



VNS SURGERY HEADCAP & CUFF IMPLANT PROTOCOL



AUTOCLAVED TRAY

- Surgical Towel
- Scissors
- Curved iris scissors
- Periosteal elevator
- Student pin holder (Drill)
- Serrated forceps
- Tissue forceps (Toothed forceps)
- (2) #5 forceps
- Curved serrated forceps
- Fine curved serrated forceps
- 1 Ligation aid
- (3) Muscle retractors (two 5.0 & one 2.5)
- Small scalpel holder
- (5) Bone Screws in small bag
- Student pin holder (Drill and Cap)

AUTOCLAVED BAG

- (2) Micro-curved hemostats
- (2) Mosquito hemostats
- Halsey needle holder
- Small flathead screwdriver wrapped in 4" x 4" gauze
- Drill bit wrapped in 2" x 2" gauze (#55 or #56)
- (~ 30) Cotton-tipped applicators
- (~ ½ Pack) 2" X 2" Gauze

OTHER EQUIPMENT

- Stereotax
- Scalpel blade
- Absorbable suture pack
- Sterile Weck cell spears
- Headcap holder
- 4 Weigh boats (with alcohol, iodine solution, iodine scrub, hydrogen peroxide)
- Headcap & cuff
- Eye ointment
- Neosporin

DRUGS

- (2) 10mL syringe & 23g needle – 5mL Dextrose, 5mL Ringers (**DR**)
- (2) 10mL syringe & 26g needle – 4mL Ringer's, 6mL Saline (**SR**)
- (4) 10mL syringe & 26g needle – 10mL Saline (**S**)
- 1mL syringe & 26g needle – 0.5mL Lidocaine, 0.5mL Marcaine (**M/L**)
- 1mL syringe & 26g needle – 0.5mL **Dopram**
- 1mL syringe & 26g needle – 0.2mL Dexamethasone, 0.5mL Saline, 0.3mL Atropine (**AD**)
- 1mL syringe & 26g needle – 0.9mL saline, 0.1 mL **Atipamezole**

CONTROLLED SUBSTANCES

- 1 mL syringe & 26g needle – 0.8mL Ketamine, 0.1mL Xylazine, 0.1mL saline (**KX**)
OR
- 1 mL syringe & 26g needle – 0.5mL Ketamine, 0.1 mL Xylazine, 0.05mL Acepromazine, 0.35mL saline (**KXA**) (or premade cocktail)
- 1mL syringe & 26g needle -0.3 mL **Buprenex** Cocktail (Pre-made)

PROCEDURE

Preparation

1. Wipe down any surfaces that will be touched during surgery i.e. lamps, microscopes, stereotax, heating pad, and surgery table.
2. Clean additional equipment including pulse oximeter, temperature probe, and heating pad.
3. Place cling wrap (or other sterile medium) on the surgical area.
4. Anesthetize the animal using a Ketamine cocktail (Ketamine, Xylazine, Acepromazine, or Ketamine, Xylazine).
5. Shave the head.
 - a. Anterior/posterior: Shave from just behind the eyes to 2 mm behind the ears.
 - b. Medial/lateral: Shave to the edge of the ears and as close to the eyes as possible without harming the animal.
6. Shave the left side of the neck.
 - a. Anterior/posterior: Shave from approximately 1 mm below (posterior) the chin to the sternum.
 - b. Medial/lateral: Shave from 3 mm to the right of the animal's sternum to the animal's left shoulder.

7. Place animal on heating pad and begin monitoring heart rate, respiration, and O₂ saturation with pulse oximeter.
8. Adjust rat into the stereotaxic frame. (*Figures 1a & 2b*)
 - a. Feel for the 2 bony ridges using a stable, fixed left ear bar and carefully insert the rat along the top ridge.
 - b. Adjust the rat so that the ear bar is going under the bottom ridge and insert the ear canal firmly into the ear bar.
 - c. While holding the animal's head with your left hand, use your right hand to insert the right ear bar into the right ear canal.
 - d. Once the animal is firmly placed in the ear bars, place the front teeth into the mouth guard of the nose piece. Tighten everything as necessary. (*Note:* The nose piece can prevent an animal's breathing. Make sure that animal is secure but can also breathe.)



Figure 1a. Animal has both ears in stereotaxic frame and teeth are being placed in mouth guard.



Figure 1b. Animal securely in stereotaxic frame with a sterile medium (cling wrap) and a heating pad underneath.

9. Insert petroleum jelly coated rectal probe for temperature monitoring and use surgical tape to attach the probe to the tail.
10. Apply eye ointment to prevent corneal drying.

Surgery-Headcap Implant

1. Sterilize the skin of the incision area by applying alcohol then iodine scrub twice, alcohol twice, and iodine solution.
2. Inject Lidocaine/Marcaine under the skin for nerve block.
3. Make a sagittal incision in the skin from 2 mm behind the eyes to 2 mm in front of the ears.
4. Scrape fascia and periosteum away from the skull toward the lateral edges of the incision with the periosteal elevator.
5. Clamp fascia at each of the four corners of the opening using hemostats. (*Figure 2*) Note: Do not clamp the skin as this can cause the animal pain and damage the skin of the animal during recovery.

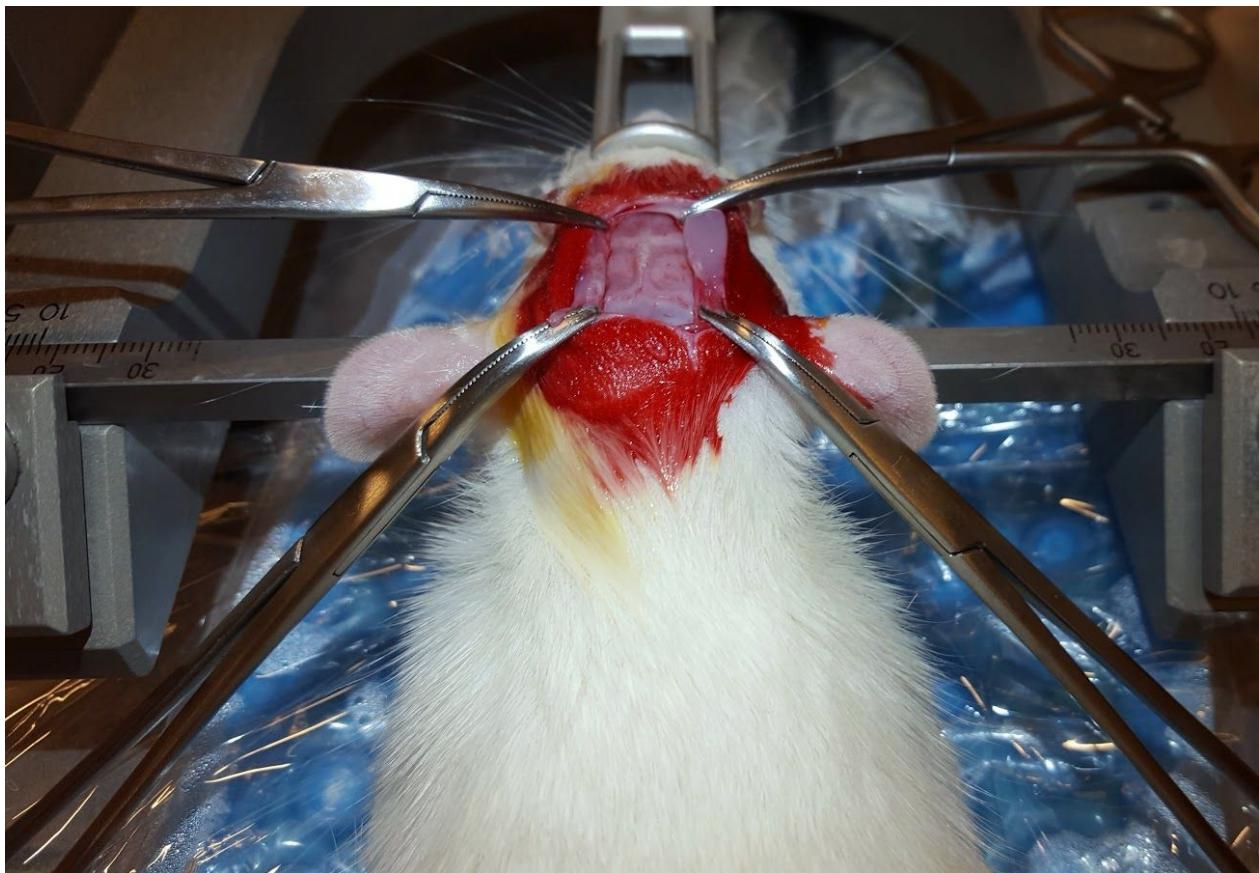


Figure 2. Fascia being clamped by serrated hemostats.

