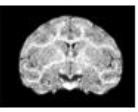
Gray Matter Research, LLC



User's Manual for the SC32-1
(32-chn semi-chronic microdrive system)

Description

SC32-1 (32-chn semi-chronic microdrive system (10 mm))

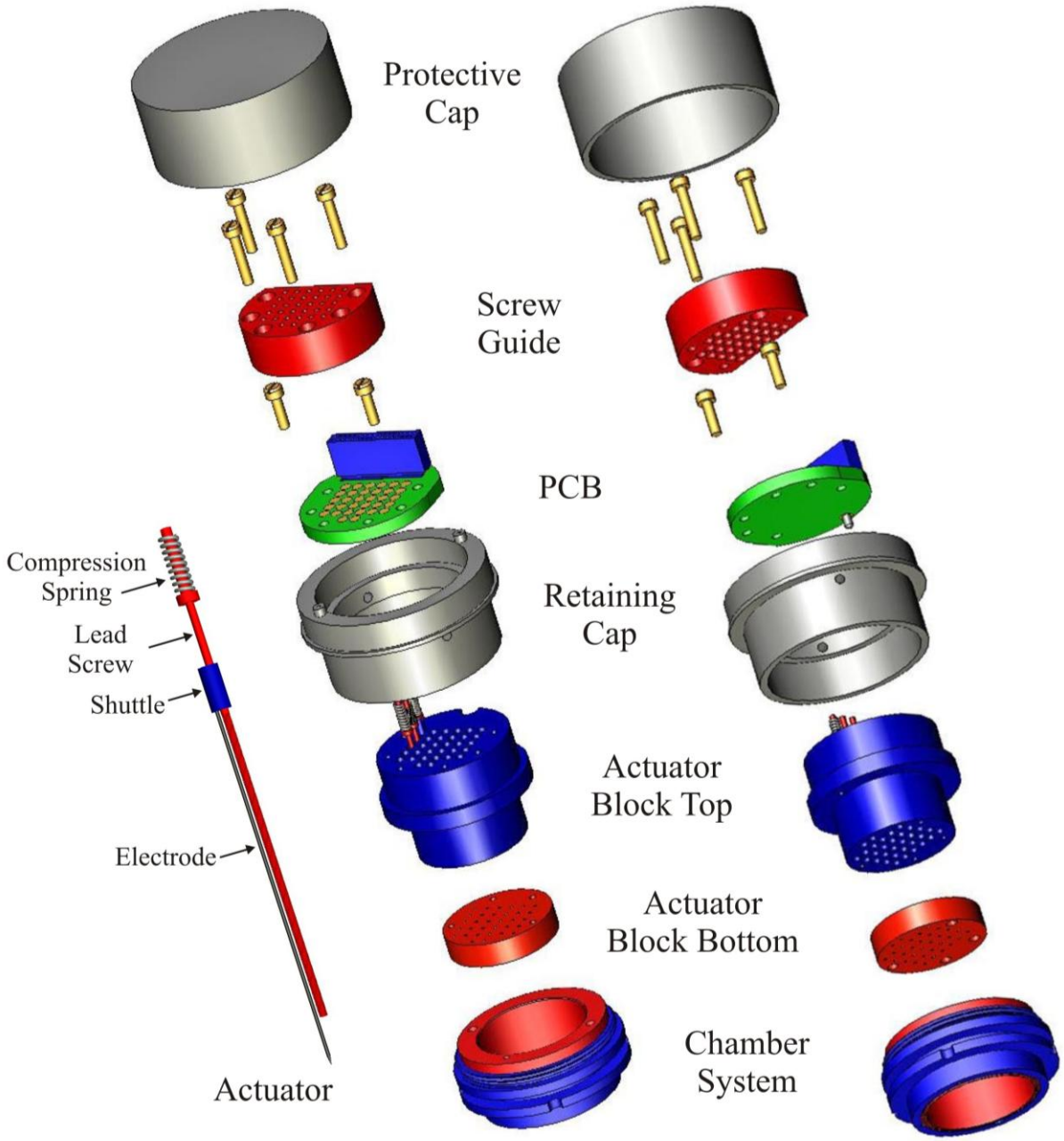


Figure 1. Exploded view of the 32-chn semi-chronic microdrive system (SC32-1) and an assembled chamber system (RC1).

The SC32-1 is a modular, replaceable micromanipulator system capable of independent bidirectional control of 32 microelectrodes. The system is designed to be semi-chronically implanted within a GMR recording chamber system. Electrode positions are controlled by miniature, screw-driven actuators, using a hand-held miniature screwdriver. Electrical contact with the electrodes is achieved through a printed circuit board, which avoids the use of wires. When assembled, the system can be implanted for weeks or months at a time to permit long term recordings of neuronal activity.

SC32-1

Components List: 32-Channel Semi-Chronic Microdrive System

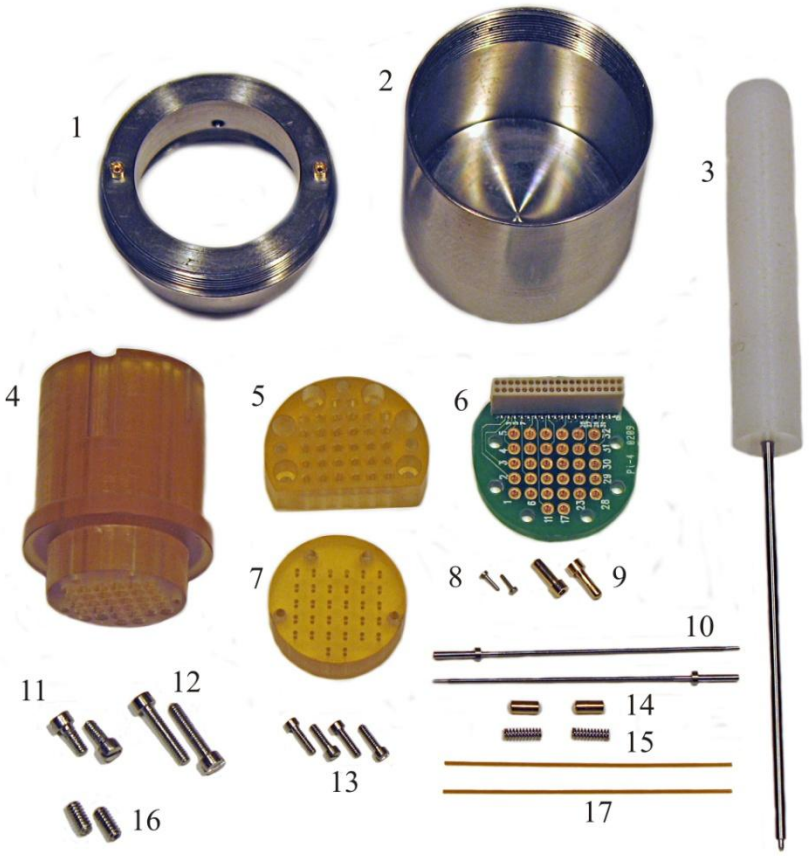


Figure 2. Components of the semichronic microdrive system (SC32-1).

