The resultant tensile strength in trial A had a mean of 23.7 ± 9.2 PSI. For trial B, there was a mean of 35.7 ± 11.5 PSI (Table 3).

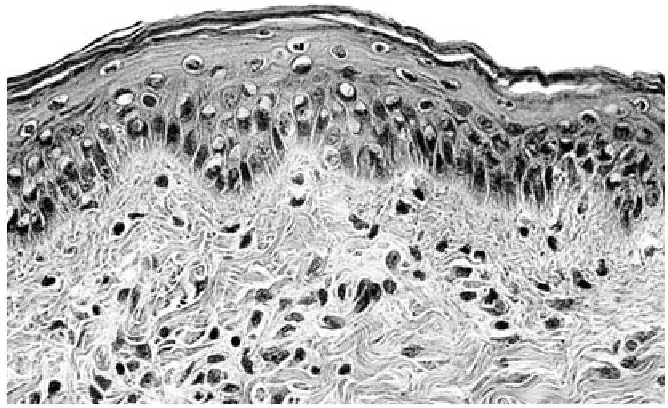

FIG. 12—*Stratum corneum histology of pigskin treated with Veet®.*

TABLE 3—*Tensile strength of different trials.*

Trial	Cyanoacrylate	Tensile Strength	Number of Tests Performed
A	Loctite supergel	23.7 ± 9.2 PSI	5
B	Loctite supergel	35.7 ± 11.5 PSI	5

Discussion

Both Temperature and Moisture Influence Adhesion to Pigskin

The paired columns in Fig. 13 refer to the mean on the left and the variation on the right. Of all the cyanoacrylate glues used in phases 1 and 2, N-butyl Vetbond™ and 2-Octyl Dermabond™ were the most effective glues for adhesion to pigskin. Their fluidity, high cost, and short working time preclude their recommendation. The four remaining ethyl cyanoacrylate gels (Threebond®, Krazy Glue®, Loctite Super Glue gel®, and Permabond®) are brittle in thin layers, yet very effective in ring adhesion. Of the four glues, Permabond® was the most effective cyanoacrylate at a mean of 17.1 ± 1.4 PSI.

All six cyanoacrylates were insoluble in 10% formalin. It is also important to note that with Threebond® there was a significant increase in adhesion when the surface of the TAK® was slightly melted (column H in Fig. 13).

This brings us to the results of the fifth experiment. It appears that slightly melting the set TAK® hydroplastic material into the mosquito fiberglass netting (trials A and B) has an added and significant effect, resulting in an increase in adhesion of ring to skin when compared to other variants (Fig. 13—columns A and B). But it would be inappropriate to make a direct correlation between trials A and B results and the Dorion Type V excision technique. The latter technique uses the mosquito fiberglass netting centrally glued with Loctite Super Glue gel® and thinly spread with a cotton roll. The TAK® hydroplastic, previously heated in water in a microwave, is then applied to the mosquito fiberglass netting. Trials A and B differ from the Dorion Type V technique in several ways: (i) the solid TAK® hydroplastic is peripherally heated and applied to the mosquito fiberglass netting, (ii) the mass for testing purposes is flat ended, while it is rounded when in contact with the human

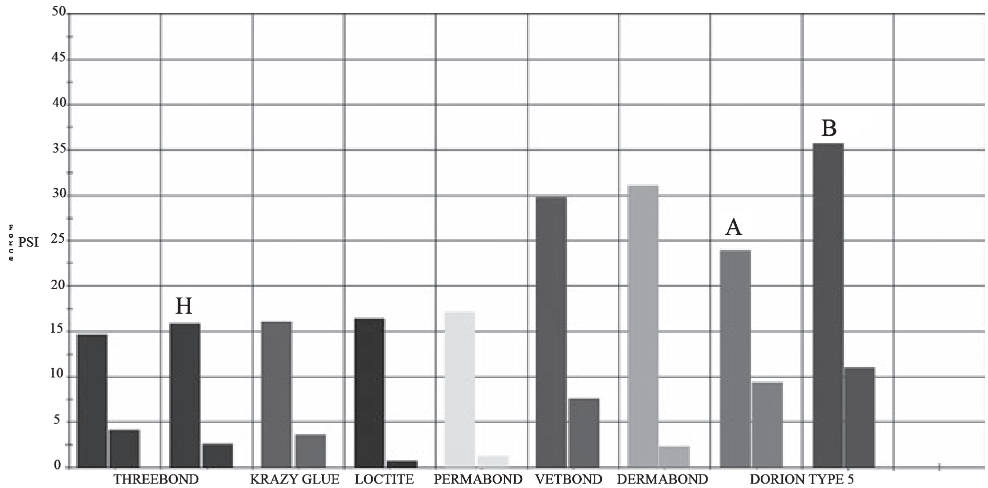

FIG. 13—*Graphic illustration of the tensile strengths of different cyanoacrylates in adhesion to pigskin and trials A and B.*

skin, and (iii) it would be inappropriate to press the heated hydroplastic mass around a bitemark for fear of distorting both.

Conclusion

Five considerations should be retained when using the Dorion Type V bitemark excision technique:

- The corpse should be left uncovered at room temperature for a period of time prior to ring fabrication to permit skin water evaporation. The skin should be devoid of moisture.
- The skin should be razor shaved, cleaned with dishwashing detergent and 98.9% ethanol for degreasing and additional surface dehydration.
- Shaving creams and/or chemical depilatories such as Veet® should never be used where ring placement is anticipated.
- The use of unopened cyanoacrylate (new) should be encouraged.
- An ethyl cyanoacrylate gel, preferably Permabond®, should be used in a very thin layer.

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