Note: Do not clamp the skin.

6. Clean the skull surface using cotton swabs and hydrogen peroxide then rinse with Saline/Ringer's. Clean thoroughly until suture lines can be seen clearly. Dry skull surface before drilling holes.
7. Drilling holes. (*Figure 3*)
 - a. Make pilot holes using the drill or use a scalpel blade to mark the spot for holes. *Note:* Do not go through the skull yet.
 - b. Drill 4 holes with the drill. (*Figure 3*) Screws will be used to anchor the headcap (headstand) only.
 - c. Pick out any bone fragments from each of the holes with #5 forceps or a 26g needle. You should be able to see the dura and underlying brain and blood vessels. Saline/Ringer's can be used to help clean the out the holes as needed.



Figure 3. All 4 holes are drilled and cleaned.

8. Make sure the skull is dry. Insert all screws tightly into the skull, then turn the screws a quarter turn back to allow acrylic to hold the screws tightly to the skull. (*Figure 4*)

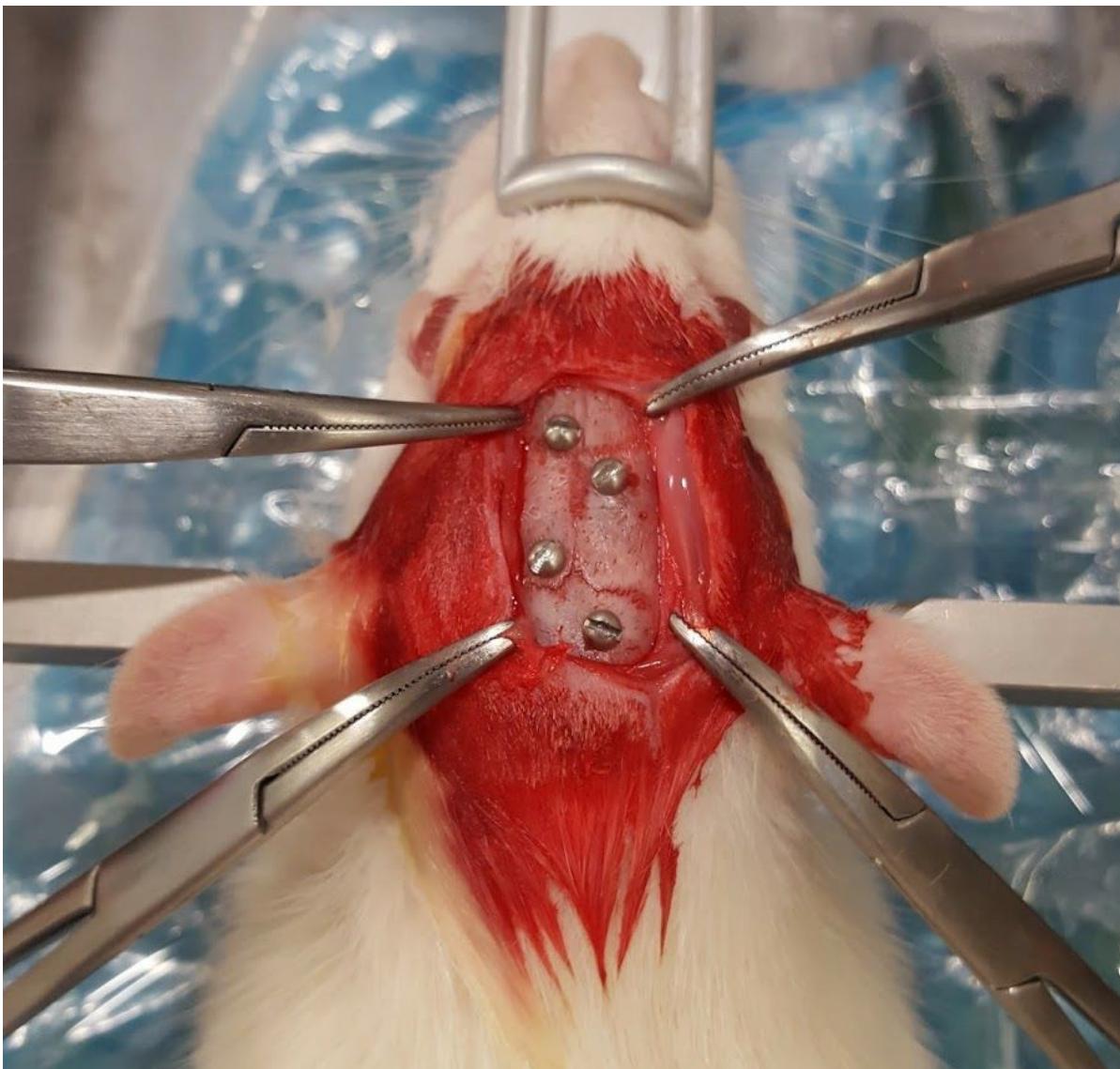


Figure 4. Screws properly fitted into the skull.

9. The headcap implant should be sterilized by wiping it using alcohol, then allowing for the headcap to dry for 15-30 seconds. Rinse the headcap with saline before lowering onto the skull.

10. Apply enough acrylic to the screws to cover the screws entirely while making sure the acrylic seeps under the screws. Avoid acrylic touching the skin or fascia. (*Figure 5a*)



Figure 5a. Acrylic base drying.

11. Once the acrylic base is dry, then apply a small amount of acrylic to the base and lower the headcap on to the center of the base. Keep the headcap steady until the acrylic has dried. Add acrylic to the headcap until firmly planted. Avoid covering the gold pins. (The gold pins from the cuff electrodes will mate with the gold pins of the headcap implant.) (*Figures 5b & 5c*)