Item#	Part#	Description	Quantity/System
1.	RTC-1	Retaining Cap	1
2.	PC-1	Protective Cap	1
3.	SD0.5unm-2	Miniature Screwdriver	2
4.	PBT32-1	Plunger Block Top	1
5.	SG32-1	Screw Guide	1
6.	PCB32-1	Printed Circuit Board (PCB)	1
7.	PBB32-1	Plunger Block Bottom	1
8.	GPIN-M1	Male Grounding Pins	4
9.	GPIN-F1	Female Grounding Pins	4
10.	S0.5unm-20mm	Lead Screw	40
11.	S1.2-0.16	1.2 x 0.16" unm screw	4
12.	S1.2-0.25	1.2 x 0.25" unm screw	4
13.	S0.8-0.16	0.8 x 0.16" unm screw	8
14.	ES-1	Eccentric Shuttle	40
15.	CSR-2	Compression Spring	40
16.	SS-2	0-80 x 1/16" set screw	8
17.	PIT-2	Polyimide Tubing	40

Actuator Mechanism, Electrode Preparation and Assembly

The SC32-1 utilizes a screw-driven mechanism to bi-directionally control electrode position along a single axis (Fig.3). Each actuator consists of a lead screw, an eccentric brass shuttle and a compression spring. The uninsulated end of each electrode is bonded to a shuttle using a conductive epoxy (Fig.5) and the electrode/shuttle assembly is loaded into the microdrive using a multistep sequence (Figs 6-11).

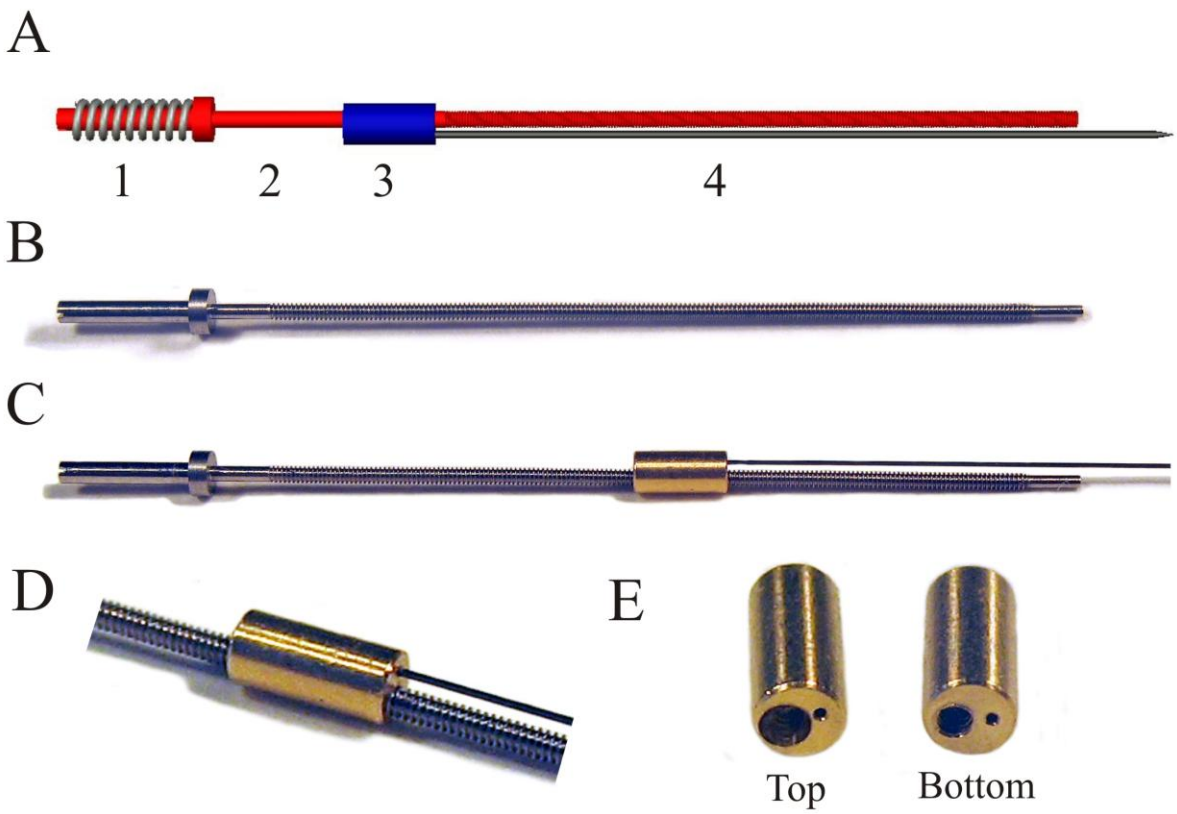


Figure 3. Actuator components. A. Design drawing of a fully assembled actuator as it would appear when loaded in the microdrive. 1-compression spring, 2-lead screw, 3-brass shuttle, 4-electrode. B. Photograph of the lead screw used in the 20 mm version of the drive. C. Photograph of the lead screw threaded through a shuttle containing a bonded electrode. D. Close-up view of the junction between the shuttle and lead screw. E. Top and bottom views of the brass shuttle. The uninsulated end of the electrode is mounted into the smaller of the two holes from the bottom end. The lead screw is loaded into the shuttle from the top end which contains a short portion without threads.

The electrodes used in the SC32-1 must be fabricated to a specific set of dimensions (Fig.4) and bonded to a small brass shuttle (Fig.5), which provides an electro-mechanical interface for controlling electrode movement and maintaining an electrical connection.

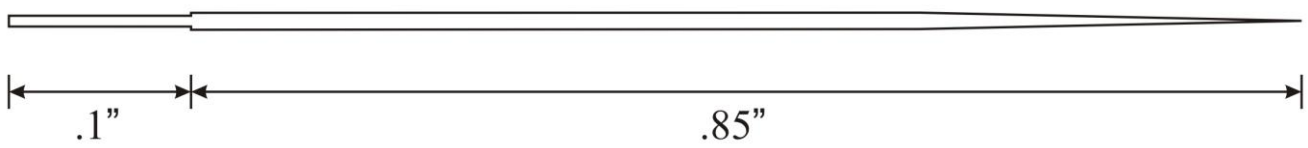


Figure 4. Dimensions of the electrodes used in the 20 mm version of the SC32-1. The uninsulated portion of the electrode is shown on the left. Wire diameter = 125 μm (.005″); Glass coated shank diameter = 250 μm (.01″).

Bonding Electrode and Shuttle

The bonding of a shuttle onto each electrode is accomplished using a conductive epoxy (Loctite 3880) (Fig.5). This provides a firm mechanical attachment and an electrical connection. Because of its small size, it is helpful to mount the shuttle into a fixture, such as a jeweler's vise or precision lathe collet mounted on a steady frame. Using a dissecting microscope, place a small amount of the epoxy on the uninsulated portion of the electrode and then insert this end of the electrode into the small opening on the bottom end of the shuttle. (Caution: *Do not use an excessive amount of the epoxy. This will cause a build up that may leak into the threaded opening for the lead screw and prevent smooth movement of the shuttle. Also, failure to mount the electrode onto the bottom side of the shuttle may prevent the loading of the lead screw.*) Once this is completed, the electrode/shuttle assembly must be heated to 125 degrees C for 10 minutes to cure the epoxy (*see spec sheet for 3880*). This can be done with a group of the assembled electrodes using a small temperature-controlled toaster oven.

