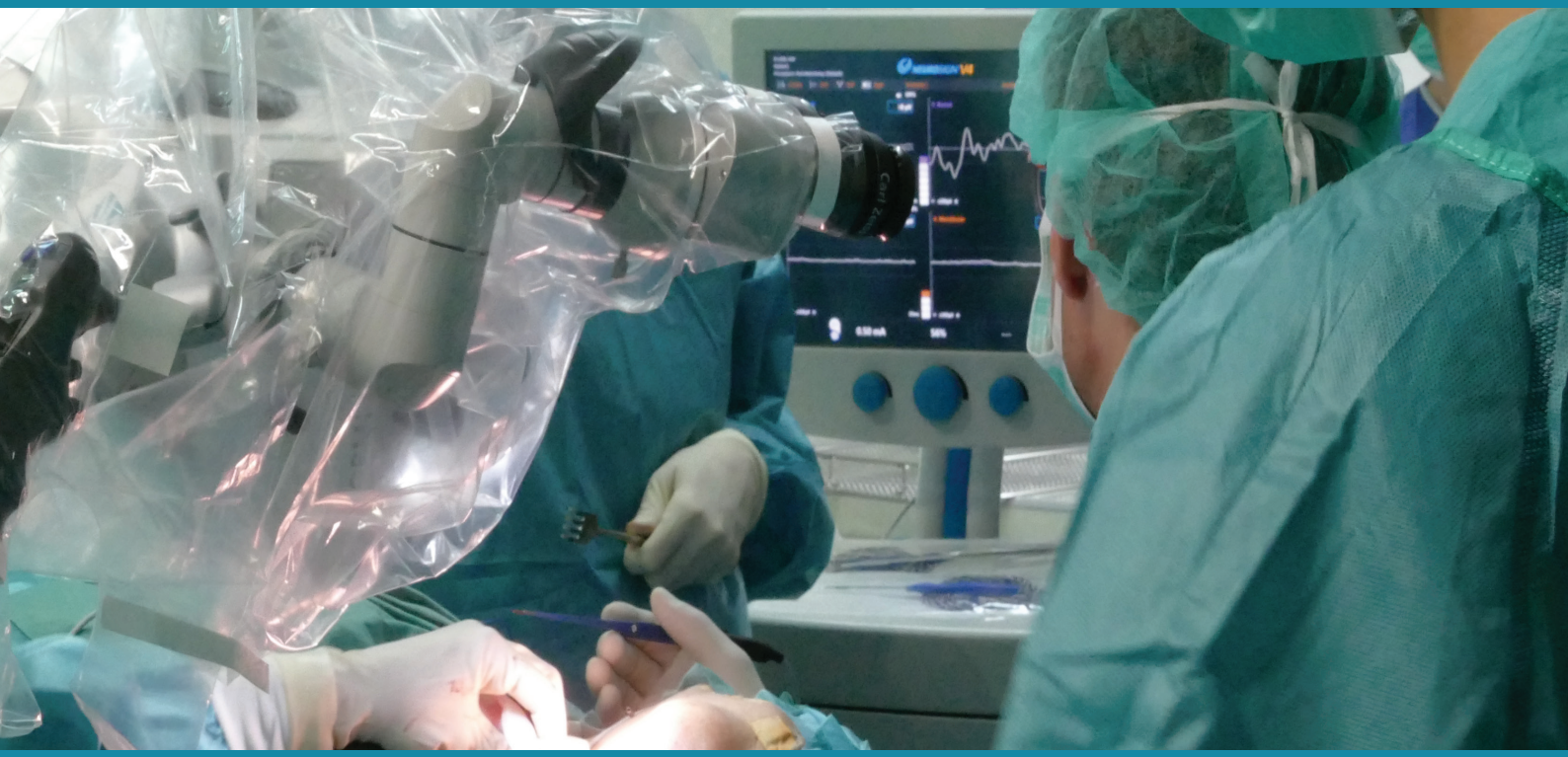
NEUROSIGN®

PROCEDURE ADVICE SHEETS

For Neurosign® V4 4 or 8 Channel Intraoperative Nerve Monitors




NEUROSIGN® V4

IMPORTANT

This document is relevant to the Neurosign® V4 - 4 & 8 Channel Intraoperative Nerve Monitors, herein known as the 'nerve monitors'. These procedure sheets are intended as general information for Operating Theatre / OR personnel. They are not intended as specific guides to surgeons or anesthetists, although some of the information may be useful. The information has been obtained from the observation of several thousand procedures using the Neurosign monitors but is not definitive and should not over-ride normal surgical decision-making. All settings mentioned for the various procedures are suggested settings. Clinical judgement is recommended to determine if adjustment is needed before applying the settings to an individual patient. Improvements to the Neurosign® V4 Intraoperative Nerve Monitor and the clinical information available are under continual review.

The information contained within this document is accurate at time of publication. We reserve the right to make alterations without prior notice.

CONTENTS

AUTHOR BIOGRAPHY

Chris Hovey has worked with Neurosign® for almost 30 years, first as an engineer to design the Neurosign® 100, then working in theatre to establish its clinical use. Using this experience, Chris Hovey then laid down the specifications for the Neurosign® 400 and 800, taking the monitors into new areas of surgery in the spine and cranium.

Neurosign® was the world's first 4 and 8 channel motor nerve monitor: the first to introduce disposable stimulating probes; the first to design and introduce an electrode to be used with an endotracheal tube for monitoring thyroid procedures, and the first to promote the technique of spinal nerve root monitoring using a commercial machine.

Chris Hovey also laid down the specifications for the Neurosign® V4, replacing the older generation of equipment. Brought up to date, the Neurosign® V4 uses the most modern electronics and software to deliver ground-breaking performance in the field of nerve monitoring.

For 20 years Chris Hovey has been providing a full intraoperative monitoring service to 2 hospitals in their Neurosurgery department, monitoring cranial nerves, spinal tumors and spinal nerve roots in a variety of complex surgeries. Chris Hovey also belonged and has presented to Neuromonitoring UK, a professional society for the advancement of neuromonitoring in the UK, which holds academic meetings several times a year.

REVIEWER 4 CHANNEL

The Procedure Advice Sheets - 4 Channel part (chapter 3-11) has been reviewed by:

Dr. Sam van Slycke.

General & Endocrine Surgeon OLV Hospital, Aalst (Belgium).

March 30, 2019

REVIEWER 8 CHANNEL

The Procedure Advice Sheets - 8 Channel part (chapter 12-18) has been reviewed by:

Dr.