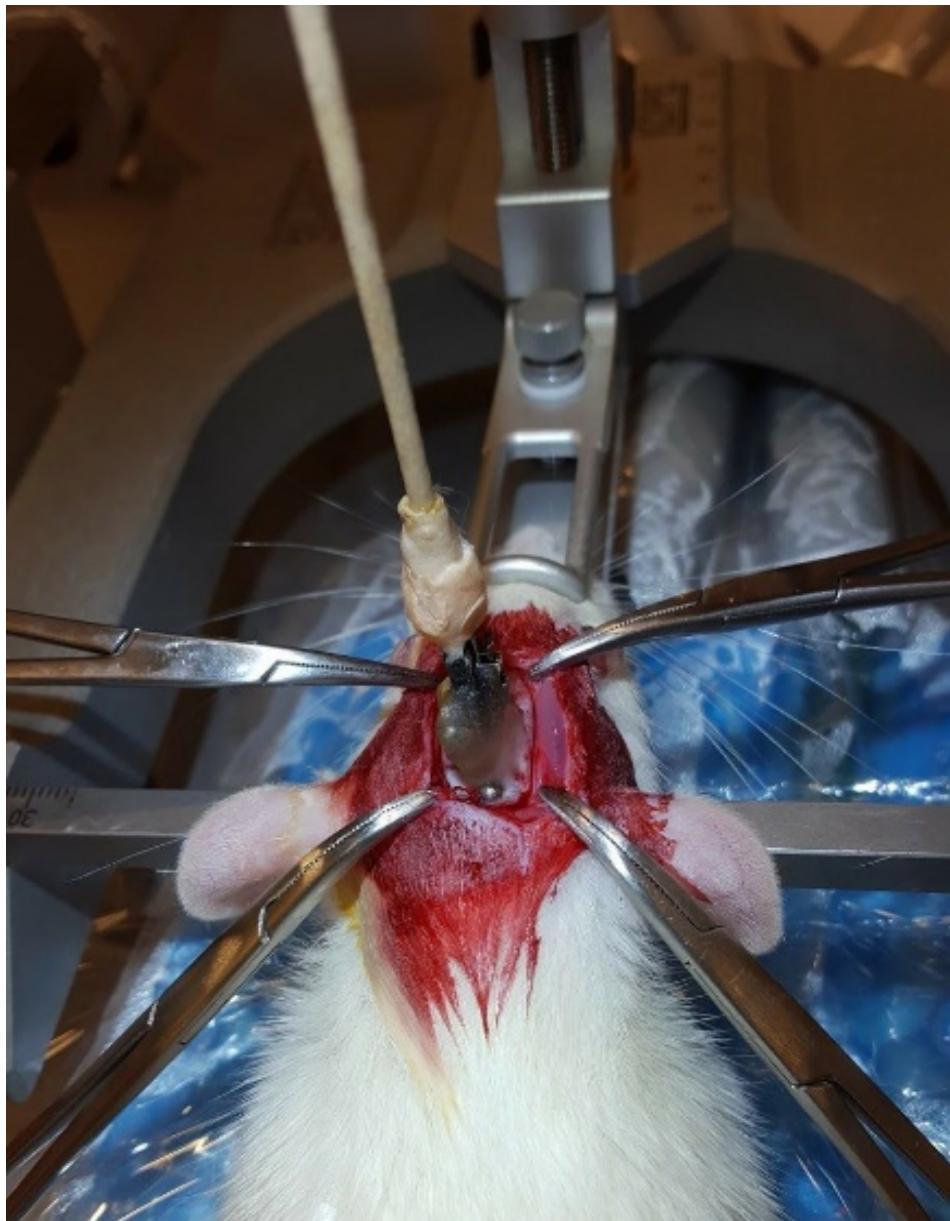


Figure 5b. Headcap firmly planted on the base.

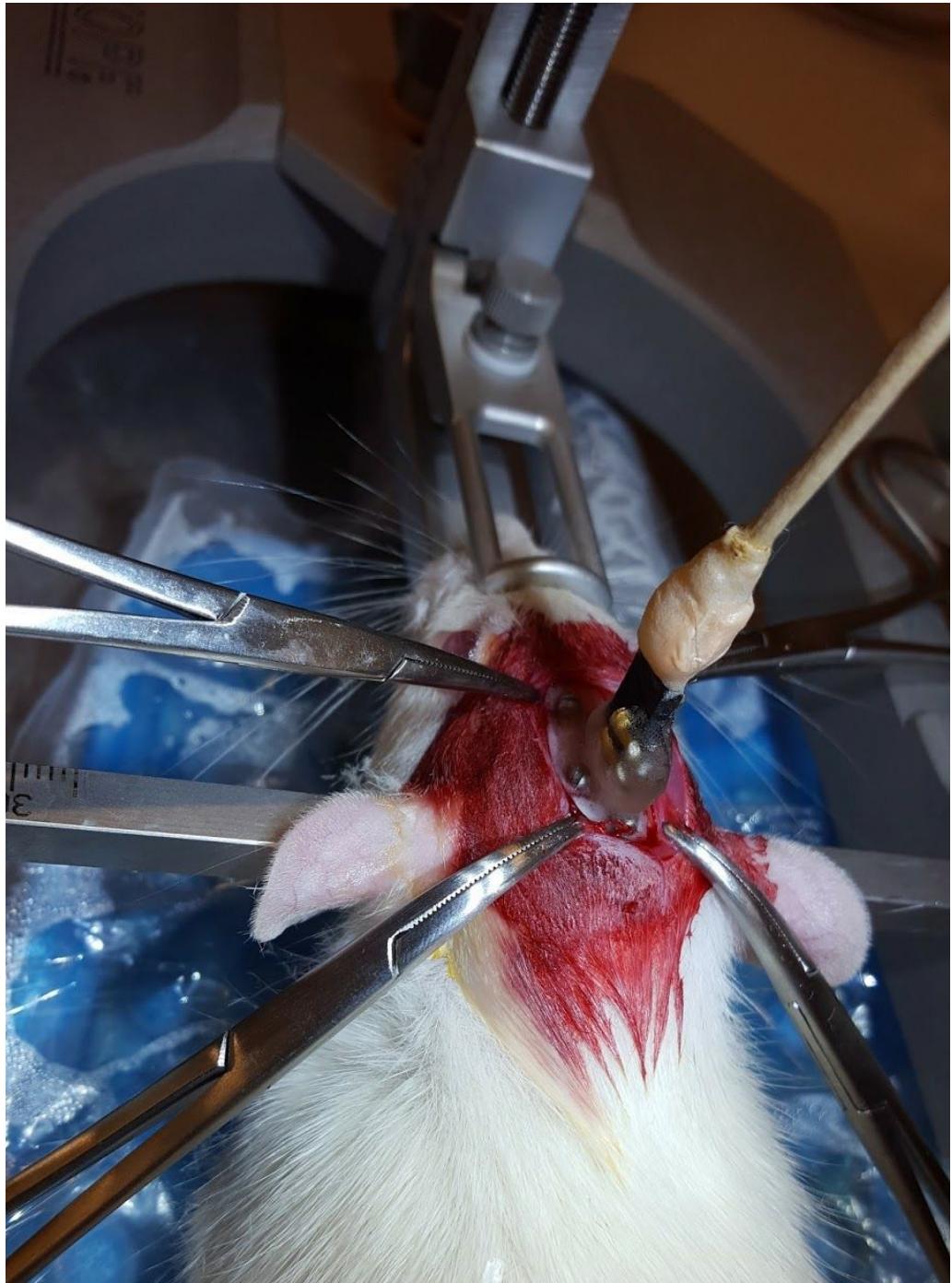


Figure 5c. Gold pins still open for addition of cuff pins later.

12. Remove the animal from the stereotaxic frame.

Surgery-Cuff Implant

1. Set up muscle retractor plate.
2. Lie the rat down on its right side in the center of the muscle retractor plate. Adjust the animal's left paw away from the surgical site using the ring of a hemostat.
3. Sterilize the skin of the incision by applying alcohol then iodine scrub twice, alcohol twice, and iodine solution.
4. Inject Lidocaine/Marcaine subcutaneously on the left side of the neck.
5. Make a 7-9 mm skin vertical incision 2 mm left of the midline, starting 1 mm above the left clavicle. (*Figures 6a & 6b*)

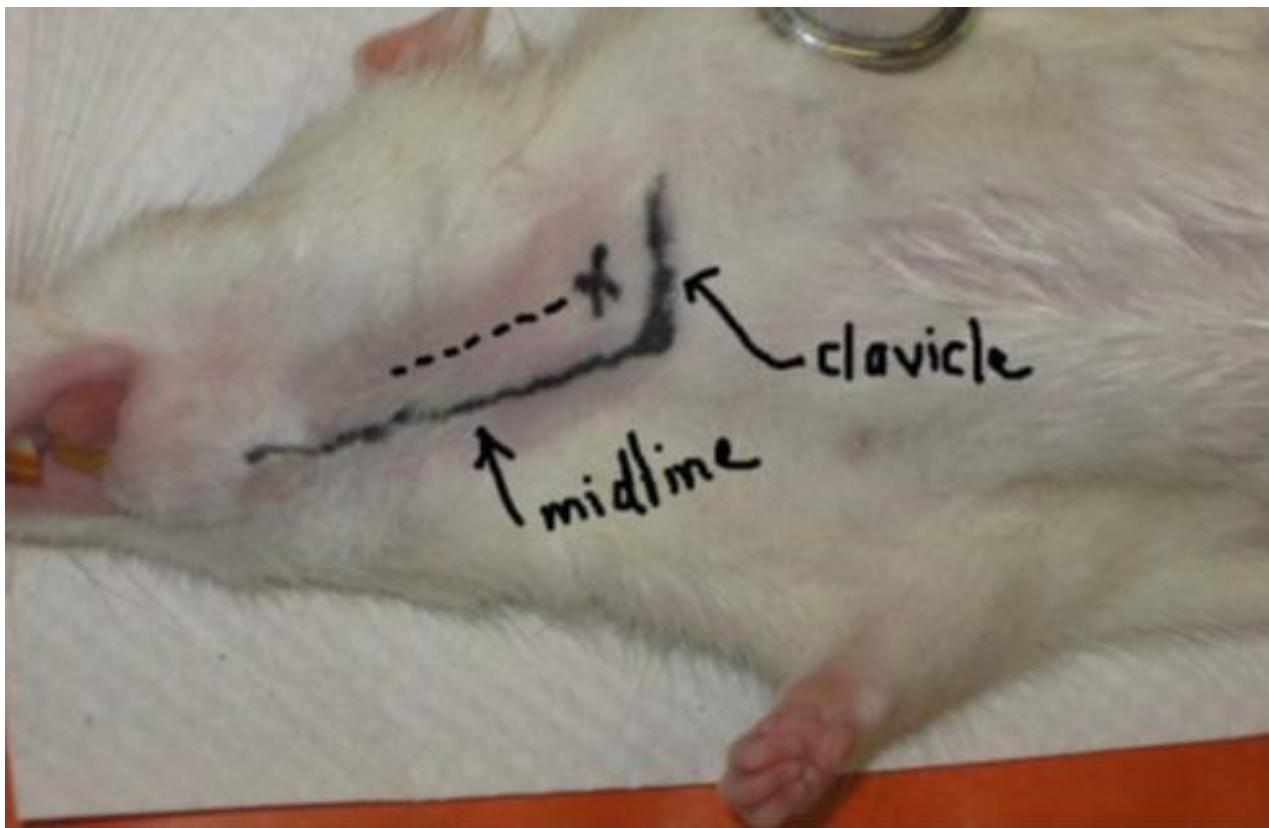


Figure 6a. Incision area with the dotted line marking the location of the incision.