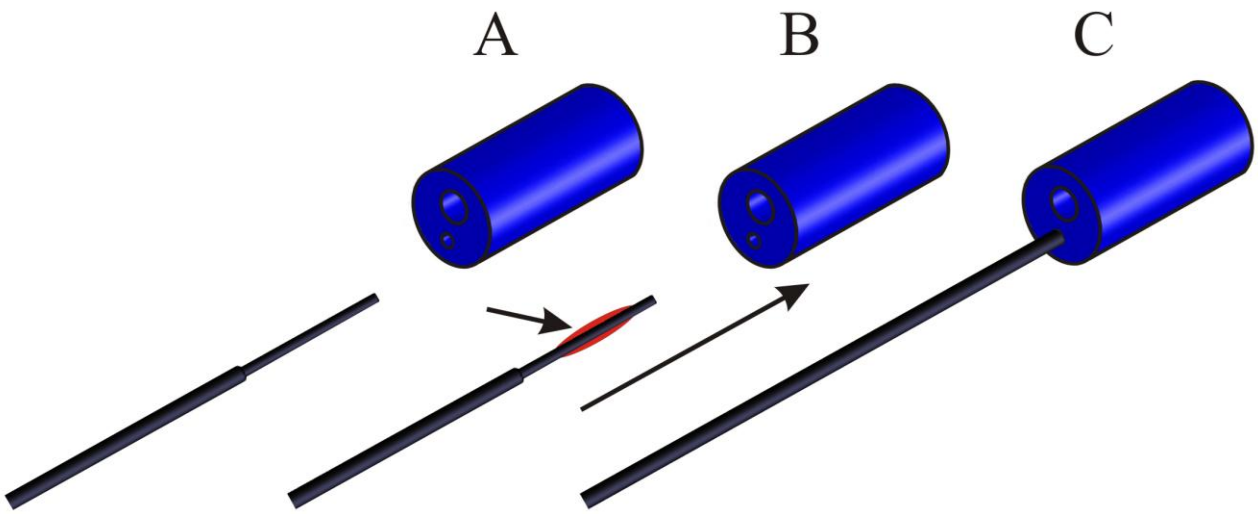


Figure 5. Bonding of an electrode into a shuttle. A. Schematic drawing of the bottom end of a shuttle facing the uninsulated end of an electrode. B. Application of a small amount of conductive epoxy onto the uninsulated portion of the electrode. C. Completed insertion of the electrode into the shuttle.

We strongly recommend that the process of bonding the electrode to the shuttle be practiced using superglue and electrode wire, rather than the conductive epoxy and finished electrodes. The epoxy is difficult to remove, especially when cured, and the finished electrodes are expensive. The parts are very small and mistakes are easily made.

Microdrive Assembly and Preparation

Loading the electrode/shuttle assemblies

Assembly of the microdrive follows a multi-step sequence, illustrated in the following pages. All operations should be performed while the actuator block is firmly mounted in the holder. All plastic and metal components should be cleaned in acetone, blown free of any particles, and the user should clean his/her hands to keep them free of skin oils. Prior to loading, each electrode should be checked under an operating microscope to make sure that the tip has not been damaged, and the impedance at 1 kHz checked using an appropriate meter.

The first step in the sequence is to mount the bottom portion of the plunger block onto the top portion (Fig.6). The fixation of these two parts uses four 0.8 unm machine screws. The threads on the screws are extremely fine and it is very important not to over-tighten the screws as this can easily damage the threads in the plunger block and prevent its future use.

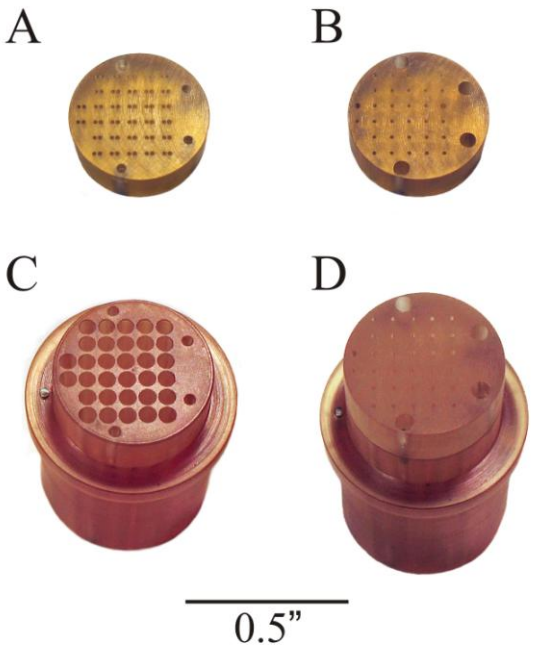


Figure 6. Plungerblock components and assembly. A,B. Bottom component of the plungerblock viewed from the top (A) and bottom (B). C. Top component of the plungerblock viewed from the bottom surface. D. Assembled plungerblock viewed from the bottom surface.

Once the plungerblock is assembled, it can be mounted into the holder and the polyimide tubing loaded into each actuator hole (Fig. 7). To facilitate this, the holder should be rotated so that the plungerblock is orientated horizontally. Each polyimide tube can be gently grasped with a fine pair of forceps and inserted into each hole from the bottom surface of the plungerblock. The tubing should be advanced until both ends are visible from the top and bottom of the plungerblock.

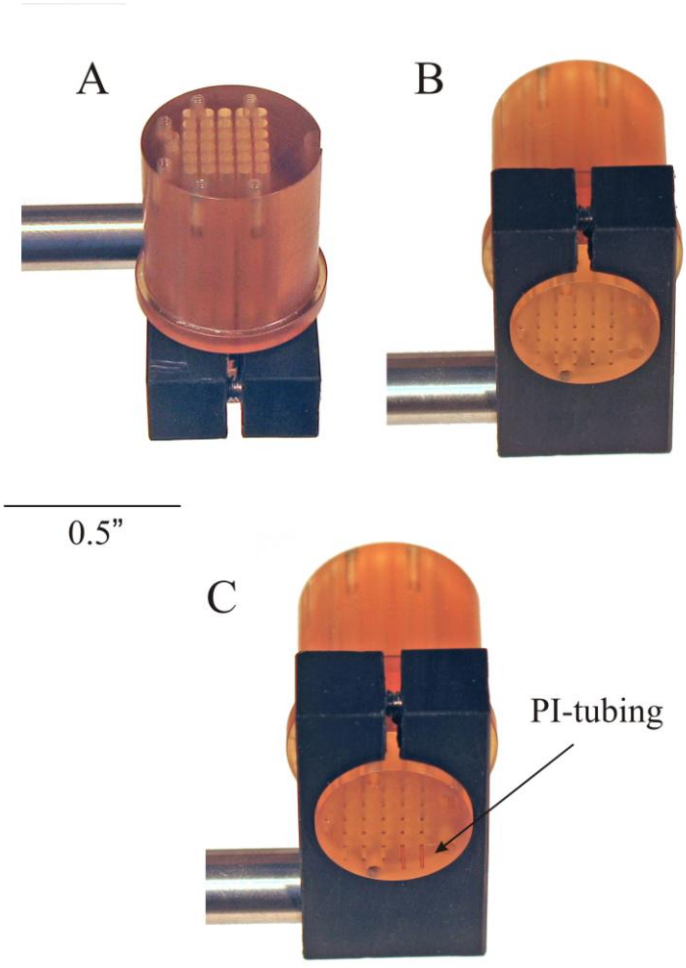


Figure 7. Mounting the plungerblock and loading the polyimide tubing. A. Assembled plungerblock mounted in the holder. B. Plungerblock viewed from the bottom surface after being rotated to a horizontal position. C. Two polyimide tubes mounted in the plungerblock.