1. DISTRIBUTION OF THE FACIAL & TRIGEMINAL NERVES

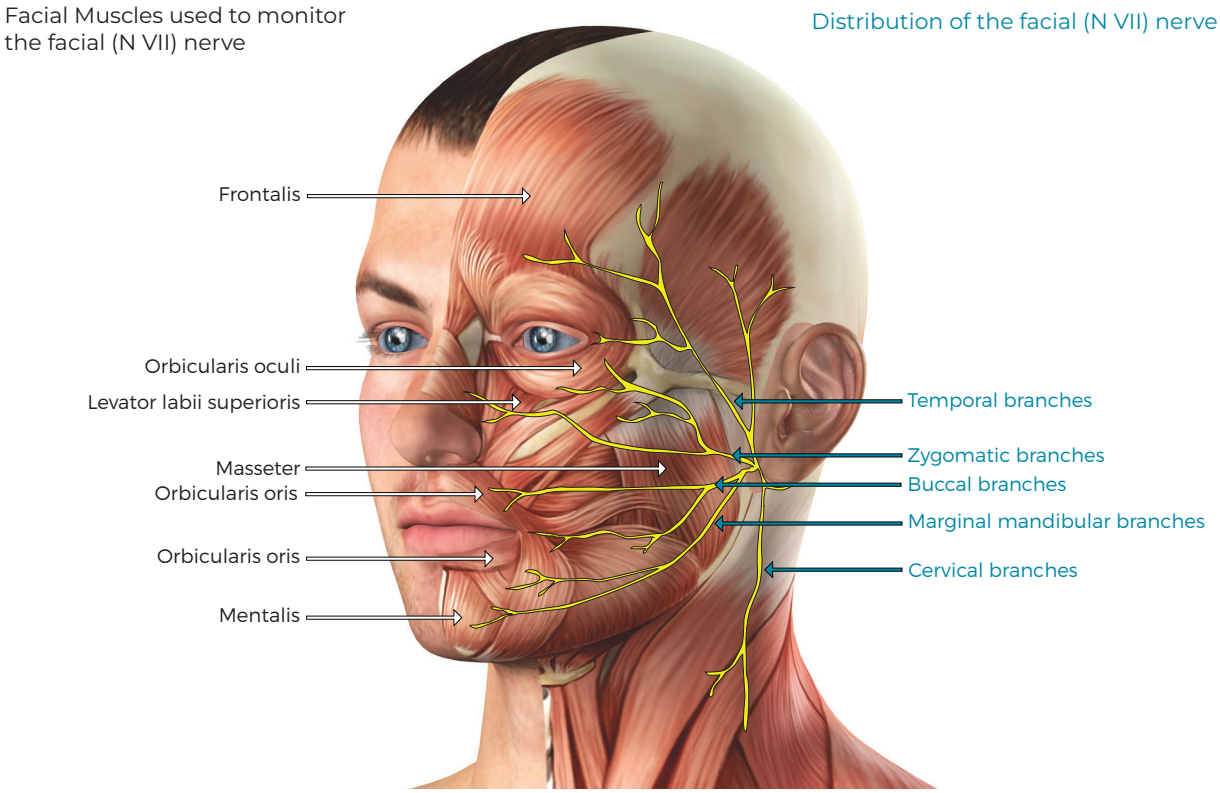


Figure 1.1: Distribution of the facial nerve (VII) and the muscles used during monitoring.

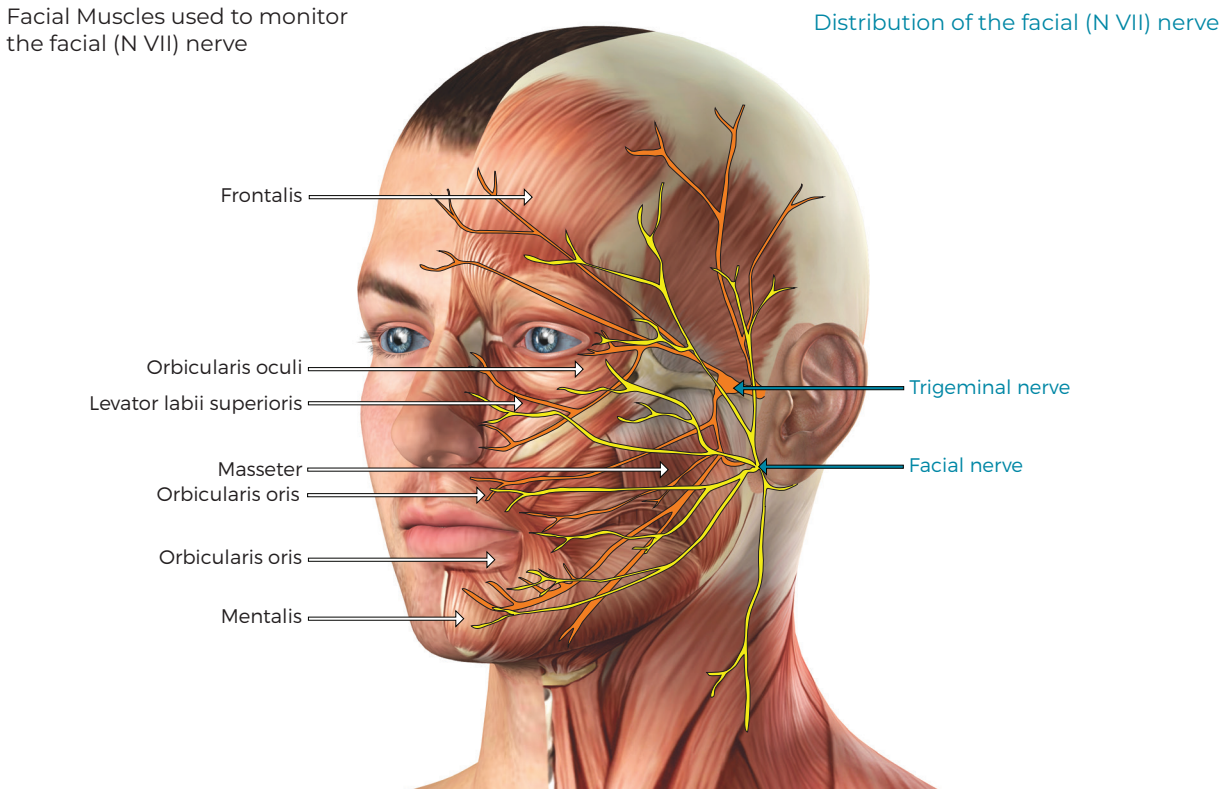


Figure 1.2: The trigeminal nerve in relation to the facial nerve and the muscles used during monitoring.