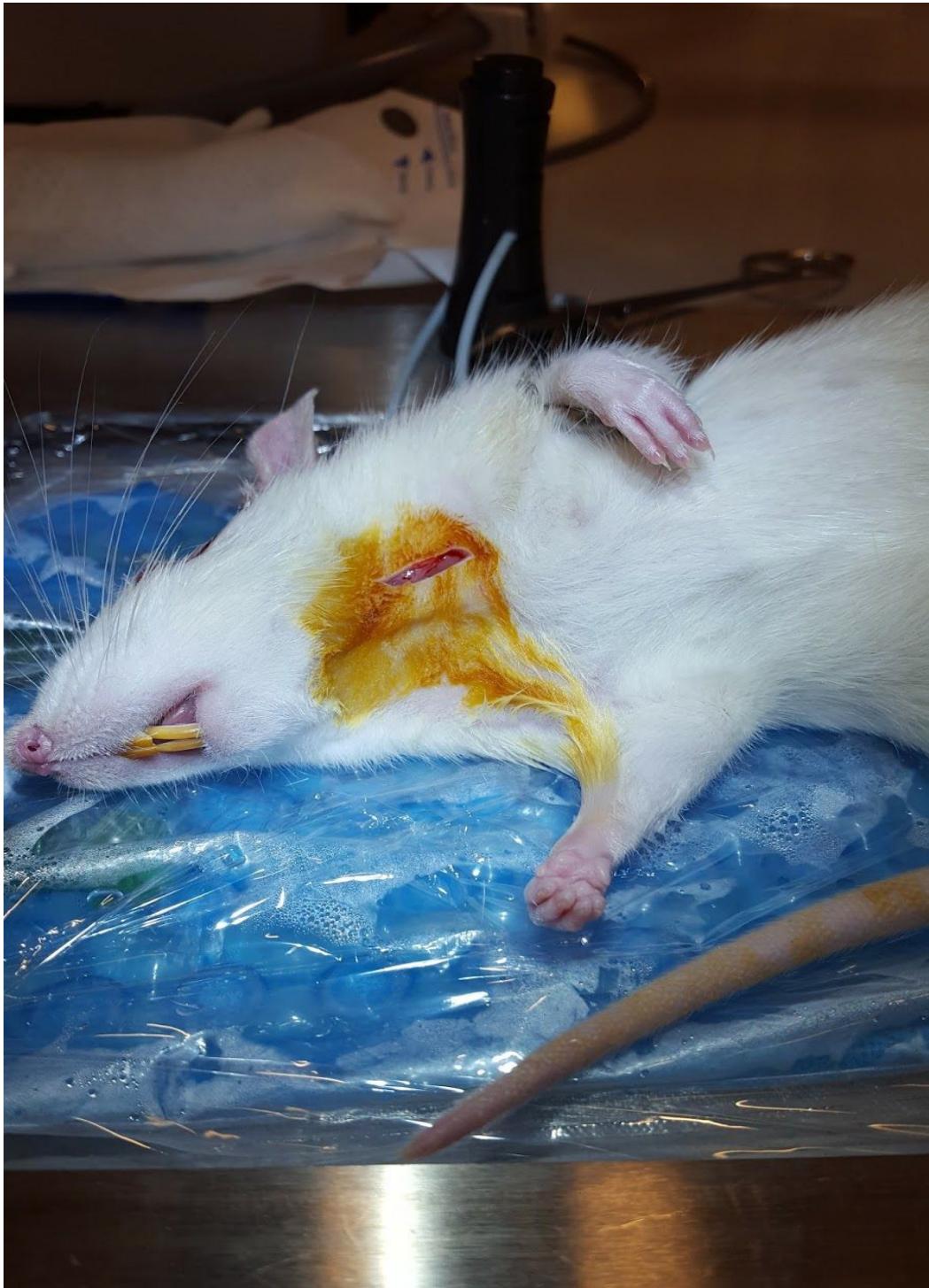


Figure 6b. Rat lying on its right side with the ring of a hemostat holding the left forelimb back and the incision already made.

6. Blunt dissect the area around the incision to allow for more space to work with later in the surgery.
7. Blunt dissect the subcutaneous fat caudal to and surrounding the parotid (salivary) gland, separate the fascia over the parotid gland to the side to expose the underlying sternocleidomastoid and sternohyoid muscles. (*Figures 7a & 7b*)



Figure 7a. Subcutaneous fat surrounding the parotid gland blunt dissected.

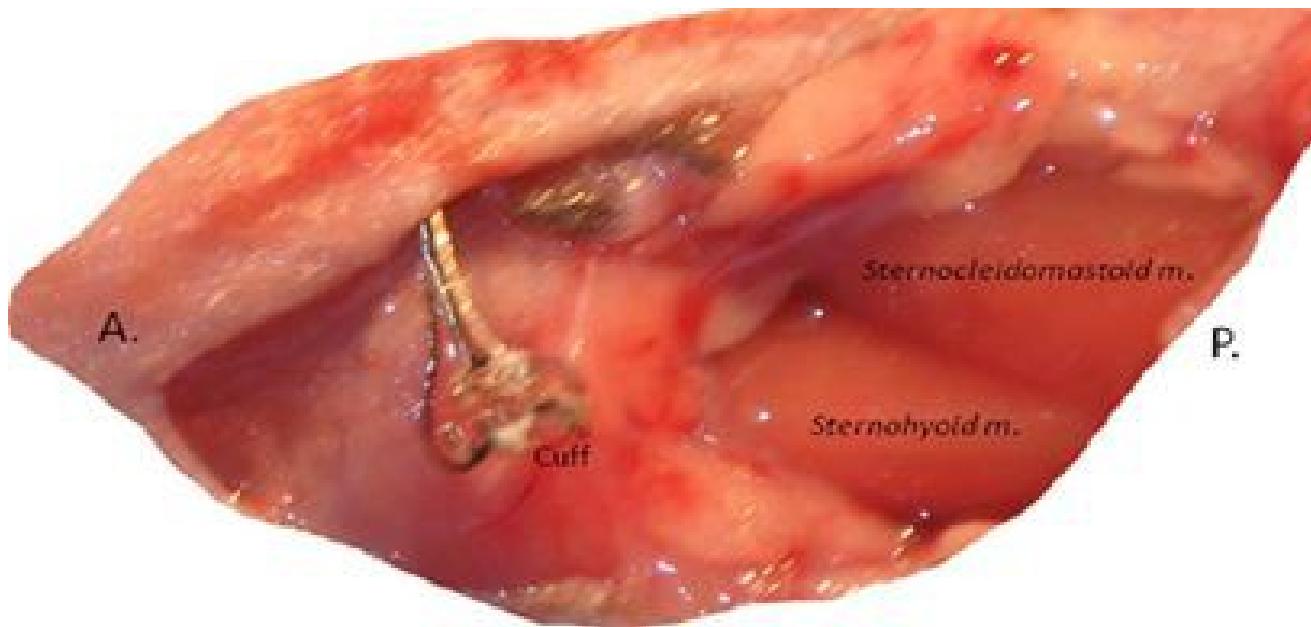


Figure 7b. The sternocleidomastoid and sternohyoid muscles exposed after the parotid gland was moved away.