Once the polyimide tubing is loaded into each actuator hole, the electrodes can be loaded into the microdrive. With the plungerblock in a horizontal orientation, and an operating microscope positioned over the opening in the top of each tube, the electrodes can be front loaded into each tube (Fig.8). The electrode/shuttle assembly should be advanced until the top of the shuttle is flush with the top surface of the plunger block. This is a delicate process, requiring a steady hand, considerable patience and a clear image through the microscope. (*It is important to avoid touching the tip of the microelectrode on the outside edge of the polyimide tubing, as this may damage the tip and impair its recording properties.*)

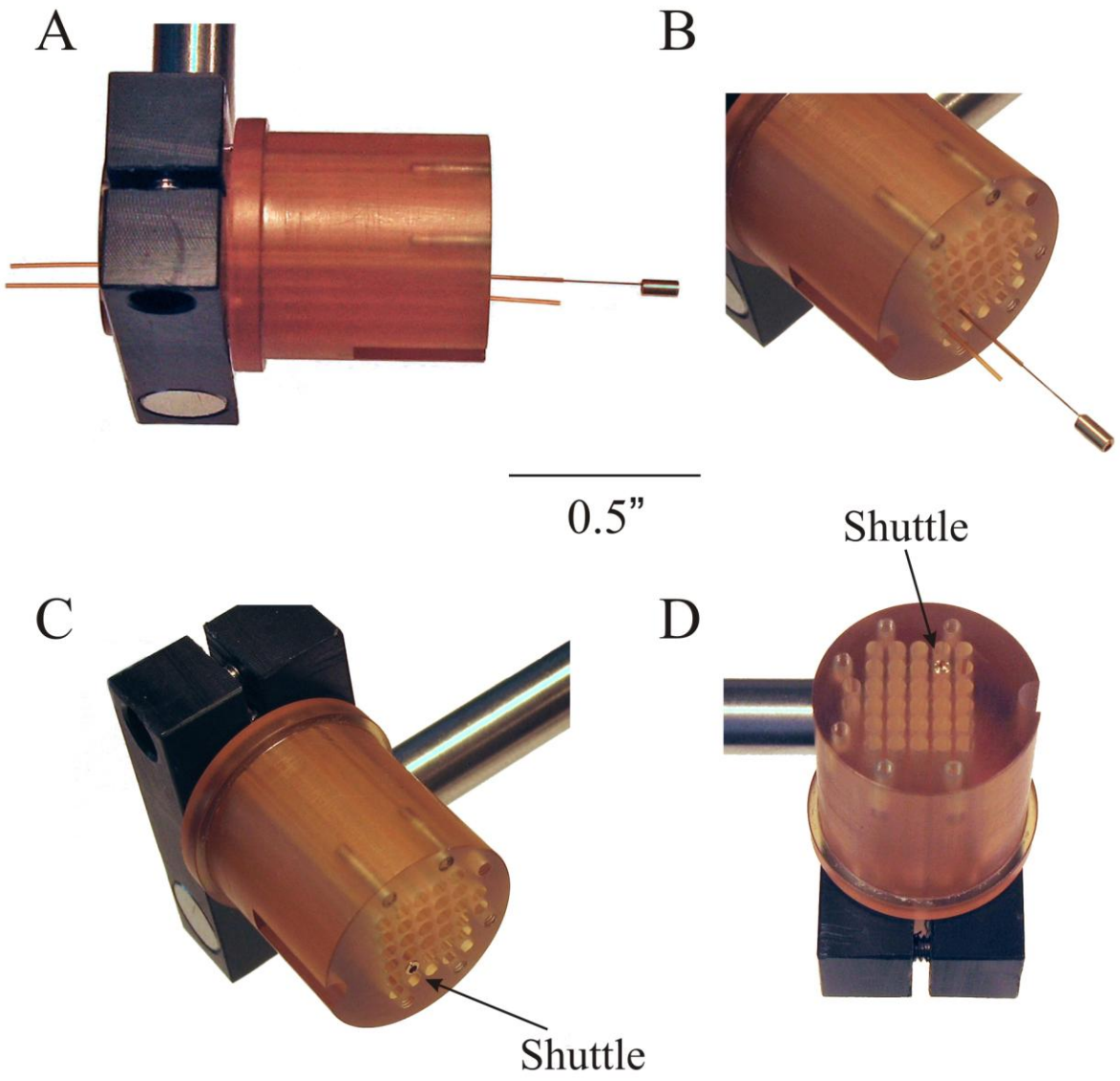


Figure 8. Loading electrodes into the plungerblock. A,B. Two views of an electrode/shuttle assembly advanced into one of the polyimide tubes. C,D. Two views of the top surface of the plungerblock after the electrode/shuttle assembly is loaded.

Once the loading of all 32 electrodes is completed, the plungerblock can once again be oriented vertically, and the retaining cap and printed circuit board mounted (Fig.9). (Caution: *At this stage it is very important that the plungerblock not be rotated beyond the horizontal orientation, as this may cause the electrode/shuttle assemblies to fall out and be damaged.*)