2. DISTRIBUTION OF THE SPINAL NERVES

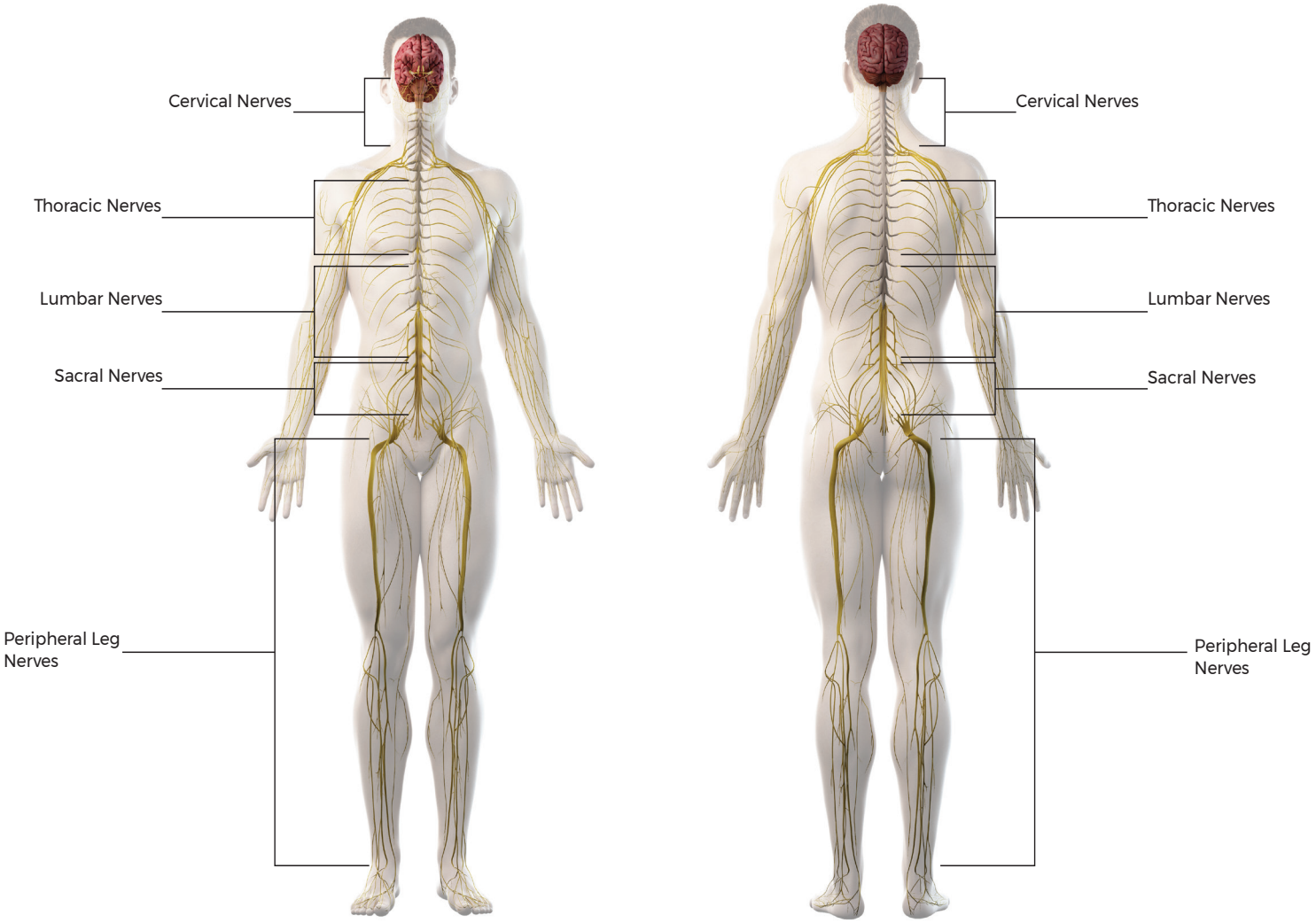


Figure 2.1: The spinal nerves

CRANIAL NERVES

3. SURGERY OF THE PAROTID GLAND

Suggested Probe: Concentric Probe 1mm, PN: 3600-00-TE
Suggested Electrodes: 4 Channel Electrode Set, PN 4470-00

