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Baseplate Implantation for Two-Part Chamber System

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Jiwon Choi[1,2], Usamma Amjad[1,2], Helen N Schwerdt[1,2]

[1]University of Pittsburgh;
[2]Aligning Science Across Parkinson's (ASAP) Collaborative Research Network, Chevy Chase, MD

ASAP Collaborative Rese…

H Helen N Schwerdt
University of Pittsburgh

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We use this protocol and it's working

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Abstract

This protocol describes how to implant a "baseplate" onto the skull. The baseplate forms the bottom layer of the full chamber, which is completed in the second surgical procedure by mounting a "second" or "third" phase (described in another protocol entitled, "Craniotomy, and Second and Third Phase Implantation to Complete Two-Part Chamber System"). The baseplate is thin enough (8 - 10 mm) that it can be completely enclosed subcutaneously. Therefore, this piece is implanted first and as a separate piece in order to create an aseptic environment for healing and to promote osseointegration without risk of infectious species spreading through the chamber margins.

Materials

2.7 mm diameter ceramic screws (Gray Matter Research)
2.7 mm diameter titanium screws (Gray Matter Research)
3d-printed PEKK baseplate (Gray Matter Research)
3d-printed drill guide plate (Gray Matter Research)
Hand-held drill guide (Gray Matter Research)
Hand drill (2 mm diameter) (Gray Matter Research)
Tap (Gray Matter Research)
Electric drill (Dremel)
Kwik-sil (World Precision Instruments, WPI)
3d-printed practice skull model (Gray Matter Research)
Stereotax
Vicryl 3-0 suture (Johnson and Johnson)
Nylon 3-0 suture (Ethilon)

Note: All of these materials were sterilized on-site with ethylene oxide gas sterilization and/or hydrogen peroxide plasma from the vendor.

Baseplate Implantation (First part of the cranial chamber implant)

1 Procedures were performed on Rhesus monkeys (n = 2) and were approved by the Institute's Animal Care and Use Committee (IACUC) at the University of Pittsburgh and were performed following the Guide for the Care and Use of Laboratory Animals (Department of Health and Human Services), the provisions of the Animals Welfare Act (USDA) and all applicable federal and state laws.

2 Monkeys were first given ketamine and atropine in their home-cage and then maintained on anesthesia with 1.5–2.0% isoflurane and 1 L/min oxygen. Analgesics, anti-inflammatory agents, and prophylactic antibiotics were administered pre- and/or post-op (i.e., meloxicam, dexamethasone, ceftriaxone, and buprenorphine).

3 Monkeys were placed in stereotactic frames to fix their head for surgical operation.

4 A sterile field was created on the skin on the top of the head and the surface was disinfected with several rounds of applying betadine and 70% isopropanol, in a serial manner, with gauze.

5 The skin was incised down the center of the cranium and retracted to expose the cranial surface.

6 A custom-designed drill guide plate (Gray Matter Research) was fitted on the surface of the cranium to mark the locations of targeted screw holes (20 screw holes total). This drill guide plate has the same geometry the actual baseplate that would be implanted, except that it incorporates added clearance on top for fitting drills and hand-held drill guides (all of these parts were custom-made by Gray Matter Research). Both drill guide plate and baseplate were designed to conform to the geometry of the skull using the extracted bone model from the CT scan (Vimago GT30).

7 The drill guide plate was aligned to the marked screw holes and shallow pilot holes were made using an electric drill and a drillbit having a diameter slightly smaller than the target diameter.

8 Further drilling was done with a hand drill (2.0 mm diameter, from Gray Matter Research). The depth of the hole was maintained between 2 - 3.5 mm deep using a drill-sleeve that controlled the depth with 0.5 mm resolution. The target drill depth was determined based on the bone thickness estimated for each hole, using the CT-extracted bone model. We aimed for each screw to pierce through the bone, while protruding less than 0.5 mm to avoid piercing the dura mater. This process was emulated on a 3D-printed skull model for each monkey to ensure that the drill depth was maintained safely within these bounds.

9 Screw holes were tapped using a tap (Gray Matter Research) and the amount of threads created was manually controlled by counting the number of turns that would allow the tap to

just barely extend beyond the thickness of the skull. The number of turns (2 - 4) for each hole was predetermined using a 3D-printed skull to directly visualize when the tap extended beyond the other side of the cranial surface. In monkey J, only holes for ceramic screws (4 total) were tapped.

10 2 holes were manually created in the bone with an electric drill that would be used to secure stainless steel "bone" screws (4-40) that were pre-installed with a wire crimp for use as electrical "ground" connections.

11 The drill guide plate was removed and replaced with the actual baseplate, and screw hole alignment was checked. If needed, manual drilling was performed to widen holes that were misaligned between the two plates. Significant misalignment occurred in 5 (monkey T) or 2 (monkey J) holes.

12 After aligning, the baseplate was secured to the cranium by screwing in the ceramic screws and titanium screws (2.7 mm diameter, with a length of 5.81 mm for ceramic screws and 6.11 mm for titanium screws as made by Gray Matter Research). Screws were tightened without excessive force. Overtightening the screws was avoided especially for ceramic screws, where the screw heads were easy to fracture with excessive torque. Screws were covered with Kwik-sil (WPI), except for stainless steel ground screws. These ground screws were covered with a thin plastic cover and a drop of Kwik-sil on top to keep it in place in order to ensure that the underlying wire crimp does not get covered by the Kwik-sil so that it remains open for subsequent electrical connection.

13 The retracted skin was pulled over the baseplate and sutured using two-layers of sutures (dissolvable suture beneath the skin and non-absorbable nylon suture for over the skin) with simple interrupted patterns.