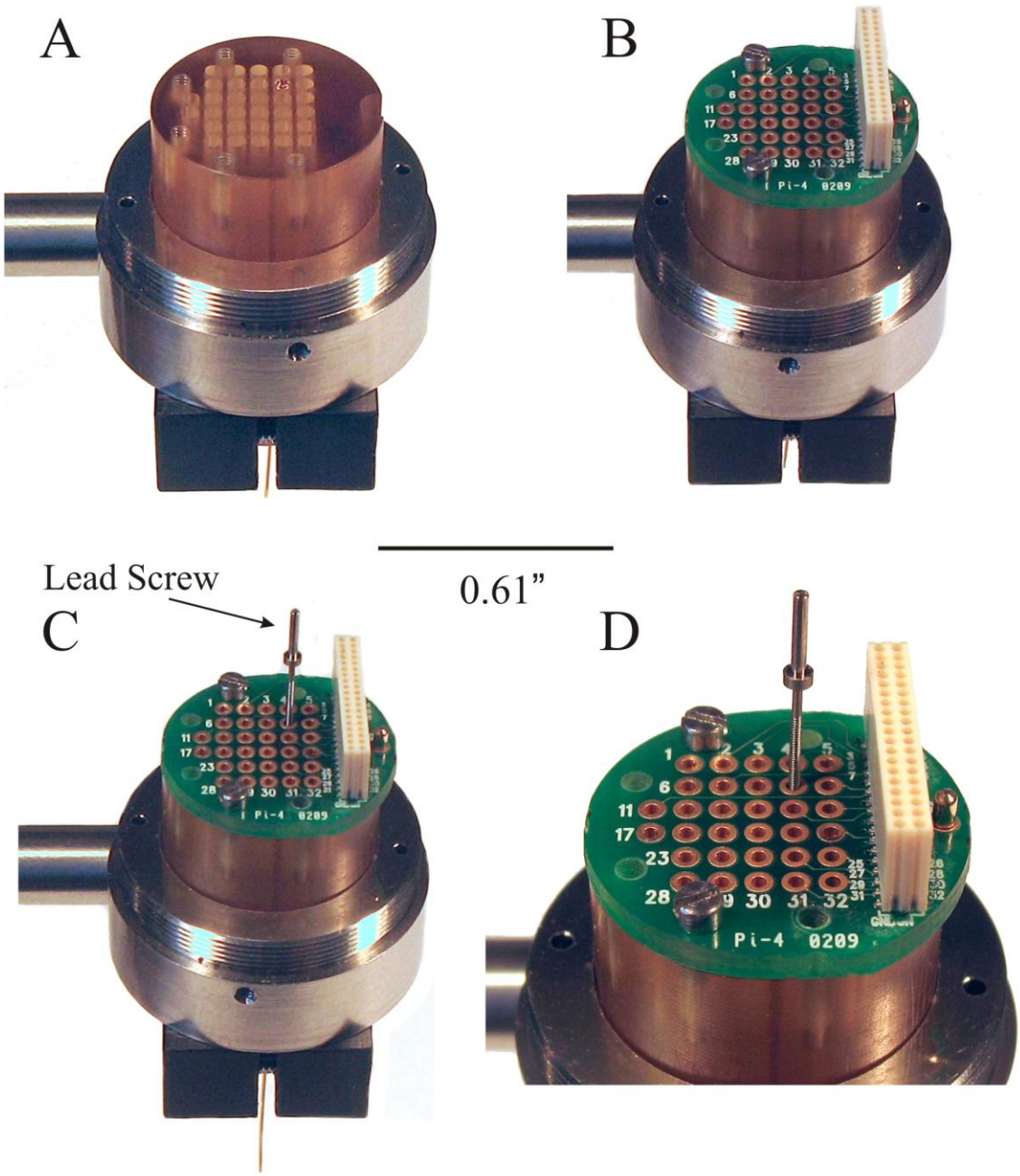


Figure 9. Loading the retaining cap, printed circuit board and lead screws. A. Retaining cap mounted over the plungerblock. B. PCB mounted onto the plungerblock and fixed in position with two 0.16" x 1.2 unm machine screws (*Note the position of these screws.*). C. A single lead screw loaded through the PCB. D. Close-up view of the image in C.

A critical step in loading the lead screws into the microdrive involves the threading of the end of the screw into the shuttle. This can be tricky and also requires patience, steady hands and care. The simplest way to do this is to load the lead screw into the hole in the PCB, slowly push down on the shuttle until it reaches the bottom of the actuator block and then rotate the screw clockwise by hand until the threads catch. When this occurs it will be possible to pull the lead screw up and observe the electrode, visible inside the polyimide tube, retract along with it. Continue rotating the lead screw clockwise so that the shuttle advances up the shaft of the screw by 5-6 mm. Then slowly advance the lead screw back down

into the plungerblock until the flange on the upper portion of the screw lies flush against the PCB. (Caution: *If the screw does not seat flush onto the PCB, do not try to force it. This occurs when the bottom tip of the screw is misaligned with the guide hole in the bottom section of the plungerblock. Simply retract the screw a few mm, and gently push it back down. Usually a few attempts will solve the problem.*) Continue this sequence until all 32 screws are seated flush against the PCB.