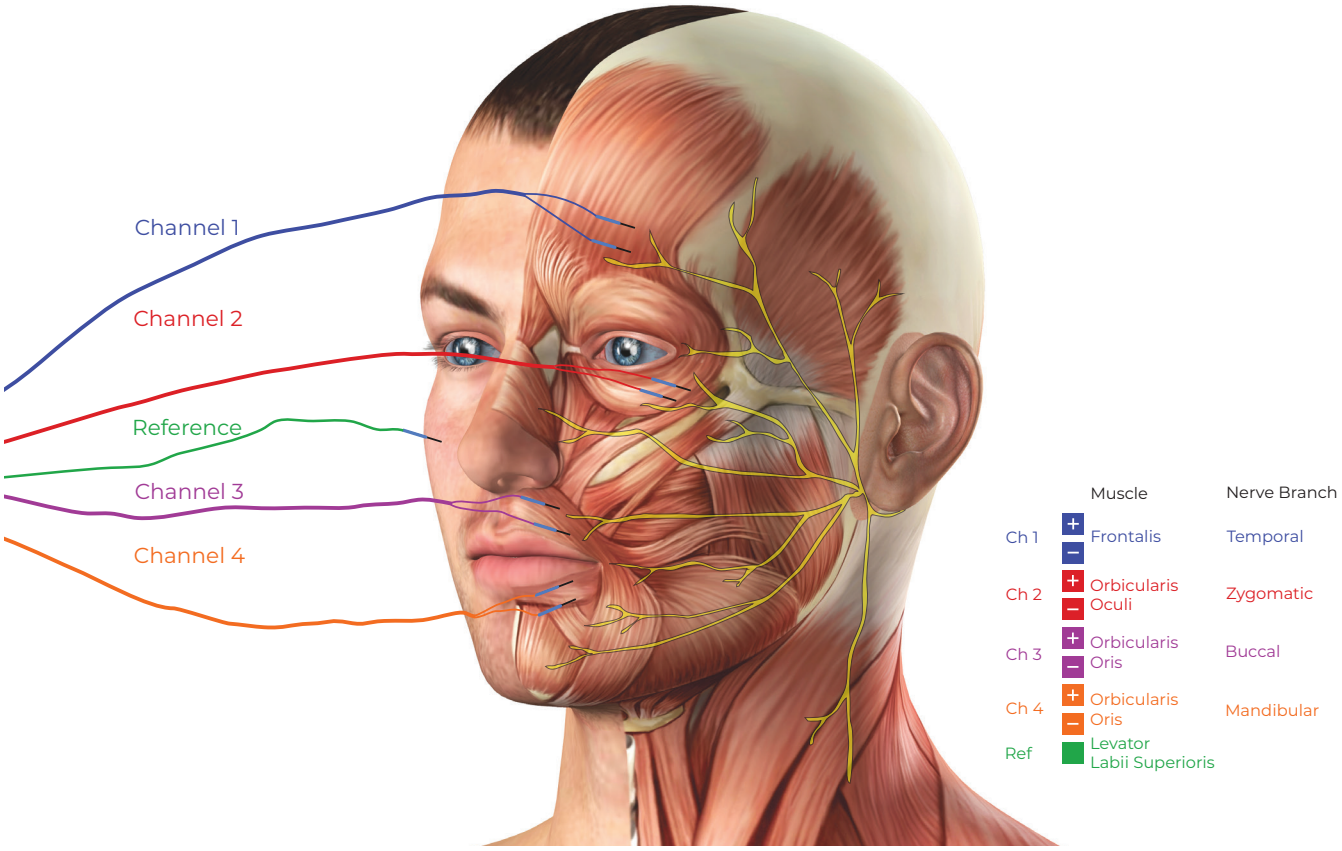


Figure 3.1: Suggested electrode placement during surgery of the parotid gland.

SURGICAL PROCEDURE INFORMATION

The surgery is generally a superficial parotidectomy, where the tumor lies on top of the facial nerve. The tumor, together with a margin of healthy tissue, is removed leaving the facial nerve lying on top of the remaining gland.

Occasionally, the tumor extends below the facial nerve; this is termed a deep-lobe parotidectomy. The facial nerve needs to be mobilized so that the tumor can be removed from above and below the nerve. This is technically more difficult, and the facial nerve is at greater risk.

The general method of locating the facial nerve is to follow the digastric muscle to the stylomastoid foramen, and locate the pes anserinus, the point at which the nerve trunk divides, and then to follow the branches until space has been created to provide sufficient access.

Use the Concentric Probe, with the stimulator current set to 0.5mA, to locate the nerve trunk; once located, reduce the current to 0.3mA and ultimately to 0.2mA once the branches are identified.

Note:
As the Neurosign® V4 Intraoperative Nerve Monitor has 4 or 8 channels, each of the 4 major branches of the facial nerve can be monitored individually. Whilst 2 channels may be used to monitor the facial nerve, using 4 channels is more reliable as it is much less likely that a stimulus will contract a muscle in an area of the face without a Subdermal Needle Electrode inserted.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 1.1 (page 1) and observe where the facial nerve lies in relation to the muscles used to monitor the various branches.
2. Insert each pair of Subdermal Needle Electrodes into the appropriate muscles indicated in Figure 3.1 (page 4), with the wires leading away from the surgical site. Ensure that the needles of each electrode are inserted adequately into the muscle and not simply under the skin.
3. Secure the Subdermal Needle Electrodes with tape.
4. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
5. Plug the Subdermal Needle Electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
6. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
7. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
8. Begin monitoring the procedure and set up a patient report (if applicable).
9. Set the stimulator current to 0.5mA (using the left stimulator control dial). This current setting is used to locate the nerve at its trunk near the stylomastoid foramen.
10. Once the relevant nerve is located, the current can be reduced to a minimum of 0.2mA.

Note:
The use of a Concentric Probe 1mm (PN 3600-00-TE) is recommended. It is very accurate, does not stimulate through tissue, and is excellent for stimulating the small interconnecting fibres between the nerve branches.

Note:
As an option, you may wish to use the Monopolar Stimulating Dissectors PN: 4013-00. Place the blue cable from the Stimulating Dissectors into the blue socket of the Stimulator-Pod. Insert the white stimulator return needle in the trapezius muscle, where the neck joins the shoulder and then connect the reference needle to the white socket of the Stimulator - Pod. You will need to adjust the SAR settings as you are now using monopolar. To do this, go to the Neurosign V4 UI and select the following: Procedure Settings – Select Filter Settings tab – Adjust the Stimulator Artefact Rejection (SAR) to 3ms.

4. SURGERY OF THE THYROID & PARATHYROID

Suggested Probe: Standard Bipolar Probe 0.75mm, PN: 3601-00-TE
Suggested Electrode: Lantern Laryngeal Electrode (LLE), PN: 4200-00 or 4201-00
Suggested Cable: Reuseable Connection Cable, PN: 4203-NM

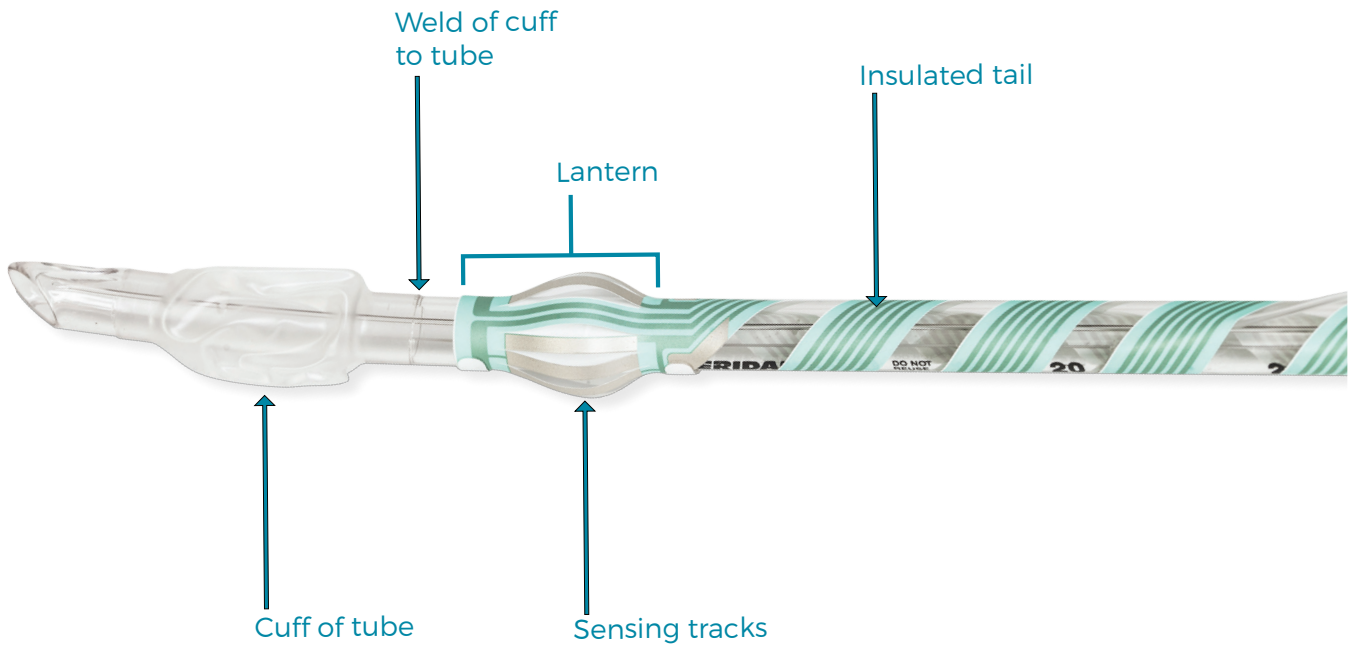


Figure 4.1: Lantern Laryngeal Electrode placement on the endotracheal tube.

