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Technical note

Necropsy observations of Arctic Common Eider (*Somatria mollissima*) and Thick-billed Murres (*Uria lomvia*) implanted with PTT-100 satellite transmitters

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Summary

We surgically implanted a 50 g PTT-100 (Platform Transmitter Terminal) in 21 Common Eiders (*Somatria mollissima*) and a 29 g PTT-100 in 10 Thick-billed Murres (*Uria lomvia*). After 2-4 months, one Common Eider implanted intracoelomically and two Thick-billed Murres implanted subcutaneously were harvested by local subsistence hunters and examined in the laboratory. External examination of the harvested birds did not reveal any morphological or pathological changes, while the surgical abdominal and cervical wounds seemed to have healed with granulation tissue in all three birds. Necropsy showed chronic inflammation and fatty necrosis in one of the murres, while the antenna Dacron cuffs were at skin level as originally attached for all three birds, with primary tissue healing and no signs of inflammation. In the eider, a few peritoneal adherences were found on the liver without additional signs of inflammation, while one murre had adherences and granulomatous tissue around the PTT with signs of severe inflammation and external rejection. These results indicate that birds can survive implantation of transmitters, even if inflammation develops around the implants. The study points to the importance of continuously refining the techniques for implanting devices in wild birds and performing necropsies on recovered birds.

Introduction

Satellite telemetry has been applied to a broad variety of bird species to map migration routes, moulting, wintering and breeding sites around the world (Dougill et al. 2000; Huettmann and Diamond 2000; Merkel et al. 2007, Mosbech et al. 2006, 2007; Petersen et al. 1995, 1999, 2004; Washburn et al., 2022). These parameters are of interest when studying the influence of anthropogenic factors, including fossil energy sources, chemical and light pollution from cities and hunting, but are also relevant to investigations of zoonotic disease outbreaks such as bird-flu pandemics and climate-driven environmental changes (*Wang et al., 2022*). In the Arctic, Common Eiders (*Somateria mollissima*), King Eiders (*Somateria spectabilis*), Thick-billed Murres (*Uria lomvia*), Steller's Eiders (Polysticta stelleri) and Spectacled Eiders (*Somateria fischeri*) have been satellite tracked to map spatial distribution, ecology, demographic patterns and population delineation information needed for planning oil exploration activities and management (Merkel et al. 2007; Meyers et al. 1998; Mosbech et al. 2006, 2007; Petersen et al. 1995, 2006). Employing Platform Transmitter Terminals (PTTs) for these investigations requires either external attachment – by use of glue or harnesses – or subcutaneous or intra-coelomic surgical implantation during anesthesia (Buck et al., 2021; Fast et al. 2011; Korschgen et al. 1996a, 1996b; Mulcahy, 2010; Sonne et al. 2011). Until now, only sparse information about the consequences of long-term implantation of PTTs has been available (Fast et al. 2011; Hupp et al. 2003, 2006; Latty et al. 2010; Meyers et al. 1998; Lameris et al., 2018; Geen et al., 2019; Beach et al.,2025) while reports on in situ location and pathology are absent in the international scientific literature. The purpose of the present paper is therefore to report post-mortem information on a Common Eider and two Thick-billed Murres harvested by local hunters in West Greenland several months following subcutaneous and intra-coelomic implantation with PTT-100 satellite transmitters as described by Sonne et al. (2011). Such necropsy information is important for scientists and veterinarians who want to conduct surgical field PTT implantations in wild birds - both to obtain reliable results from healthy birds, and to ensure good animal welfare in these wild experimental birds. Necropsies provide opportunities for refinement of implantations.

Materials and methods

Field sites and surgical implantation

The fieldwork and surgical study were approved by the Greenland veterinary authorities and by the Directorate of Environment and Nature (permission no. J.nr:28.40.50/2002). We implanted PTT-100 intra-coelomically in 21 Common Eiders and PTT-100 subcutaneously in 10 Thick-billed Murres in 2002 and 2005, respectively (Figure 1). The PTT-100 from Microwave Telemetry, Columbia, Maryland 21045 USA (https://www.microwavetelemetry.com/implantable_ptts) weighed either 50 g (eiders) or 29 g (murres) depending on the types of batteries supplied by the manufacturer.