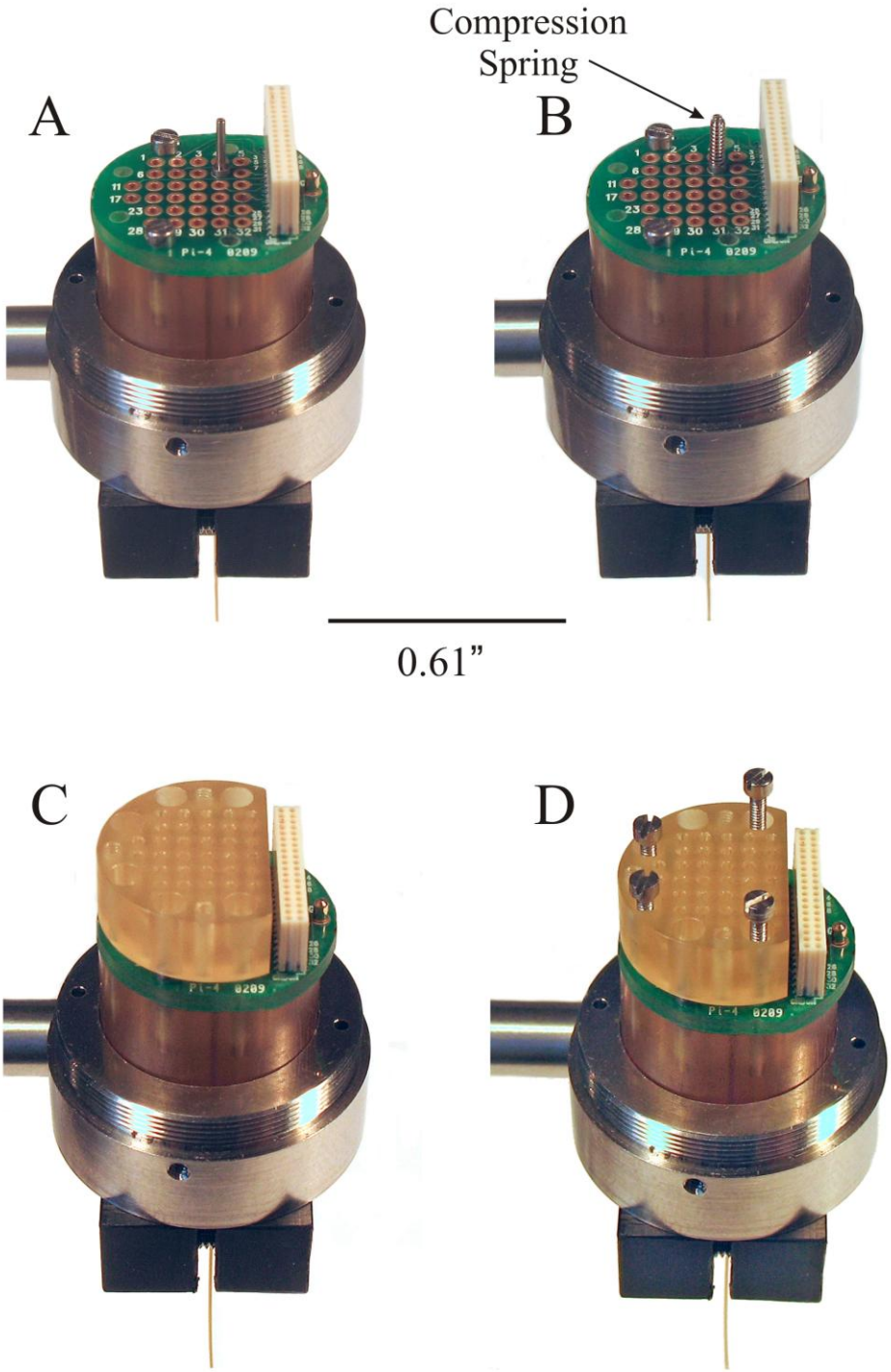


Figure 10. Loading the lead screws, compression springs and screw guide. A. A lead screw loaded flush against the top surface of the PCB. B. A compression spring is fitted over the top of the lead screw. C. The screw guide mounted over the lead screws and springs. D. Placement of the machine screws in the guide.

Once this sequence is completed, place a compression spring over each lead screw, gently mount the screw guide over the screws and springs, and insert the machine screws into the screw guide (Fig.10). It is important to maintain uniform pressure across the screw guide when securing it to the PCB and plunger block. This can be done by incrementally advancing the machine screws a turn or two at a time in sequence. If the screw guide becomes tilted at an angle it may damage the actuators and/or PCB.

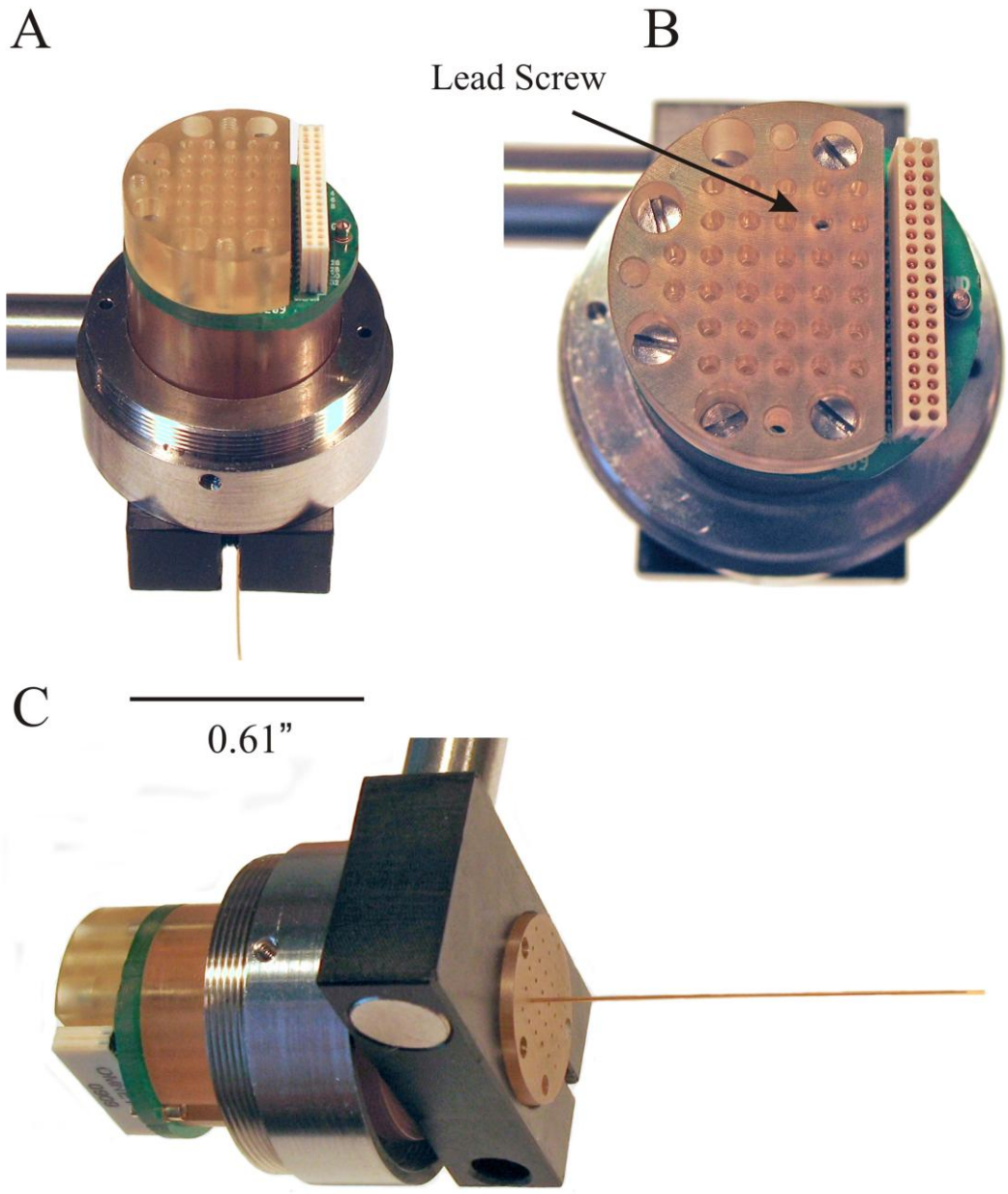


Figure 11. Completed assembly of the screw guide (A) with the top of the lead screw visible within the guide (B). At this stage of assembly, the electrode is visible within the polyimide tubing (C).

Once the screw guide is fixed in place, the top surface of the lead screws will be visible through the guide, and the electrodes will be visible within the polyimide tubing (Fig.11). At this point the electrodes can be partially retracted by clockwise rotation of the lead screws and the polyimide tubing removed using a pair of forceps. The electrode impedances can be tested to check their integrity, and then sterilized in a cold sterilizing solution. (Caution: *When doing these steps, it is important that the solutions not come into*

contact with the bottom of the plungerblock. If this happens, the solution will flow into the plungerblock by capillary action and interfere with or damage the actuators and their electrical connections.) Once the sterilization is complete, the electrodes should be soaked in sterile water and then gently blown dry. The electrodes can then be fully retracted into the microdrive. In order to calibrate the electrode starting positions, it is necessary to observe the point at which the electrode tip is flush with the bottom surface of the plungerblock. This is the starting position. Each electrode should then be retracted an additional 4 full turns of the lead screw to insure that the tips are protected prior to mounting the microdrive in the recording chamber.