8. Blunt dissect between the sternocleidomastoid and sternohyoid muscles while being careful to avoid damaging the muscles. Continue to blunt dissect the two muscles from each other and hold them apart with muscle retractors.
9. Blunt dissect the omohyoid muscle from the medial edge of the sternomastoid muscle. Do further blunt dissections until you can clearly visualize the vagus nerve and carotid artery in the triangular area formed between the two muscles. The vagus nerve usually lies lateral to the carotid artery. (*Figures 8a & 8b*)

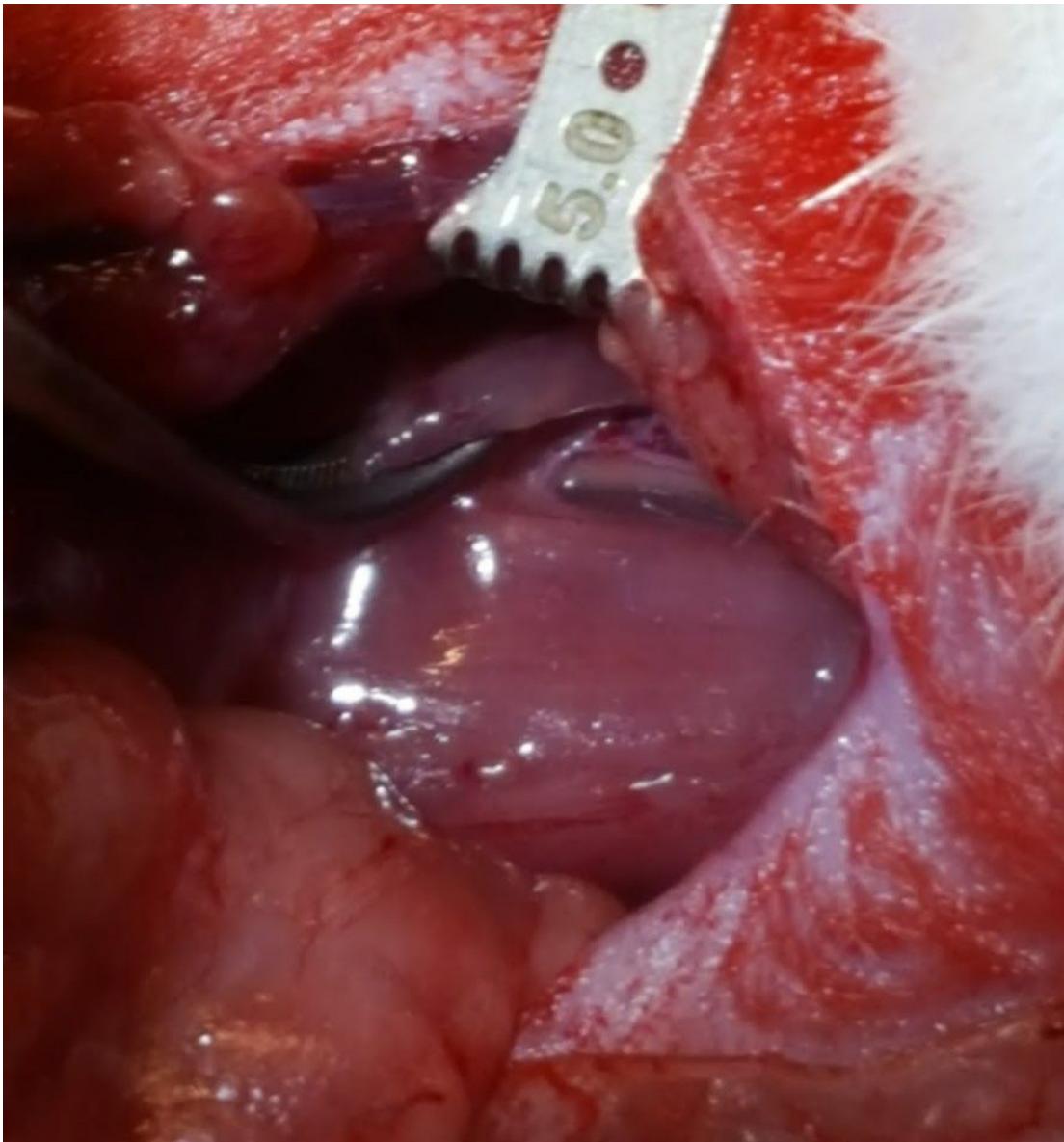


Figure 8a. Curved forceps holding the omohyoid. Blunt dissection will occur in the fascia between the sternohyoid muscle and the omohyoid muscle.

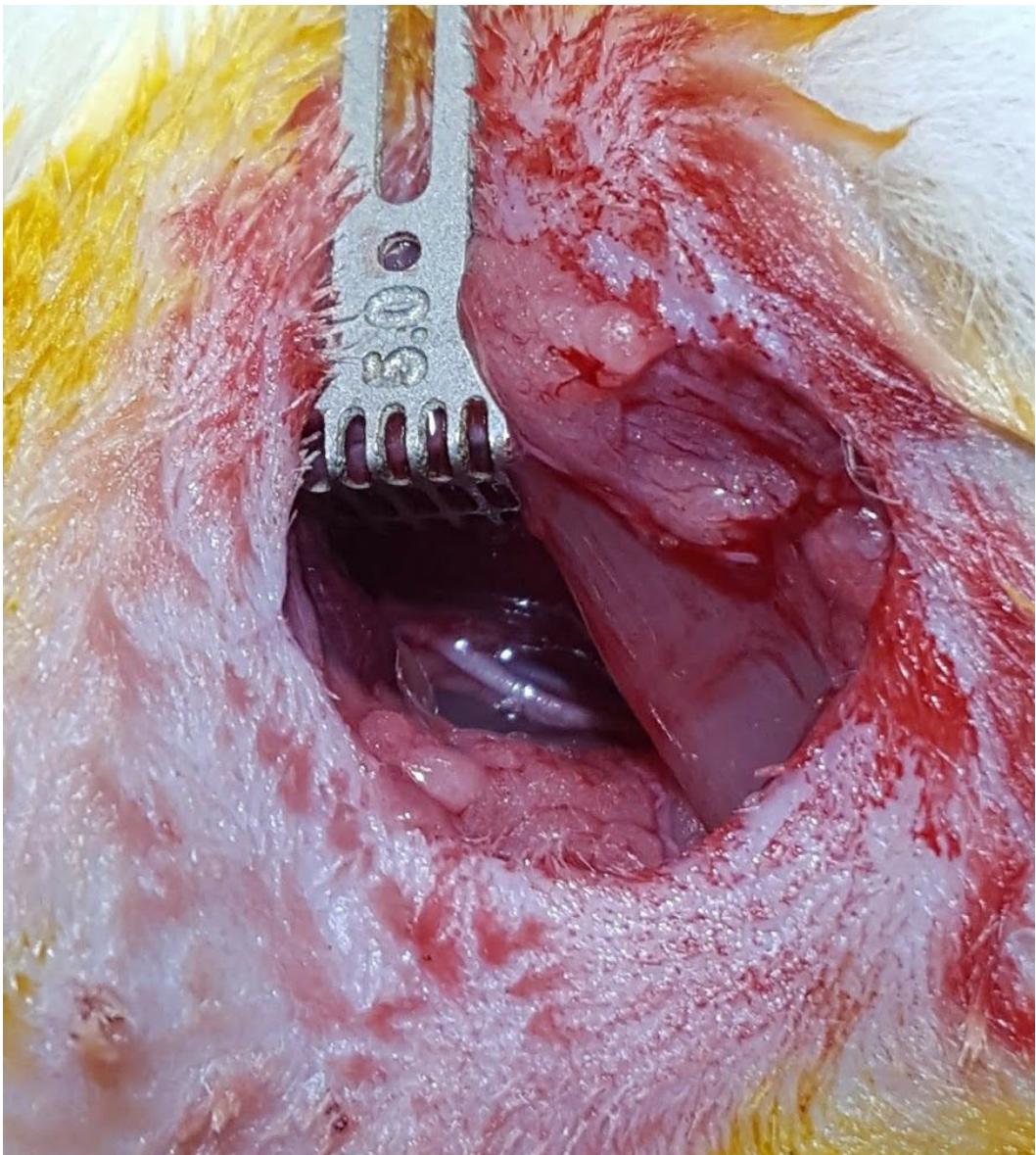


Figure 8b. Triangular area exposing the vagus nerve and the carotid.

10. Branches of the vagus nerve (i.e., cardiac branches) became visible at this point. Do not pick up or pinch these nerves.
11. The carotid and vagus nerve can be seen in the carotid sheath.