All 3 birds were captured in West Greenland as described by Mosbech et al. (2007) and Sonne et al. (2011). The two capture sites are shown in Figure 2 together with general movement patterns of the two species and the location of their harvest by local subsistence hunters. The eiders were caught in mist nets and nest traps at a colony in Upernavik June 2002 (Figure 3), while the murres were caught at Ritenbenk on their nest site in July 2005.

Both the pre-surgical preparations and surgical implantations followed Korschgen and coworkers (1996a, 1996b), but with some modifications as described by Sonne et al. (2011). PTT weights were less than 5% of body weights in both murres and eiders (range: 2.5-3.5%). Furthermore, as a refinement the PTTs were gently preheated to 35°C prior to implantation, as this would help to prevent hypothermia in the birds. The transmitters were pre-implantation disinfected in 70% medical ethanol/isopropyl alcohol for 12 hours and after implantation a sterile peritoneal Dacron cuff (DuPont® Dacron cuff, DuPont, Wilmington, North Carolina 28405, USA) was attached at the antenna base and secured with 5 mm sterile heat shrunk plastic coating. Corneal lubricant (80% Vaseline, 20% paraffin oil) was gently applied to the cornea to prevent dryness. Birds were anaesthetized through a closed-mask-system using Isoflurane (Isovet®, Merck & Co, Schering-Plough Animal health, Whitehouse Station, New Jersey 08889, USA) and medical oxygen (induction: 3% in 2000 ml O2 × min-1; maintenance: 1.5-4.5% in 2000 ml O2 × min-1) via a precision-vaporizer and a modified Bains' coaxial system (Dameca Cyprane Limited Fluotec, Dameca a/s, DK-2610 Rødovre, Denmark).

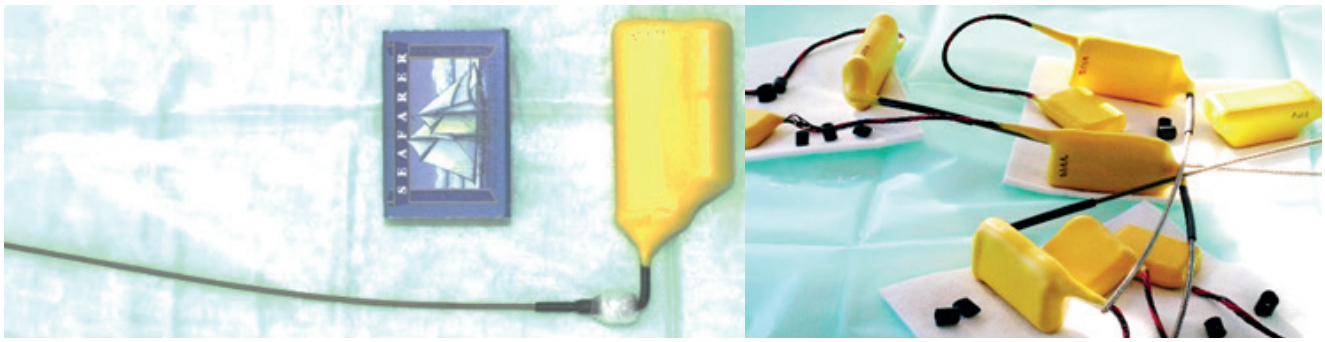

Figure 1: Left: coelomic implantable PTT-100 (50g). Right: subcutaneous implantable PTT-100 transmitter (29g). Photo: Anders Mosbech

