The Use of a Thermoplastic Cap to Protect Against Self-induced Trauma in a Nonhuman Primate

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Abstract | A custom-made, thermoplastic cap was designed to temporarily protect the head of a nonhuman primate after the attachment of a prosthetic device. Thermoplastic proved to be an appropriate material because it was durable, easy to mold, nonirritable, and lightweight. The temporary cap adequately guarded against self-trauma and injury.

Case History

A 3-year-old female rhesus monkey (*Macaca mulatta*) weighing 3.5 kg was obtained from Primate Products, Inc. (Redwood City, CA). She was weaned from her mother when 3 months old and was pair-housed with an infant male of the same age. Due to early social deprivation, the monkeys arrived at our facility "clinging" onto one another. Within a few months, it was noticed that, despite environmental enrichment and social grouping (pair-housing in a cage facing four other animals), the female monkey exhibited mild self-traumatic behaviors.

The female rhesus monkey underwent surgery; two procedures were performed: 1) the attachment of a titanium head post to the skull for restraint of the animal's head during neurophysiological experiments and 2) the implantation of a loop of wire under the conjunctiva for the recording of eye movements (1). During the surgery, an acrylic island and two layers of closure sutures were placed on the right posterior region of the head. Post-operatively, the monkey was returned to the cage and monitored until fully recovered from anesthesia and sitting on the perch. The monkey remained caged individually for 2 to 3 days to allow time for recovery. Daily observation was performed by the veterinary staff and principle investigator's staff. Post-operative treatment included a 24-h course of Buprinex (Reckitt and Colman Products, Hull, England) (0.01 mg/kg subcutaneously twice daily) followed by acetaminophen (10 mg/kg orally as needed) and a 10-day course of trimethoprim (6 mg/kg orally twice daily) and sulfamethoxazole (30 mg/kg orally twice daily). Post-operative care followed the standards in the *Guide and Care of Laboratory Animals* and *Preparation and Maintenance of Higher Mammals During Neuroscience Experiments* (2, 3).

Normally, rhesus monkeys groom and clean around incisions and surgical prostheses without causing damage. In this instance, while still isolated, the monkey was seen grooming compulsively and forcefully, tearing the sutures out of the skin and enlarging the incision. This behavior necessitated immediate intervention to protect the wound from further self-inflicted damage and infection. While the monkey was under anesthesia, the wound was cleaned with iodine, treated with topical antibiotics, and closed with sutures. By using thermoplastic material, a protective cap was designed to protect her head until the irritated area healed properly. A typical medical application of thermoplastic is in the splinting of human upper extremities after surgery or injury. It has also been used to protect and immobilize nonhuman primate upper extremities (4, 5).

All procedures were approved by the Institutional Animal Care and Use Committee and facility veterinarian and were conducted in compliance with state and federal laws and standards of the United States Department of Health and Human Services.

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Materials and Methods

The protective cap was made with a low-temperature, perforated thermoplastic (Orthoplast II, Johnson & Johnson, New Brunswick, NJ). The material was heated to 150–170°F in a water bath (a nonstick electric skillet) to make it pliable. Thermoplastic rapidly decreases in elasticity as the material cools, but it is still pliable when the surface of the material is at a temperature that is comfortable to the touch. This property allowed us to place the cap directly on the anesthetized animal's head, as an aid in molding the cap. It was imperative that the cap edges were close enough to the scalp to prevent the animal from reaching underneath to either access the wound or lift up the cap, but the edges could not be so close as to produce pressure ulcers. Enough material was placed on the upper section of the cap so that the animal could not bend the descending portions of the cap away from the wound margin.

Scissors were used to trim the warm thermoplastic to the desired shape and size. Because the material adheres to itself, it was folded and doubled to reinforce the edges of the cap. A 5 mm clearance hole was punched in the center of the cap. The hole was reinforced by embedding a washer in a thick layer of thermoplastic around the hole. Once molding was complete, the cap was placed in cool water to facilitate setting. The cap was then attached to the threaded titanium head post by using a single screw with a broad head (Figure 1). This method of at-

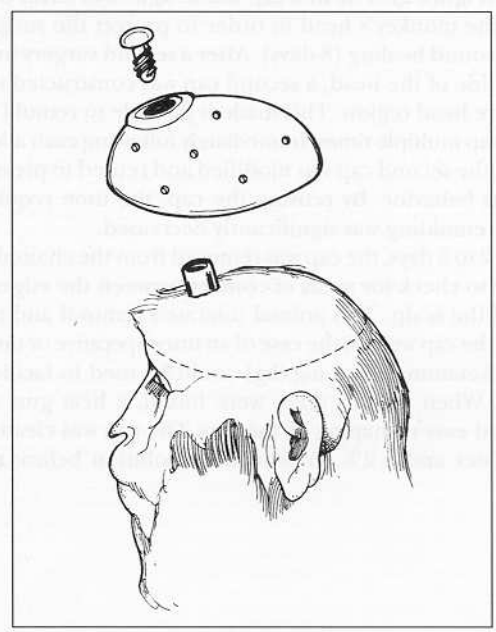

FIG. 1. A diagram of the components and orientation of the thermoplastic cap. Dashed line indicates where the margin of the cap would sit. The surgical incision (not shown) lies inside the dashed line.