SURGICAL PROCEDURE INFORMATION

Thyroid surgery carries a small risk (1-3%) of permanent injury to the Recurrent Laryngeal Nerves (RLN) which control the vocal cords. Damage to these nerves may lead to hoarseness, difficulty with speech, swallowing and a compromise of the airway. More frequently a subtle change to the voice timbre may occur, which can be serious for those using their voices professionally.

Because of the nature of the Lantern Laryngeal Electrode and the manipulation of the larynx during the surgery, movement artefacts are common. The purpose of monitoring the larynx is to locate the RLN with the use of the stimulating probe. Once identified, the surgeon can avoid the RLN.

The nerve is usually identified at Berry's ligament or in the esophagotracheal groove.

The RLN appears to behave differently from the facial nerve in that it has a distinct threshold below which it will not stimulate. It is recommended that the stimulator current be set at 2.0mA as the RLN threshold varies and can be as high as 1.5mA.

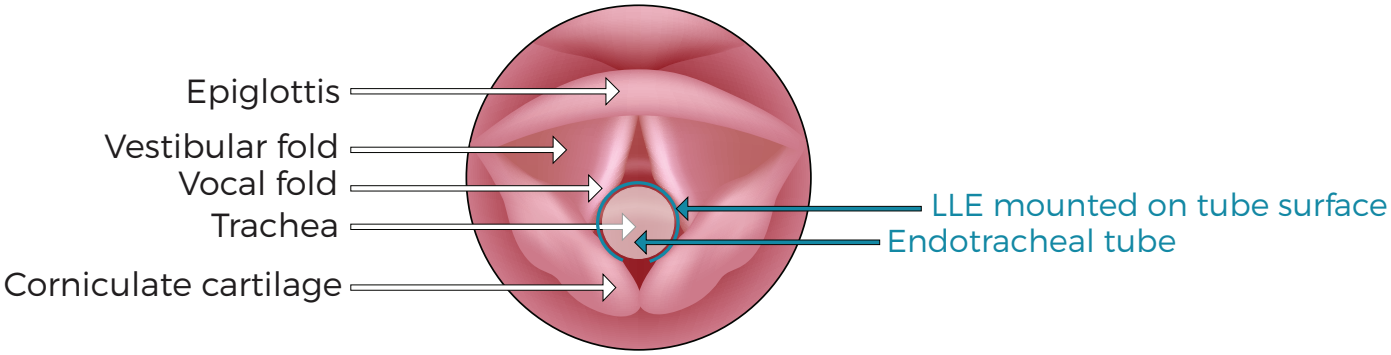


Figure 4.2: View of the Larynx after intubation with the LLE attached.

NERVE MONITORING - THE PROCEDURE

1. Select the correct size of LLE, according to the endotracheal tube size used.
2. Do not grease the tube until the LLE is attached.
3. Attach the LLE to the endotracheal tube according to the instructions for use provided. If the edge of the lantern (Figure 4.1, page 6) is placed 2-3mm from the weld of cuff to tube, the black lines on some tubes will remain visible.
4. Intubate as normal, move the patient onto the operating table, then confirm that the LLE is still located between the vocal cords with the patient's neck extended and at their final resting position (Figure 4.2, above). If the LLE is correctly placed on the endotracheal tube, the tube should be approximately 19cm at the teeth in women, 20cm in men (allow for patient variation).

   Note:
   Connect the LLE to the Reusable Connection Cable PN: 4203-00 (for Neurosign N100 nerve monitor) or 4203-NM (for Neurosign V4 nerve monitor).
5. Plug the Subdermal Needle Electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.

   Note:
   If using cable PN: 4203-00, connect the yellow wires into the Neurosign® V4 4 or 8 Channel pre-amplifier channel 1, and the blue wires into the pre-amplifier channel 2.
6. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and select Thyroidectomy in the procedure list (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
7. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.

Step 8-9 continued on next page.

NERVE MONITORING - THE PROCEDURE

8. Begin monitoring the procedure and set up a patient report (if applicable).
9. Set the stimulator current to 2.0mA (using the left stimulator control dial). It should not be necessary to change the current.

Note:
The use of a Bipolar Probe 0.75mm (PN 3601-00-TE) is recommended.

As an option, you may wish to use the Monopolar Stimulating Dissectors PN: 4013-00. Place the blue cable from the Stimulating Dissectors into the blue socket of the Stimulator-Pod. Insert the white stimulator return needle in the sternum and then connect the reference needle to the white socket of the Stimulator - Pod. You will need to adjust the SAR settings as you are now using monopolar. To do this, go to the Neurosign V4 UI and select the following: Procedure Settings – Select Filter Settings tab – Adjust the Stimulator Artefact Rejection (SAR) to 3ms.

5. SURGERY INVOLVING THE MASTOID PROCESS

Suggested Probe: Precision Bipolar Probe, PN: 3604-00-TE
Suggested Subdermal Electrodes: 2 Channel Electrode Set, PN 4469-00