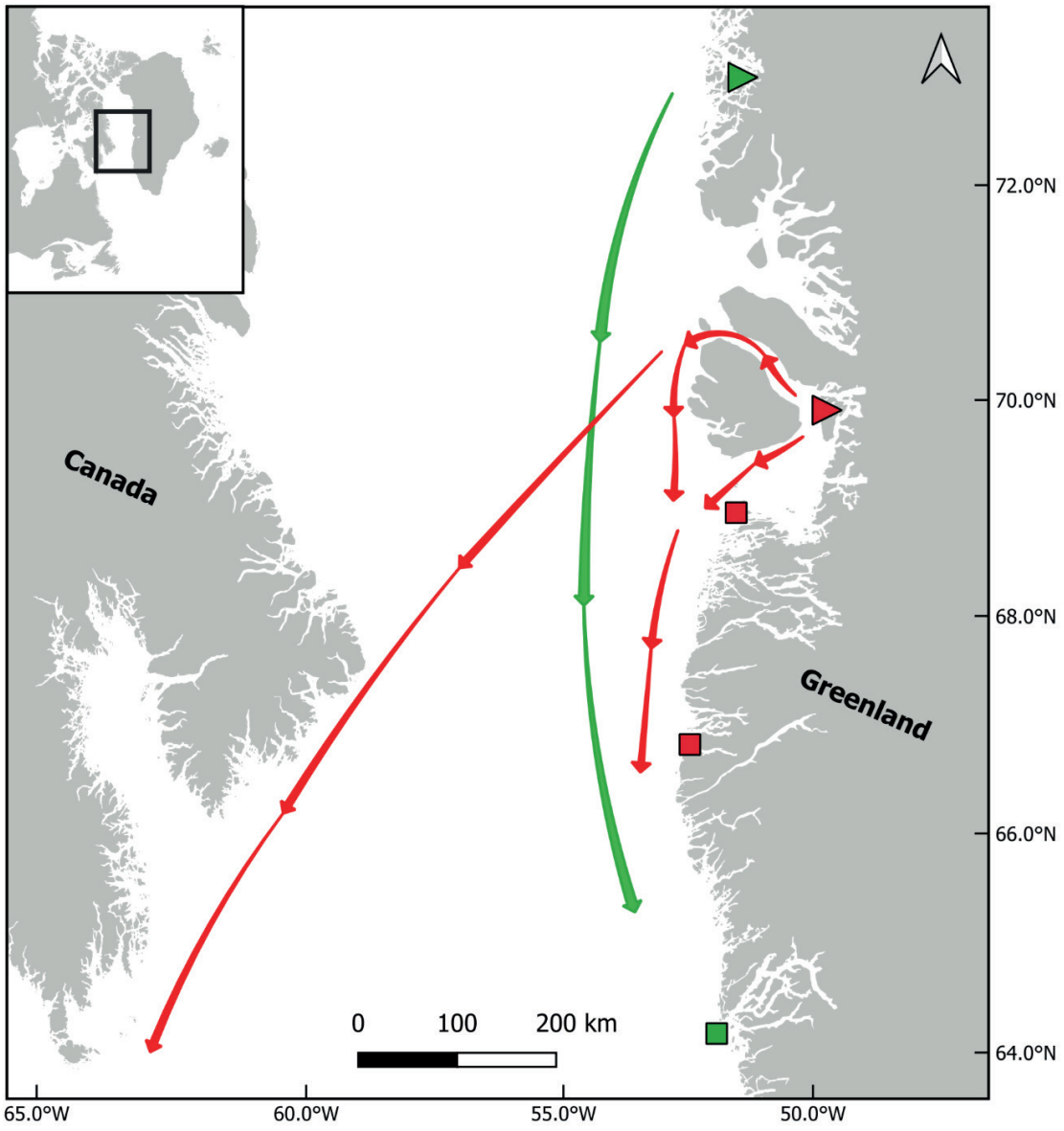

Figure 2: General movement patterns (arrows) of Thick-billed Murres (red color) and Common Eiders (green color) deployed with satellite transmitters in West Greenland in 2002 and 2005. Deployment sites are marked with triangle symbols, while the square symbols show where the 3 examined birds were harvested by local hunters.

Figure 3: Field work in Upernavik, West Greenland 2002, implanting PTT-100 transmitters (50g) in Common Eiders. Top from left: operating theatre, surgical implantation and nest trap (note encircled eggs and slit opening at the front of the trap). Lower left: mist nets trapping on a small island used regularly by the birds (note poles on left and right marked with white arrows). Right: post-surgical release of adult female eider (note vertical antenna encircled).