Blunt dissect the carotid sheath for about 5-6 mm and separate the vagus from the carotid artery using two fine #5 forceps (fine serrated forceps and curved iris scissors may also be used). Do not pinch the nerve while performing this step. Grip the vagus nerve using the connective tissue around it. (*Figures 9a & 9b*)

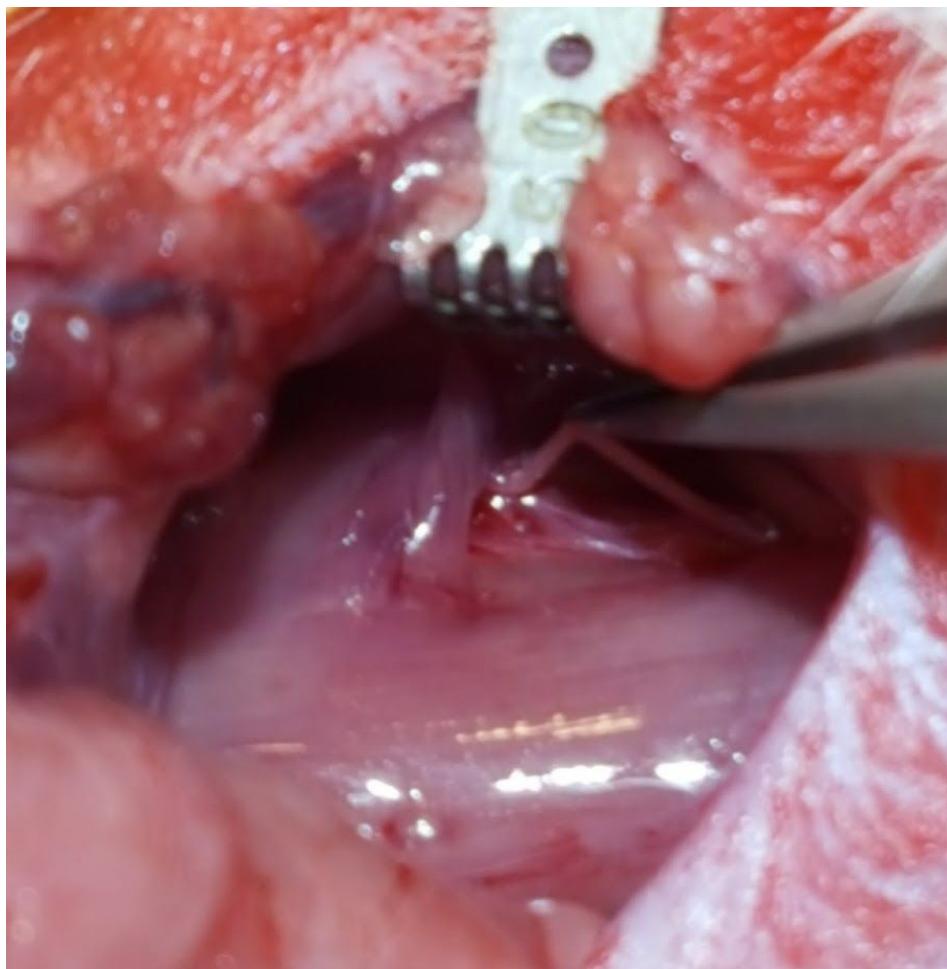


Figure 9a. Vagus nerve being picked up using #5 forceps by only using the connective tissue around the nerve after some blunt dissection.



Figure 9b. Vagus nerve being held with a ligation aid after blunt dissection was completed around the nerve.

12. Remove the muscle retractors. Making sure to only go through fascia, blunt dissect under the skin of the left cheek until reaching the incision made on the head using the curved iris scissors.
(Figure 10a)



Figure 10a. Blunt dissecting a tunnel from the neck to the head to allow the leads to pass through to the neck.

13. Without pulling out the scissors, push toothed forceps through the tunnel. Once the forceps are in the tunnel, remove the scissors. (Figure 10b)



Figure 10b. Toothed (muscle) forceps pushed through the tunnel made by the curved iris scissors.

14. Clean the entire cuff implant with isopropyl alcohol, then rinse the cuff implant using saline and dry with gauze.
15. Insert the golden pins on the cuff implant into the golden pins in the headcap implant. Once the pins are secure, then pull the cuff through the tunnel along the left cheek using the toothed forceps.
(Figures 11a, 11b, & 11c)

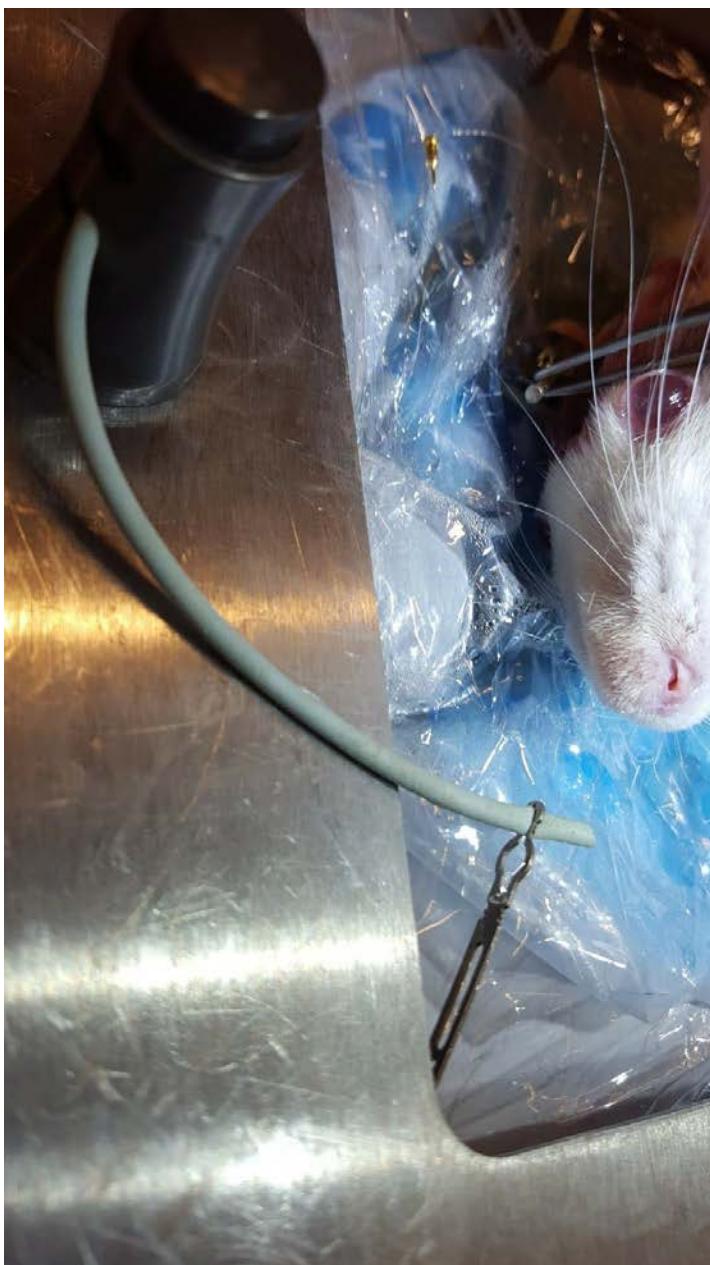


Figure 11a. The bottom pin inserted into the headcap.



Figure 11b. The top pin inserted into the headcap.