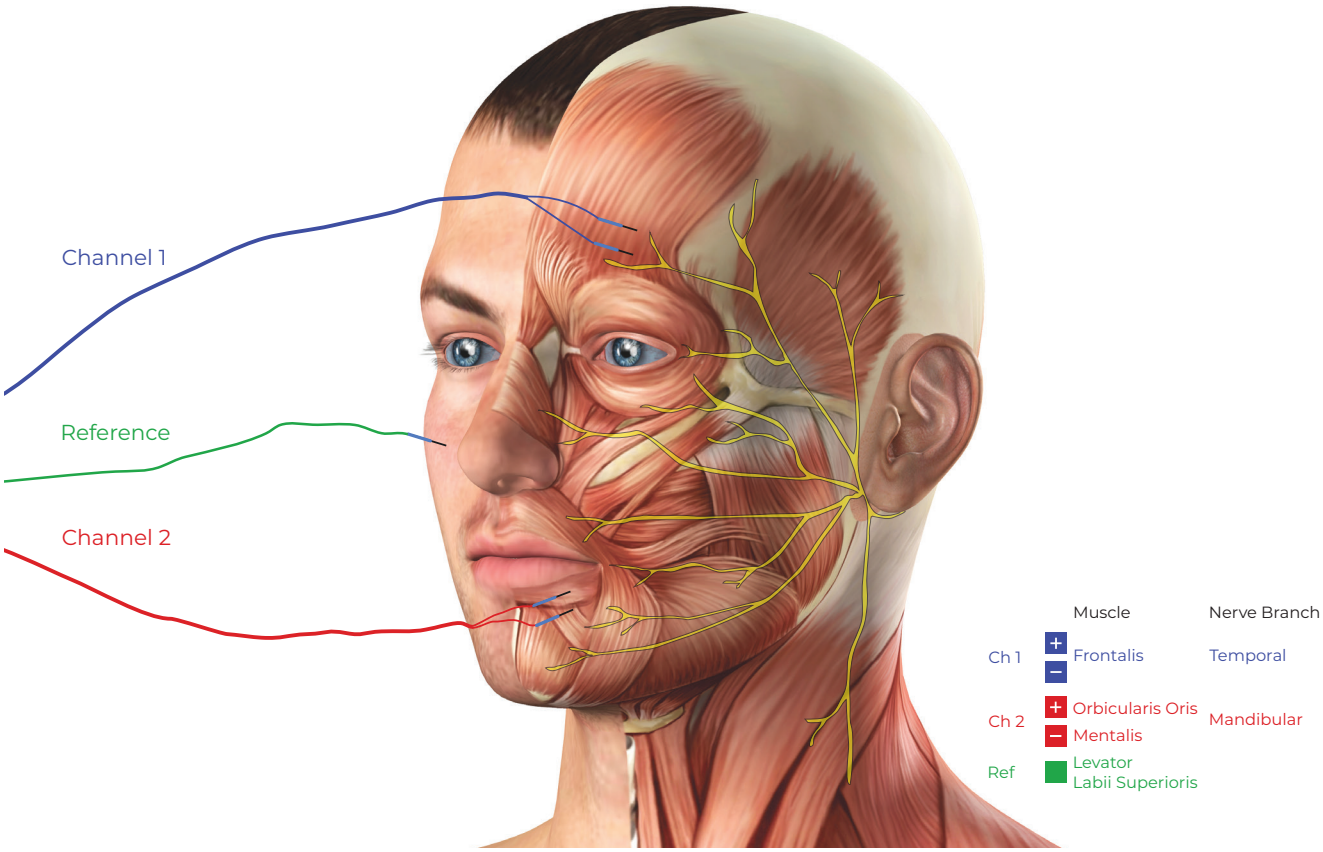


Figure 5.1: Suggested electrode placement during surgery involving the mastoid process.

SURGICAL PROCEDURE INFORMATION

The mastoid process is a section of the skull behind the ear which resembles a sponge in structure, being full of cavities. These cavities may become infected and diseased leading to destruction of the bone, in particular the incus, malleus and stapes. The surgical technique required is to drill away the bone until fresh, clean bone is exposed, then to seal the cavities to prevent air-borne infection from other tissue. At the same time, prostheses may be fitted to improve hearing and replace the missing or destroyed ossicular chain.

The facial nerve runs within a canal on the edge of the mastoid process. It is important that the surgeon does not drill through the canal and the nerve. Sometimes disease may have attacked the canal and the nerve is dehiscent - then the canal will need to be accessed in order to clear out diseased tissue within it.

Vibration from the drilling is often heard and can serve as an early warning that the nerve is nearby. A high-pitched whining indicates that either the nerve is affected by the drilling, or that the frontalis electrodes are touching bone and picking up the vibration. Check the bargraphs or waveform, equal amplitude indicates that the nerve is being affected, whereas signals only from channel 1 indicate vibration transferred by the bone and can be ignored. If the response continues once the drill has stopped, this is an indication of heating of the nerve and irrigation must be used to cool both the nerve and the drill.

The nerve is often left within the canal and so the Neurosign® V4 Intraoperative Nerve Monitor may not appear to be particularly useful. However, it is a guard against a small but catastrophic risk.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 1.1 (page 1) and observe where the facial nerve lies in relation to the muscles used to monitor the various branches.
2. Insert each pair of Subdermal Needle Electrodes into the appropriate muscles indicated in Figure 5.1 (page 9), with the wires leading away from the surgical site. Ensure that the needles of each electrode are inserted adequately into the muscle and not simply under the skin.
3. Secure the Subdermal Needle Electrodes with tape.
4. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
5. Plug the Subdermal Needle Electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
6. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and select Mastoid procedure from the procedure list (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
7. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
8. Begin monitoring the procedure and set up a patient report (if applicable).
9. Set the stimulator current to 0.5mA (using the left stimulator control dial).

Note:
A higher current may be necessary because the surgeon will be stimulating through bone; 0.5mA is a safe value to start. If there is no response at 0.5mA, increase the current until a response is heard. If the anatomy is normal, it may require 5.0mA to stimulate through the bone. If the nerve is dehiscent, only 0.2mA will be necessary - hence the starting value of 0.5mA.

The use of a Precision Bipolar Probe 0.75mm (PN 3604-00-TE) is recommended for accuracy. The blue tip of the Precision Bipolar Probe is the stimulator, the white tip is the return. Stimulate with the blue tip over the nerve or on overlying bone. The white tip must also make contact with the bone to act as the return. The Precision Bipolar Probe can give an indication of depth of bone between the Precision Bipolar Probe and nerve. Bearing in mind that stimulation at 0.2mA represents exposed nerve, and 5mA denotes normal anatomy, as the drill is used the stimulation current can be reduced and early warning given when there is very little bone remaining.