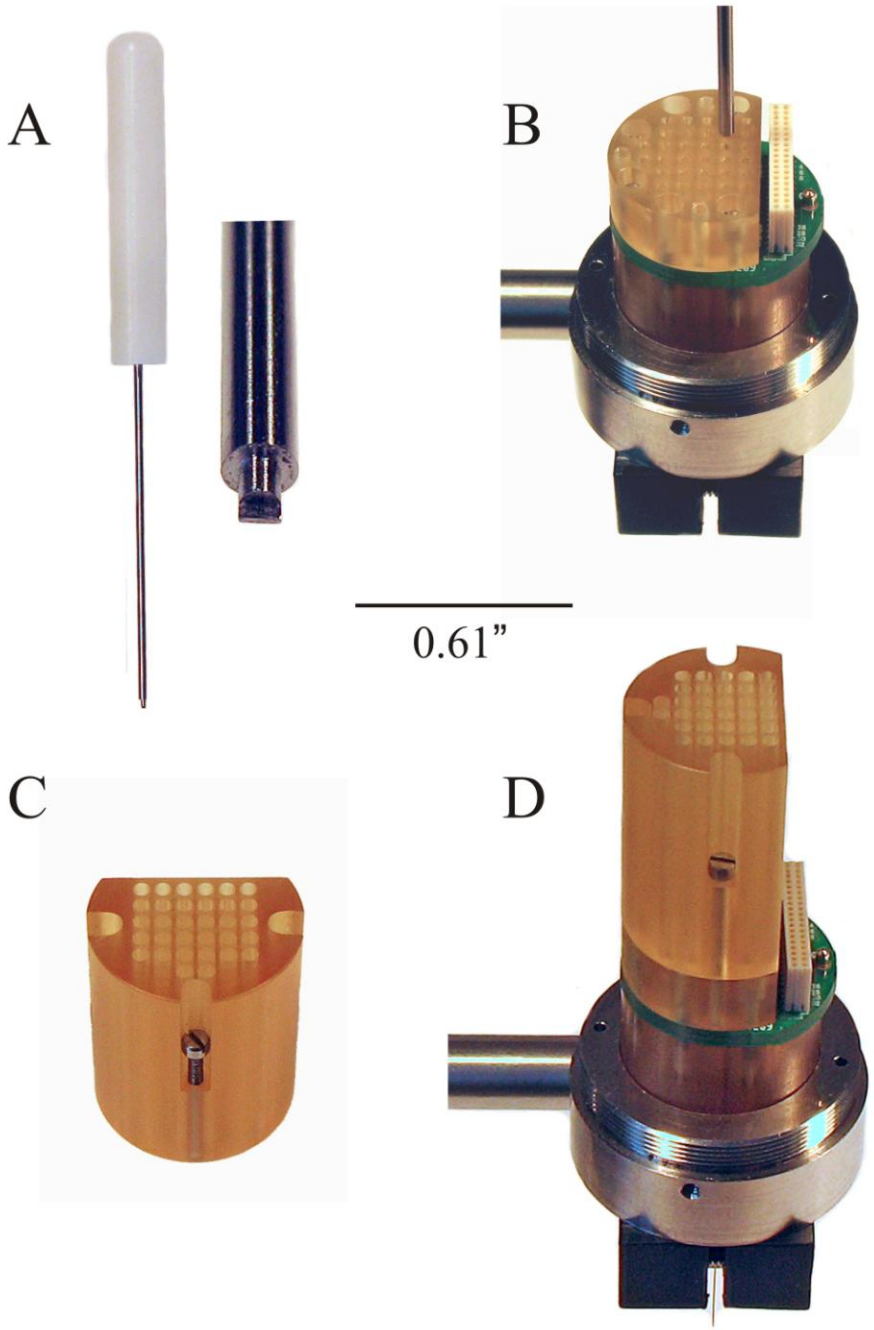


Figure 12. A. Photograph of the precision screw driver and close-up of the tip (right). B. Placement of the screw driver into the lead screw and screw guide. C,D. The secondary screw guide (C) and its placement onto the assembled microdrive (D).

Figure 12 illustrates the design of the screw driver and its placement onto the screw guide. It is important to note that the screw driver blade is quite delicate and can be easily broken if the screw driver is tilted off axis when rotating the screw. To help avoid this, a secondary screw guide is available (Fig.12C,D) that can be mounted onto the primary guide. This insures that the screw driver maintains a vertical alignment when advancing the electrodes.

Sterilizing and Sealing

A critical step in the preparation of the microdrive prior to implantation involves the sterilization of the electrodes and the sealing of the bottom surface to prevent fluids from traveling back into the guide holes of the plungerblock. Because the microdrive components are plastic and delicate and the electrodes are retracted within the actuator block, autoclaving, gas sterilization, or UV irradiation are impractical. Thus, for electrode sterilization we recommend back filling the guide holes with antibiotic ointment (*we recommend ophthalmic Bacitracin, Neomycin, Polymixin (BNP)*). This insures that the electrodes become sterilized before they are advanced into the tissue following implantation. To insure that cerebrospinal fluid does not seep into the guide holes and potentially disrupt the electrical signals or disturb the mechanical movements of the actuators, we recommend that the bottom surface of the actuator be coated with a fine layer of sterile bone wax. These procedures are illustrated in figure 13.