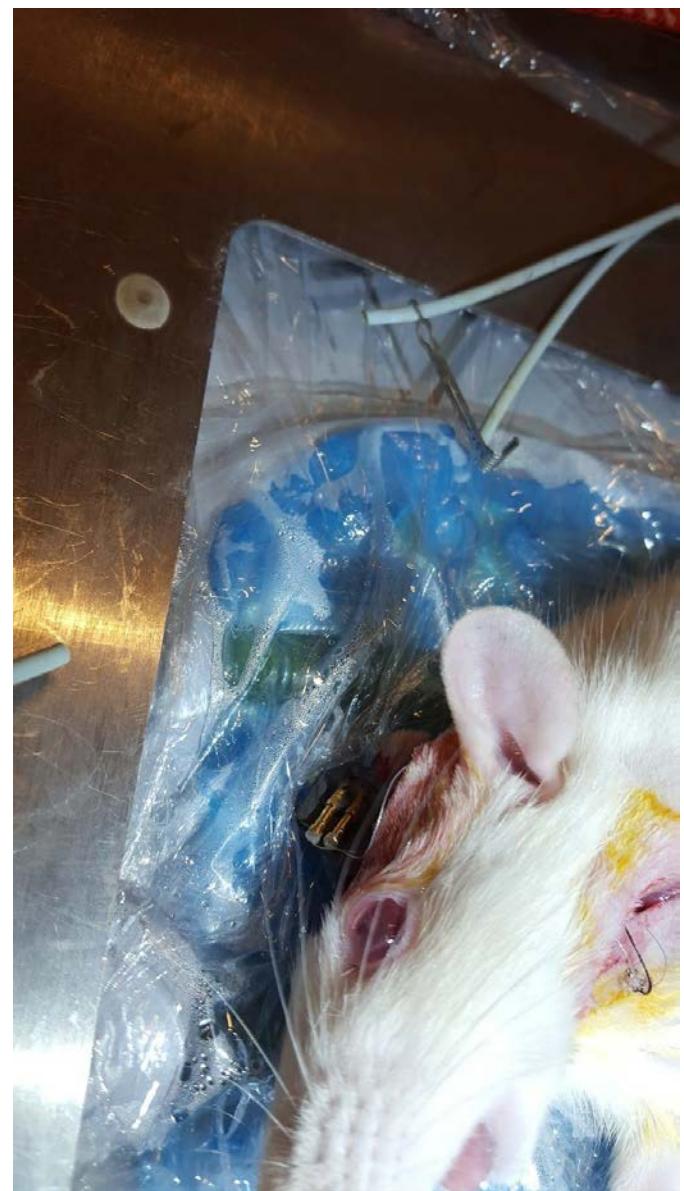


Figure 11c. Both pins inserted and the cuff pulled through the tunnel.

16. Place the muscle retractors back in their original positions.
17. Align the cuff parallel to the vagus nerve. (The leads of the wire may need to have a small kink in order to lie parallel to the vagus nerve.) (*Figure 12a*)

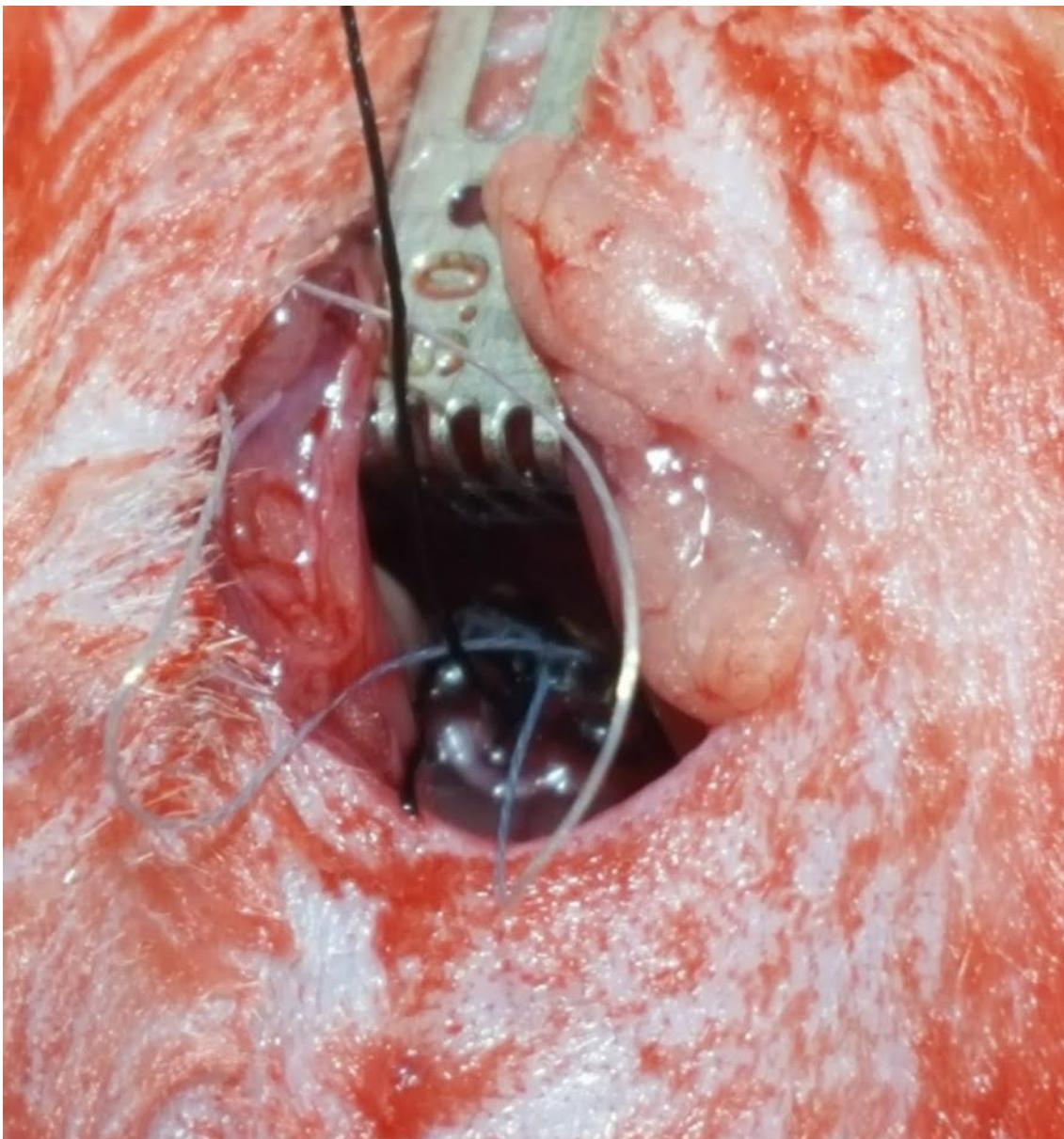


Figure 12a. Cuff placed parallel to the vagus nerve and the carotid vessel.

18. Using a pair of #5 forceps and a ligation aid (or curved forceps), pull the suture under the vagus nerve and place the vagus nerve directly on the cuff opening. Open the cuff using the sutures. The vagus nerve should fall into the cuff easily. (*Figure 12b*)