To reduce post-release heat loss, feather removal was avoided at the abdominal and cervical incision sites. Instead, the feathers were pushed aside by use of alcohol and subsequently taped. When needed, ice was applied to the webbed skin to reduce hyperventilation. The antenna exit site was prepared as dorso-cranially to the ischia bone as possible. Haemostatic forceps and a sharpened 4 mm urinary metal catheter were used to perforate the subcutis, muscle layer and peritoneum. The antenna was then pulled through the skin, and the cuff was secured tightly to the cutis and peritoneum with two single interrupted knots. Only the heat-shrunk plastic-coated antenna penetrated the skin. Murre surgeries were performed in a 12 m2 surgical theatre tent with temperature ranging 16.4 - 24.2°C and 17.2 - 21.4°C for murres and eider, respectively. (Table 1). The cloacal temperature (CT; °C) was continuously measured using an electronic thermometer with probe (OBH Nordica® Type 4850/51, OBH Nordica Denmark A/S, DK-2630 Taastrup, Denmark). Heat loss was compensated by placing an electric heat blanket (OBH Nordica® Type 4015, 50W, OBH Nordica Denmark A/S, DK-2630 Taastrup, Denmark; heat 1: low temperature at 30°C and heat 2: high temperature at 50°C) under the birds. In a few cases an aluminized rescue blanket (All Pro Rescue Blanket Co., Ltd., Qingdao 260035, China) was placed over the birds. In addition, a heat gun (Black & Decker, 2000W, Black & Decker Headquarters, Towson, Maryland 21286, USA) was used occasionally near the bird to warm up the surroundings. An electrocardiograph (ECG) (Schiller Cardiovit AT-4, Schiller AG, CH-6341 Baar, Switzerland) was employed to continuously monitor heart rate (HR; beats×min-1) which, together with extremity movements, corneal reflex and respiratory frequency (monitored but not logged), constituted the basis for adjustment of anaesthesia depth (Isoflurane %). Isotonic Ringers-acetate was used as vascular transmitter to obtain transduction of cardiac electric signal from skin to electrodes. Medical oxygen was administered until the bird had fully regained consciousness. The birds were held in a box fitted with absorbent pads until release 60-120 minutes post-surgery. All data were logged manually. Based on registration of PTT body core temperature, all released birds survived their first post-surgery month. As pain killer and antibiotics, we used meloxicam 0.5 mg/kg s.c. and enrofloxacin (Baytril) 10 mg/kg i.m. Information about the eider and two murres is shown in Table 1.

	Common Eider	Thick-billed Murre	Thick-billed Murre
Location	Upernavik, West Greenland	Ritenbenk, West Greenland	Ritenbenk, West Greenland
Ring	d779	413750	4137509
PTT#	307762	23168	7794
Age, sex	Adult Female	Adult Female	Adult Female
PTT Type	I	S	S
Implanting Date	21 June 2002	21 July 2005	22 July 2005
Recapture date	16 Oct 2002	10 Nov 2005	16 Sept 2005
Implanting weight (g	1510	810	880
Recapture weight (g)	1887	769	925
Wound #1	Granulation tissue present. Primary tissue healing. No signs of inflammation	Granulation tissue present. Primary tissue healing. No signs of inflamma-tion	Excessive scar (granulation) tissue present. Signs of chronic granulomatous inflammation and fatty necrosis. Secondary tissue healing. Open external pouch.
Wound #2	Dacron cuff at skin level as originally placed. Primary tissue healing. No signs of inflam¬mation	Dacron cuff at skin level as originally placed. Primary tissue healing. No signs of inflammation	Dacron cuff at skin level as originally placed. Primary tissue healing. No signs of inflamma¬tion.
PTT	Intra-coelomic as original implanted. A few peritoneal adherences to the liver were present. PTT in "pouch" of peritoneum. No signs of inflammation or antigenic reaction	Subcutaneous as ori¬ginal implanted. No adherences present. PTT in epithelial pouch. No signs of inflammation or anti¬genic reaction. Battery wire by suture in interverte-bral ligament as originally placed. Battery in epithelial pouch as originally placed.	Subcutaneous as original implanted. Adherences and granulomatous tissue around PTT body. PTT in an open epithelial pouch. Signs of severe inflammation and ex-ternal rejection of PTT due to inflammation and/or anti-genic reaction. Battery wire by suture in intervertebral ligament as originally placed. Battery in pouch but in a phase of rejection.