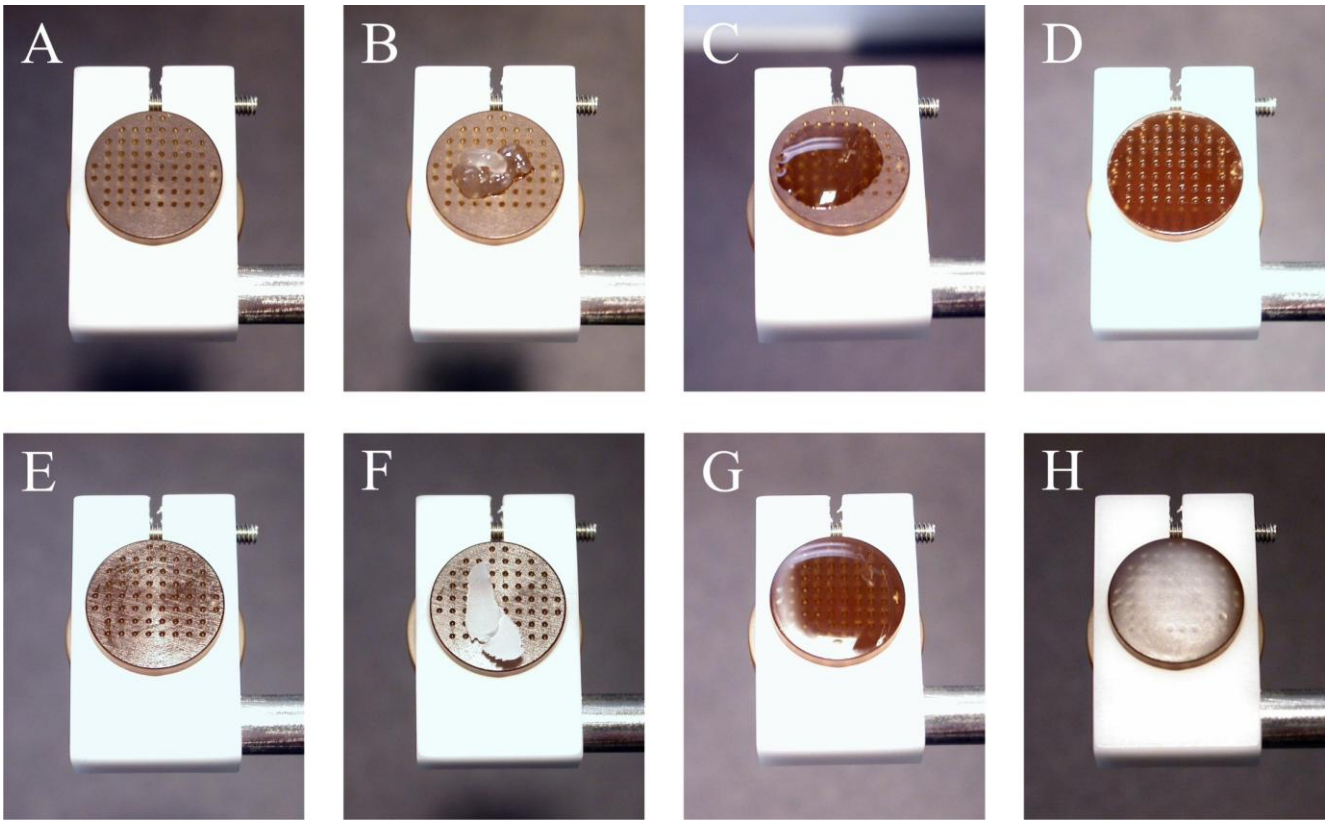


Figure 13. Sterilization and sealing of the microdrive. A) Once the loading is complete, the holder can be rotated so that the bottom surface is facing up. B) A small amount of BNP ointment can be placed on the bottom surface of the plungerblock. C,D) A small torch can be used to heat the ointment to its melting point so that it flows over the surface and into the guide holes. This step can be repeated. E) The excess ointment can be removed with a sterile Q-tip. Care should be taken to avoid getting any of the ointment on the sides of the actuator block. F) A small amount of sterile bone wax is placed on the bottom surface.

G) The wax is heated with the torch until it melts and flows over the surface. H) Once the flame is removed the wax will solidify and provide an even layer over the surface. The layer of solidified bone wax should not be more than approximately 0.5 mm thick. The microdrive is now ready to mount within the recording chamber implanted on the animal.

Mounting of the Microdrive

Once the animal is ready and the microdrive is fully loaded, tested and sealed, it can be mounted within the recording chamber. This procedure is simple and quick and can be done while the animal is awake and sitting in a primate chair with its head fixed. *We recommend that whenever the chamber cap and plug are removed all procedures be done using sterile technique within or around the chamber.* The procedure requires two people, one that maintains sterility and performs the procedures, and a second to assist.

1) Remove the protective cap and plug. Then repeatedly flush the interior of the chamber with a 50:50 mixture of sterile saline and Betadine solution. Complete the flush with a final rinse of sterile saline and remove any excess fluid with suction.
2) Load the microdrive into the chamber, being sure to align the centering pin on the microdrive with the corresponding hole on the top surface of the chamber sleeve.
3) Tighten the retaining cap firmly against the chamber. Then advance the set screws on the retaining cap until they make contact with the microdrive. Apply a small droplet of cyanoacrylate cement to each set screw to insure that they do not loosen.
4) Mount the protective cap and secure tightly.
5) Further protection of the microdrive, from the effects of any impacts that might occur in the animal's home cage, can be achieved by building up an additional layer of acrylic cement around the outer wall of the retaining cap. Because the acrylic cement can be difficult to remove when it is necessary to dismount the microdrive, we recommend sealing the set screw holes with bone wax and covering the outer surface of the retaining cap with a thin layer of lubricating oil. This will prevent the acrylic cement from bonding directly to the retaining cap.
6) Mount the ground wire into the female pins located on the underside of the PCB and top of the retaining cap.

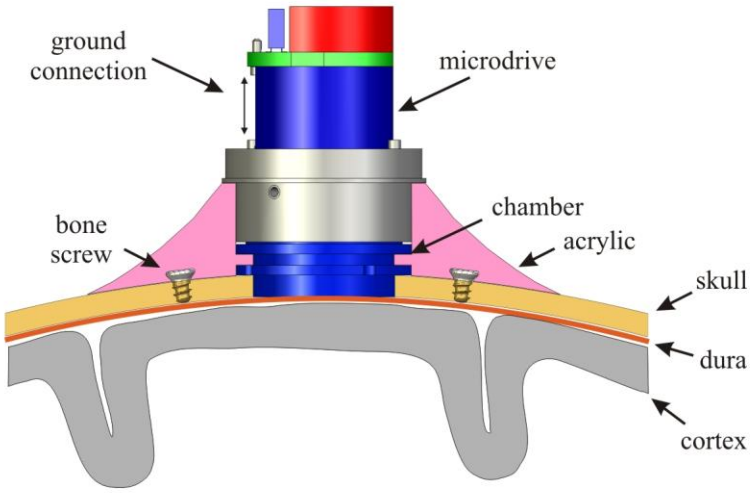


Figure 14. Diagram illustrating the placement of the chamber, microdrive and retaining cap relative to the cranial bone. The acrylic cement (pink) can be built up around the retaining cap to provide a secure implant that is resistant to impact.

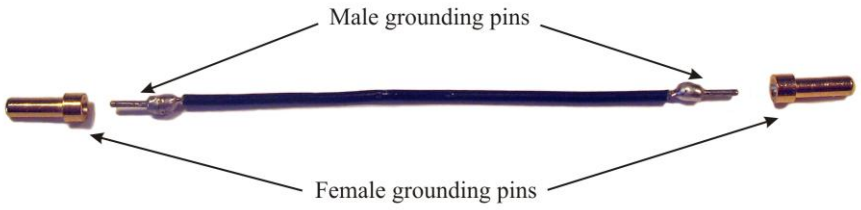


Figure 15. The ground cable is made by soldering the male grounding pins to each end of a short segment of hookup wire. The female grounding pins are mounted in the top of the retaining cap and the PCB, respectively.

Advancing the Electrodes and Recording Neuronal Activity

Advancing the electrodes is a simple procedure that is done while the animal is awake and sitting in a primate chair with its head restrained.

1) Remove the protective cap and make the connection between the amplifier head stage and the connector on the PCB of the microdrive.

2) While listening to the output of the recording amplifier, slowly advance one of the actuators about 1 turn at a time until electrical contact between the electrode and the surface of the dura is made. This point represents the zero position of that actuator. Care should be taken at this point to maintain a record of the number of turns, as this will provide information on the depth of the electrode.

3) Continue advancing the actuator ½ to 1 turn at a time until the discharge of extracellular spike activity can be detected. Note the position of the actuator (i.e. # of turns) at this point.

4) Choose a second actuator location and repeat the steps above, continuing this process at the desired rate. We find that it is possible to advance 8-10 electrodes on a given day. Therefore it should take several days to advance all of the electrodes into the surface of the brain. This procedure can be done more rapidly, but we believe that proceeding too fast could lead to excessive dimpling of the tissue and possible damage.

Specifications

Number of channels	- 32
Electrode travel distance	- 20 mm
Inter-electrode spacing	- 1.5 mm
Weight (fully assembled)	- xx g
Lead screw thread pitch	- 8 threads/mm