6. SURGERY OF THE MIDDLE EAR

Suggested Probe: Precision Bipolar Probe, PN: 3604-00-TE
Suggested Subdermal Electrodes: 2 Channel Electrode Set, PN 4469-00

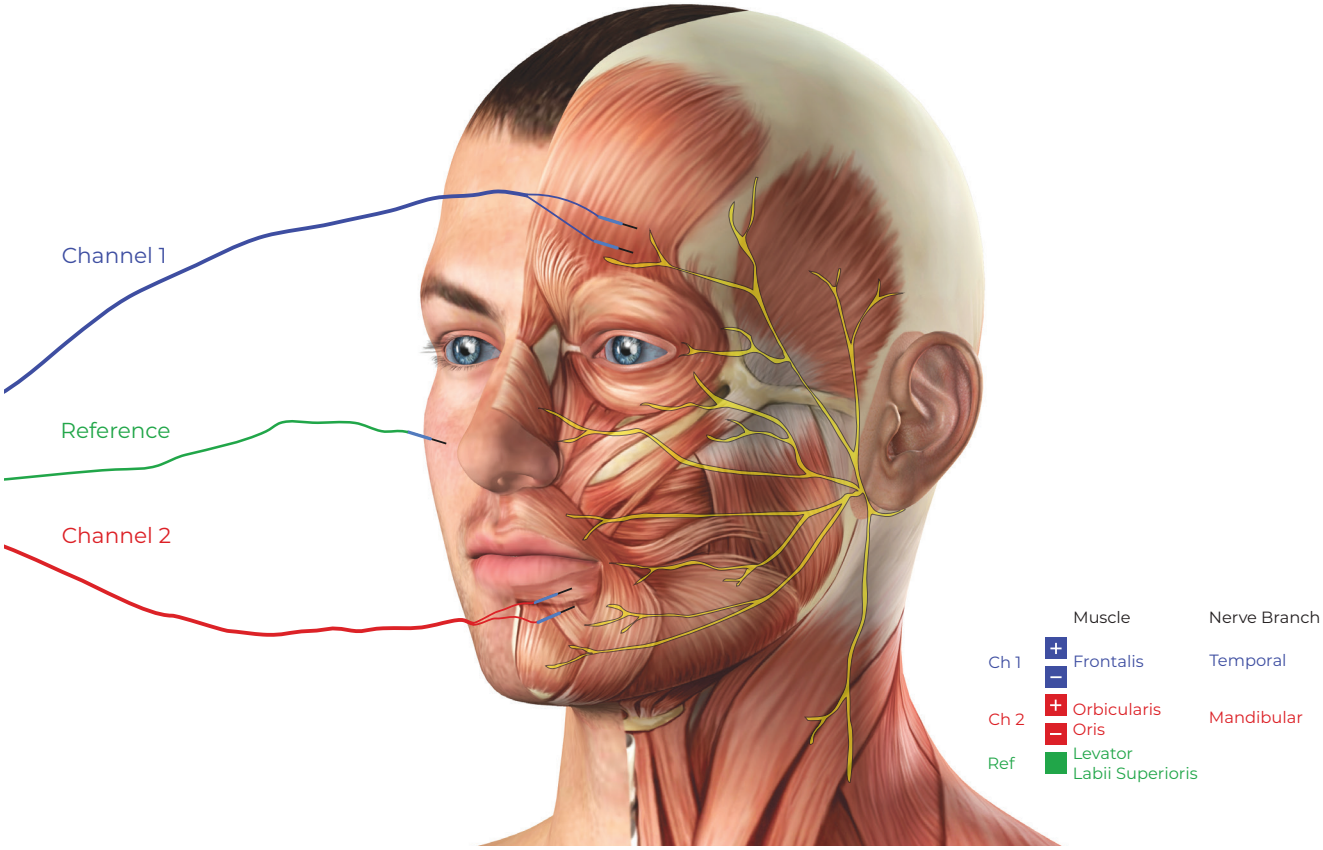


Figure 6.1: Suggested electrode placement during surgery of the middle ear.

SURGICAL PROCEDURE INFORMATION

The risk of injury to the facial nerve during a stapedectomy, or other middle ear procedures, is small but usually occurs because of a dehiscence in the fallopian canal above the oval window. This allows the facial nerve to lie unprotected outside of its normal anatomy. The use of the nerve monitor allows this condition to be verified or confirmed at an early stage.

If the nerve is not visible under the microscope, the surgeon can use the Precision Bipolar Probe to stimulate the canal and gain a response, verifying that the nerve is in its normal position. The nerve is dehiscent in about 50% of cases presenting for surgery. If the nerve is dehiscent, a response will be gained with a stimulator current close to 0.2mA. If the nerve is not dehiscent, 0.5mA - 5.0mA will be required in order to gain a response, depending on the thickness of intervening bone. An initial stimulator current of 0.5mA is recommended, which can then be increased or decreased until a response is gained.

As the surgeon drills, a high-pitched whining may be heard, which changes frequency with the drilling. This is caused by one of two factors; either the drill is vibrating the canal and the nerve is reacting, or the needle electrodes in the frontalis muscle are resting against the bone and the vibration in transmitted directly to them. In this case this is not a fault with the Neurosign® V4 Intraoperative Nerve Monitor and no action need be taken. However, if the response continues once the drill has stopped, this is an indication of heating of the nerve and irrigation must be used to cool both the nerve and the drill.

Once the nerve has been identified, the Neurosign® V4 Intraoperative Nerve Monitor is not likely to be used further. The primary purpose of the Neurosign® V4 Intraoperative Nerve Monitor in this surgery is to guard against the risk to the nerve before it has been located, and so prevent accidental injury.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 1.1 (page 1) and observe where the facial nerve lies in relation to the muscles used to monitor the various branches.
2. Insert each pair of Subdermal Needle Electrodes into the appropriate muscles indicated in Figure 6.1 (page 11), with the wires leading away from the surgical site. Ensure that the needles of each electrode are inserted adequately into the muscle and not simply under the skin.
3. Secure the Subdermal Needle Electrodes with tape.
4. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
5. Plug the Subdermal Needle Electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
6. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
7. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
8. Begin monitoring the procedure and set up a patient report (if applicable).
9. Set the stimulator current to 0.5mA (using the left stimulator control dial).

Note:
A higher current may be necessary because the surgeon will be stimulating through bone; 0.5mA is a safe value to start. If there is no response at 0.5mA, increase the current until a response is heard. If the anatomy is normal, it may require 5.0mA to stimulate through the bone. If the nerve is dehiscent, only 0.2mA will be necessary - hence the starting value of 0.5mA.

The use of a Precision Bipolar Probe 0.75mm (PN 3604-00-TE) is recommended. The Precision Bipolar Probe can give an indication of depth of bone between probe and nerve. The blue tip of the Precision Bipolar Probe is the stimulator, the white tip is the return. Stimulate with the blue tip over the nerve or on overlying bone. The white tip must also make contact with the bone to act as the return.

Note:
Stimulation at 0.2mA represents exposed nerve, and 5.0mA denotes normal anatomy, as the drill is used the stimulation current can be reduced and early warning given when there is very little bone remaining.