I: intra-coelomic. S: subcutaneous. Wound #1: abdominal/dorsa-cervical incision. Wound #2: antenna exit site.

Necropsy procedure

All three birds were harvested by local subsistence hunters and frozen when taken in the field and brought to the Department of Small Animal Science, Faculty of Health at University of Copenhagen, Denmark. First the birds were examined grossly (antenna and incision sites), and biometrics were measured. Then the birds were x-rayed to determine the in situ location of the PTT body and antenna, after which the birds were necropsied focusing on the wound healing procedures, the antenna exit site and encapsulation of the PTT body. Histopathology was conducted to diagnose gross pathology findings.

Results

The eider was an adult female implanted in June 2002 and harvested by local subsistence hunters in October 2002 south of Upernavik in West Greenland (Table 1). It had gained 377 grams (25%), and external examination of the bird did not reveal any morphological or pathological changes, while the surgical abdominal and cervical wounds seemed to have healed with granulation tissue. X-ray of the eider showed the in situ location of the PTT to have been maintained caudally in the coelomic cavity following implant and encapsulation (Figure 4A). Necropsy showed that there was granulation at the abdominal incision site with primary tissue healing and no signs of inflammation. At the pelvic percutaneous antenna exit site, the Dacron cuff was at skin level as originally placed with primary tissue healing and no signs of inflammation. The PTT was located intra-coelomically in a peritoneal pouch at the original implantation site with a few liver-peritoneal adherences, and with no signs of inflammation or antigenic reactions.

The two murres were both adult females implanted in June 2005. One was harvested by subsistence hunters four months later in November 2005 at Itilleq south of Sisimiut in West Greenland and had only lost 41 grams (5%). According to the hunter the murre had shown normal behavior and was taken accidentally because the antenna was not visible prior to shooting. External examination of the bird did not reveal any morphological or pathological changes, while the surgical cervical wounds seemed to have healed with granulation tissue. X-ray of the murre showed the in situ placement maintained for both the transmitter body and battery at the cervical incision along the scapula and cervical vertebrae (Figure 4B). Necropsy showed that the cervical incision had granulation tissue present with primary tissue healing and no signs of inflammation. The PTT was positioned as originally implanted and there were no adherences; the PTT was located in an epithelial pouch. At the percutaneous antenna exit site, the Dacron cuff was at skin level as originally placed with primary tissue healing and no signs of inflammation. Battery wire was located by the suture in the intervertebral ligament as originally placed and the battery was in an epithelial pouch as originally placed.

The second murre was harvested by local subsistence hunters in September 2005, two months after implantation, near Aasiaat in West Greenland. It had gained 45 grams in weight (5%). Necropsy showed that around the cervical incision site,excessive granulation tissue was present with signs of chronic granulomatous inflammation and fatty necrosis, and with the PTT in an open external epithelial pouch. The battery wire was located by the suture of the intervertebral ligament as originally placed with no signs of inflammation. However, the battery was in a pouch but in a phase of rejection being located more proximally than the original cervical placement. At the percutaneous antenna exit site, the Dacron cuff was at skin level as originally placed and included primary tissue healing.