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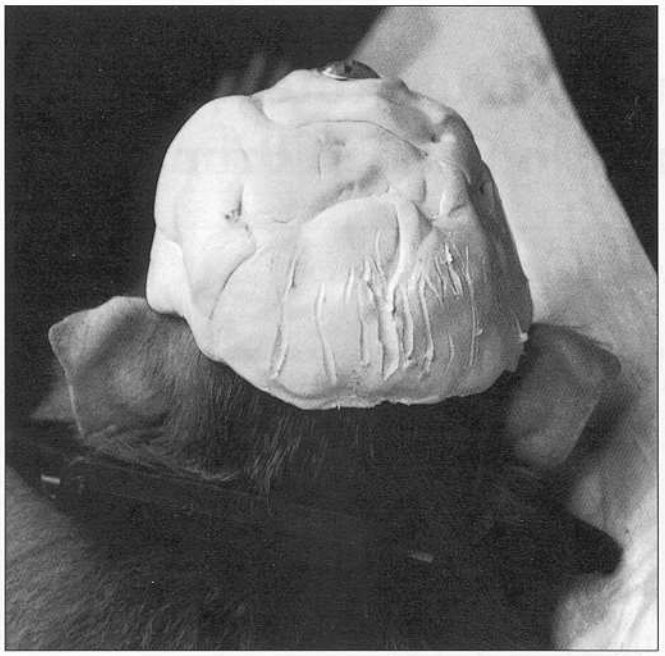

FIG. 2. The thermoplastic caps weighed ~ 75 g and measured 96 x 77 x 35 mm and 93 x 87 x 51 mm. Note the parallel grooves produced by the cage mate's biting. Additional ventilation holes were placed subsequent to this photograph (see Figure 1). The white background in the photograph is a mat on which the animal was lying.

tachment was convenient in light of the head post design, but the attachment method could be modified to suit alternative designs. The entire process lasted approximately 1 h.

One disadvantage of thermoplastic is that the area beneath the material is not exposed to air (6). A lack of airflow to the skin beneath the material could irritate the wound and prolong healing. To solve this problem, a space of approximately 3–5 mm was left between the monkey's head and the cap for ventilation, and multiple holes were drilled approximately 1.5-in apart in a recent modification to the cap design.

Results

Two protective caps were made and used on five separate occasions (Figure 2). The first cap was designed to cover the right side of the monkey's head in order to protect the surgical site during wound healing (8 days). After a second surgery involving the left side of the head, a second cap was constructed to cover the entire head region. This made it possible to remold and reuse the cap multiple times. Immediately following each additional surgery, the second cap was modified and reused to prevent self-injurious behavior. By reusing the cap, the time required for custom remolding was significantly decreased.

Every 2 to 3 days, the cap was removed from the chaired, awake monkey to check for areas of contact between the edges of the cap and the scalp. This animal tolerated removal and replacement of the cap well. In the case of an uncooperative or untrained animal, ketamine (12.5 mg/kg) could be used to facilitate the process. When contact areas were found, a heat gun allowed rapid and easy reshaping of the cap. The cap was cleaned with warm water and a 2% chlorhexidine solution before replacement. When replacing the cap, the screw had to be fully tightened, thus preventing the monkey from rotating the cap. Because the cap was molded to the exact shape of the animal's head, rotating the cap could have driven the cap edges into contact with the scalp, potentially leading to pressure sores.

While the monkey wore the cap, the damaged area was protected from any further self-trauma, allowing the incisions to heal without any difficulty. The animal tolerated the cap well. The cap did not interfere with the normal activities of the animal and proved durable enough for use during pair-housing. When the cap was removed, the animal made no further attempts to traumatize the healed wound.

Discussion

A thermoplastic cap allowed a surgical incision to heal and stopped potentially dangerous self-traumatic behavior. Alternate protective strategies would have required continuous physical or chemical restraint for at least five days. The cap eliminated the need for such drastic measures. Caps were lightweight and durable, and they could not be bent or broken. Neither the capped monkey nor its cage mate were able to remove the protective cap, although they did score its surface (Figure 2). The advantage of thermoplastic over other materials (e.g., plaster or acrylic) was its strength coupled with ease of molding and reshaping. In addition, the thermoplastic did not irritate the skin or wound. This procedure has been used five times during throughout the course of a year and has shown long-term success. These results demonstrate that thermoplastic is a suitable material for use in those animals in which protection from self-trauma after surgery is required.

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