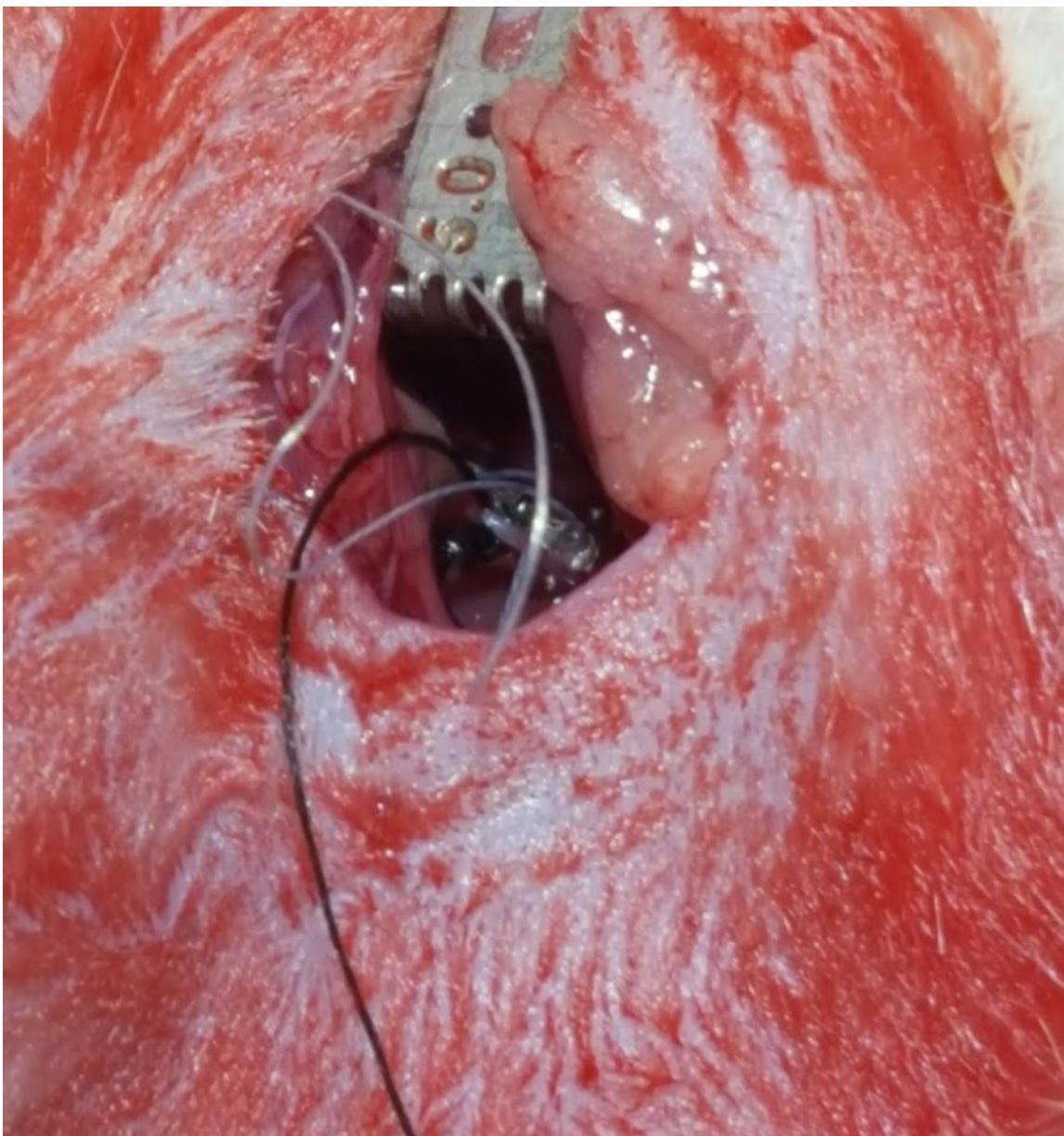


Figure 12b. Vagus nerve placed on top of the cuff. Sutures need to be pulled apart and the vagus nerve will fall in.

19. Test the cuff

- a. Plug the rat into a swivel attached to a stimulator and oscilloscope.
- b. Stimulate for 10 seconds.
 - i. Oscilloscope should have a sine wave.
 - ii. SpO₂ should drop approximately 10-15%.

20. Tie the two ends of the suture with 3 knots to close off the slit.

Cut the extra length of the suture.

21. Pull out the muscle retractors, and then let the muscles and skin fall into place. Curved forceps may be used to help put all tissue back in its original place.

22. Using absorbable suture, suture the sternocleidomastoid and sternohyoid muscles loosely together to help the muscles heal and maintain the cuff in place. (*Figure 13a*)



Figure 13a. Loose suture in the sternocleidomastoid and sternohyoid muscles.

23. Close the wound edges with interrupted sutures. The edges should be in close approximation but should not be tied tightly or else it will lead to inflammation and discomfort. Start suturing at one end of the incision and proceed with regular spacing to the other end. (*Figure 13b*)



Figure 13b. Neck is sutured with absorbable, internal interrupted-sutures.

24. Clean the wound using alcohol, betadine solution, alcohol, betadine solution, and alcohol two times at the end. Apply topical antibiotic to the sutured incision.
25. Place rat in the prone position. Clean off dry blood using saline, cotton swabs, and gauze.

26. Apply acrylic over the gold pins of the head implant sealing the gold pins entirely. Apply acrylic over the cuff leads from the head implant to the edge of the skull. Do not let acrylic fall over the muscle. (*Figure 14a*)

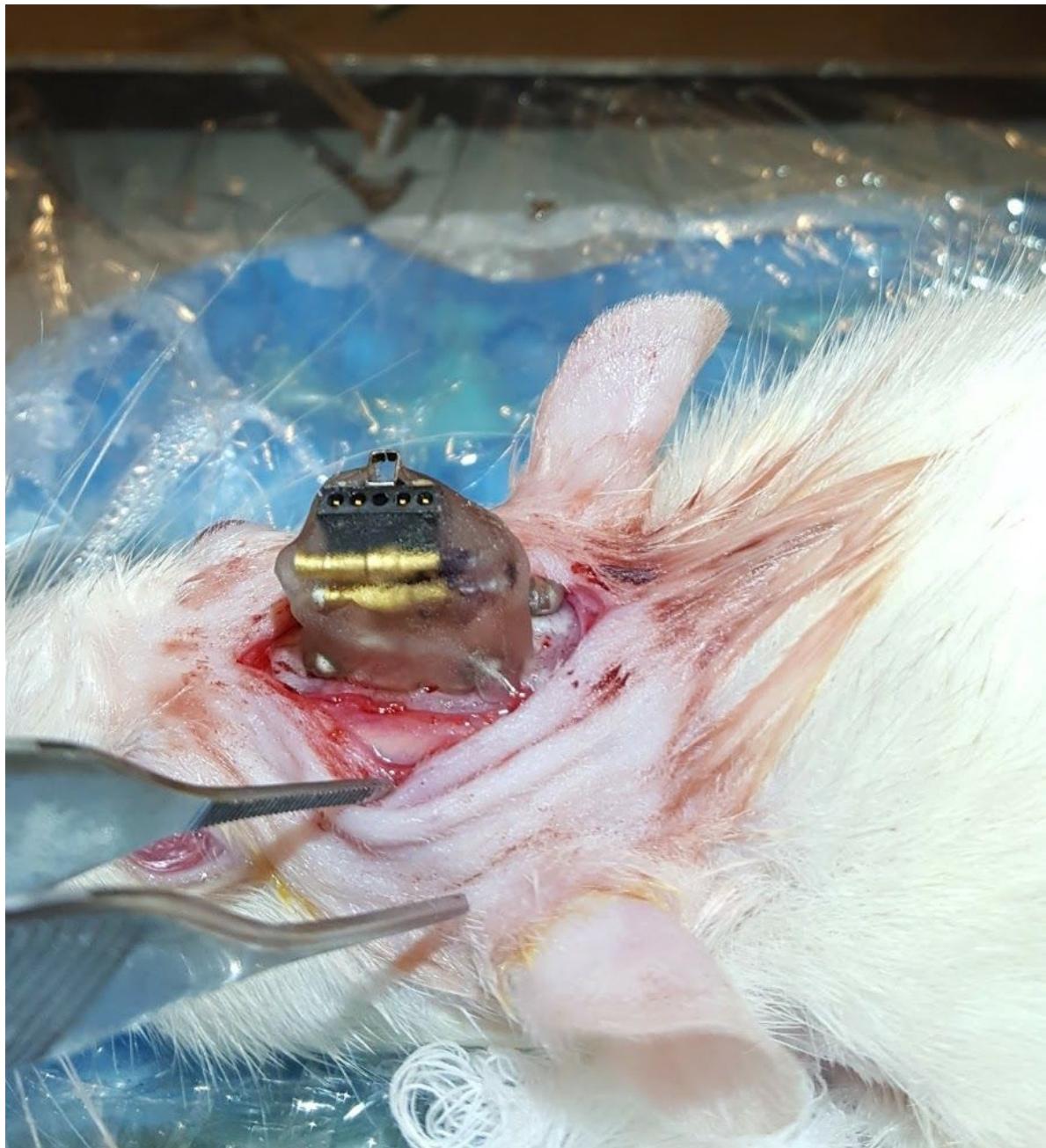


Figure 14a. Acrylic covering the pins and wire on the head implant in such a way that the animal cannot damage the head implant.

27. After the acrylic has dried, suture the head incision up to the head implant. (*Figure 14b*)



Figure 14b. Sutures closing the remainder of the head incision.

28. Clean the wound using alcohol, betadine solution, alcohol, betadine solution, and alcohol two times at the end. Apply topical antibiotic to the sutured incision and on the skin around the head implant.

Postoperative Procedures

1. Administer fluids to animal to aid with recovery time and to replace any fluid loss during the procedure. Suggested to use between 5-10 mL.
2. Administer atipamezole hydrochloride & saline cocktail (Xylazine reversal drug).
3. Place rat in a clean cage located on a heating pad.
4. Animal should remain on a heating pad until awake.
5. Once animal is awake, then give animal antibiotic food tablet (Helicobacter) and anti-inflammatory (Rimadyl) food tablet.

* *Suggested additions:*

- Animal should not be given food until medication tablets have been eaten to encourage eating medication.
- A small water bowl may be added to allow easier access to water.
- Soft bedding may provide the animal with easier recovery.

- Some animals may need to have bedding removed while waking up. Recovery pads or puppy pads may be used while animal recovers mobility.

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