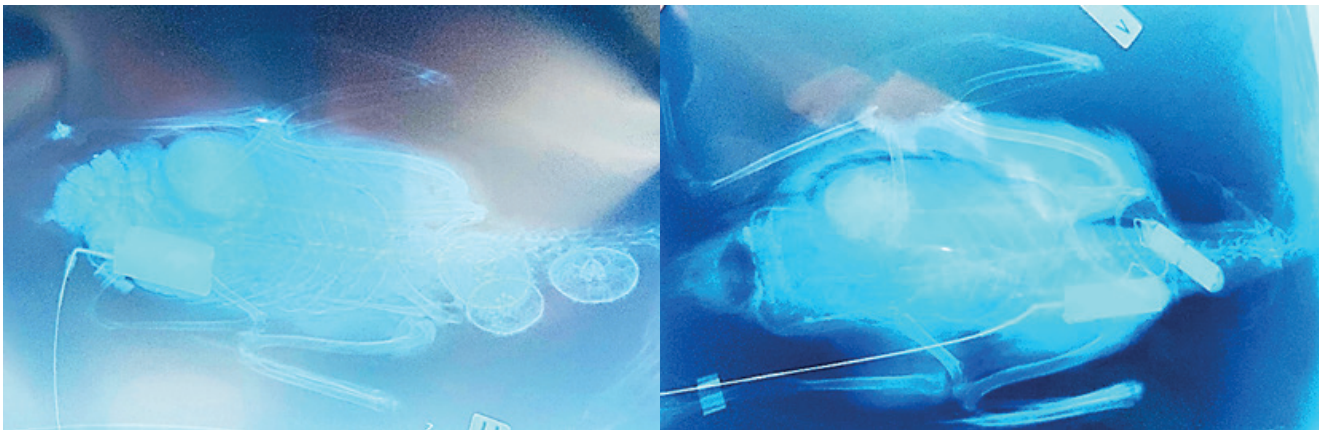

Figure 4: X-rays of the Common Eider (A) and Thick-billed Murre #1 (B) implanted with PTTs (dotted arrows). Note the wire between battery and transmitter in the subcutaneous cervical region of the murre (solid arrow), and the intra-coelomic caudal placement of the PTT in the eider. In addition, for clarification of image A, three sea urchins are present in the oesophagus (encircled) being an important food source for Common Eiders.

Discussion

These kinds of field studies are associated with the significant challenge that experimental animals typically cannot be observed after they are released following tagging, surgery or other experimental procedures. It is therefore important that all the procedures are carried out so that animal welfare is good from the beginning, as it is not normally possible later to medically treat or euthanize the animals. Here, necropsies of the animals provide valuable knowledge that can optimize procedures. Even a small number of necropsied animals can, as here, provide knowledge of significant importance. The study emphasizes the importance of refining experimental procedures on wild birds. Surgery should be performed as aseptically as possible under field conditions. The use of antibiotics together with painkillers can be considered, but it should be remembered that treatment cannot be resumed after the bird has been set free. Careful planning of procedures that allow for refinement is therefore important, albeit difficult during field trials.

The rule of thumb is to keep the transmitter weight at a maximum of 5% of body weight to avoid changes in body draft and weight balance (Casper 2009, Barron et al. 2010). The PTT-100 transmitters with percutaneous antennae used in the present study were quite large and the surgical implantation probably had more impact compared to smaller ones. The large size can lead to limping and limited feeding, diving, flight and mobility (Latty et al. 2010). Guillemette et al. (2002) implanted Common Eiders with 16-gram data loggers and no effects were found on hatching success, laying dates and clutch size compared to control females. Fast et al. (2011) reported on female Common Eiders implanted with a PTT-100 and showed that, compared to controls, no differences in time allocated to basic behaviors. Surprisingly, the implanted birds were not more likely to pick or preen their surgical sites. The implanted females showed a lower survival rate the year after implantation compared to controls (Fast et al. 2011). The following years no difference could be found in survival. This shows that PTT implantation in Common Eiders leads to a decline in survival in the first years and some short-term behavior changes. Modern PTT implants weigh around 29-50 grams (https://www.microwavetelemetry.com/implantable_ptts), but if they can be made smaller in the future, it will undoubtedly present the potential for refinement Any temperature change and handling-induced stress require increased foraging, resting and preening to increase immune competence, maintain homeostasis, and counteract altered dive performance (Davis and Bissonnette 1999; Latty et al. 2008a, 2008b; Olsen and Perry 2008a, 2008b). Such adverse effects should be avoided if possible. Surgical stress may prolong recovery time and subsequently reduce both reproductive success and survival (Davis and Bissonnette 1999; Latty et al. 2008a, 2008b; Olsen and Perry 2008a, 2008b). The number of necropsied birds is a limitation in this study. The study cannot therefore give a true picture of how often complications arise after implantation of such devices in wild birds. A larger number of necropsies is therefore needed in future studies.

Conclusions

We have necropsied three birds with GPS transmitters, one eider and two murres. While no signs of inflammation were detected in two birds, one murre was characterized by chronic inflammation. The study points to the importance of refining surgical interventions on wild birds and evaluating the techniques by necropsying birds successfully collected after death occurred.

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Conflict of interest

The authors declare that they have no conflict of interests.

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