7. SURGERY OF THE SUBMANDIBULAR GLAND

Suggested Probe: Concentric Probe, PN: 3600-00-TE
Suggested Subdermal Electrodes: 2 Channel Electrode Set, PN 4469-00

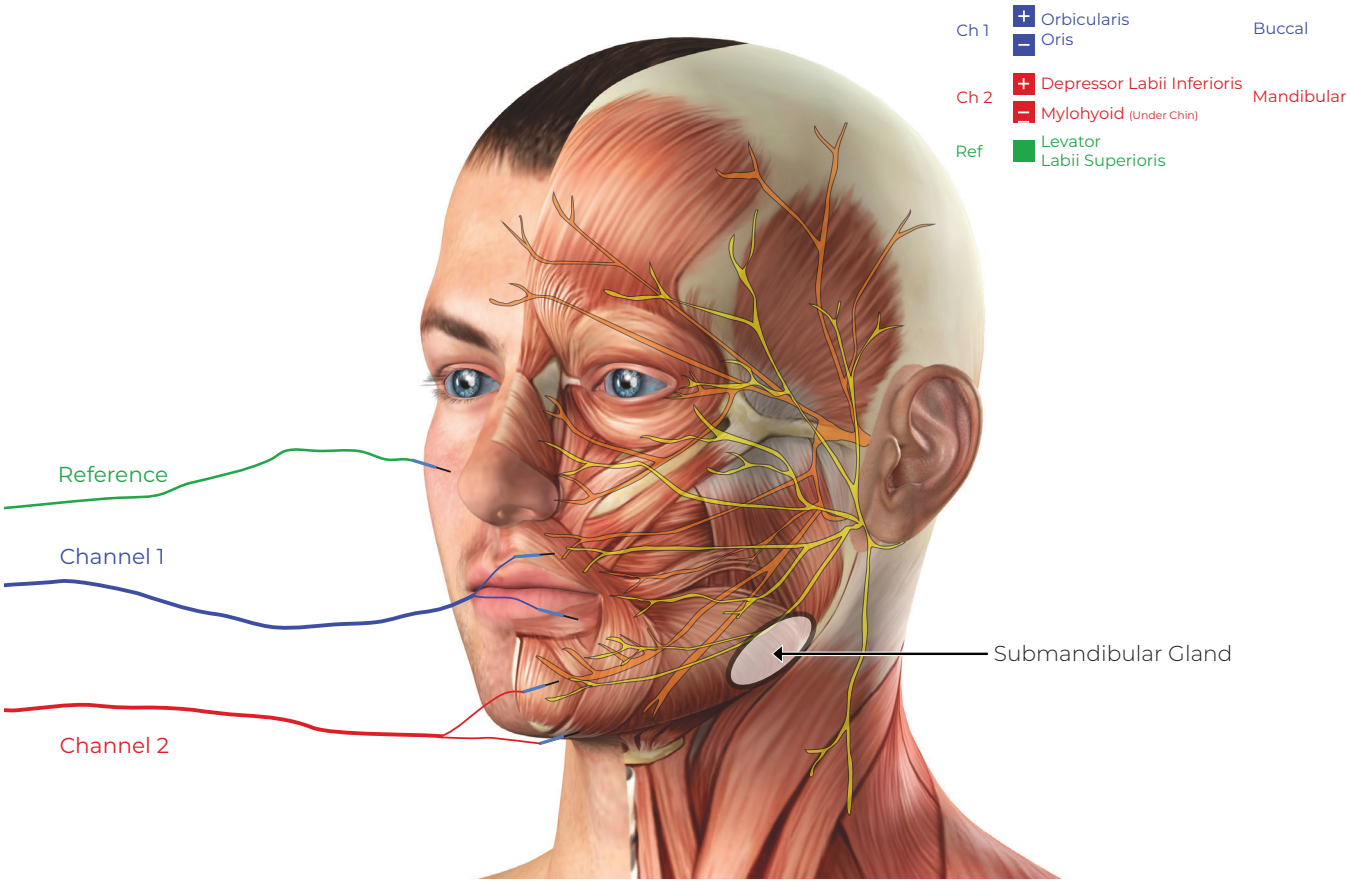


Figure 7.1: Suggested electrode placement during surgery of the submandibular gland.

SURGICAL PROCEDURE INFORMATION

The nerve to the mylohyoid muscle is a motor branch of the trigeminal nerve (V). Branches of both the facial and trigeminal nerves may be monitored in this procedure as both these nerves run close to the submandibular gland. If the tumor is extensive, the surgeon may need to consider monitoring the masseter muscle as well, as it is innervated by a different branch of the trigeminal nerve.

The lingual nerve is a sensory branch of the trigeminal nerve which connects with the lingual gland and supplies mucous membranes on the floor of the mouth and the anterior of the tongue. Being a sensory nerve, it cannot be directly monitored using the Neurosign® V4 Intraoperative Nerve Monitor, but it can be differentiated as a sensory nerve rather than a motor nerve.

The part of the facial nerve most at risk is the mandibular branch monitored by the orbicularis oris below the lower lip, but if there is a chance that the buccal branch may be involved, one Subdermal Needle Electrode should be placed above the upper lip. If the surgeon is certain that this branch will not be involved, this Subdermal Needle Electrode may also be placed below the lower lip.

As two different nerves are being monitored, a response may be seen from only one channel of the Neurosign® V4 Intraoperative Nerve Monitor when using the stimulator.

The current required to effectively stimulate the nerve to the mylohyoid muscle may not be the same as that required for the facial nerve, and it may be necessary to increase the current setting to 0.5mA to stimulate this nerve.

If the surgeon is to explore the parotid gland as well, then consider locating the Subdermal Needle Electrodes as shown in "3. Surgery of the Parotid Gland" on page 4, using a 4 Channel Electrode set (PN: 4470-00). At the appropriate stage of the surgery, you can then mute the channels which are no longer required.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 1.1 (page 1) and observe where the facial nerve lies in relation to the muscles used to monitor the various branches.
2. Insert each pair of Subdermal Needle Electrodes into the appropriate muscles indicated in Figure 7.1 (page 13), with the wires leading away from the surgical site. Ensure that the needles of each electrode are inserted adequately into the muscle and not simply under the skin.
3. Secure the Subdermal Needle Electrodes with tape.
4. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
5. Plug the electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
6. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
7. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
8. Begin monitoring the procedure and set up a patient report (if applicable).
9. Set the stimulator current to 0.5mA (using the left stimulator control dial). This current setting is used to locate the nerve.
10. Once located the current can be reduced to a minimum of 0.2mA.

Note:
The use of a Concentric Probe 1mm (PN 3600-00-TE) is recommended. It is very accurate, does not stimulate through tissue, and is excellent for stimulating the small interconnecting fibres between the branches.

8. COCHLEAR IMPLANT

Suggested Probe: Precision Bipolar Probe 0.75mm, PN: 3604-00-TE
Suggested Electrodes: 2 Channel Electrode Set, PN 4469-00

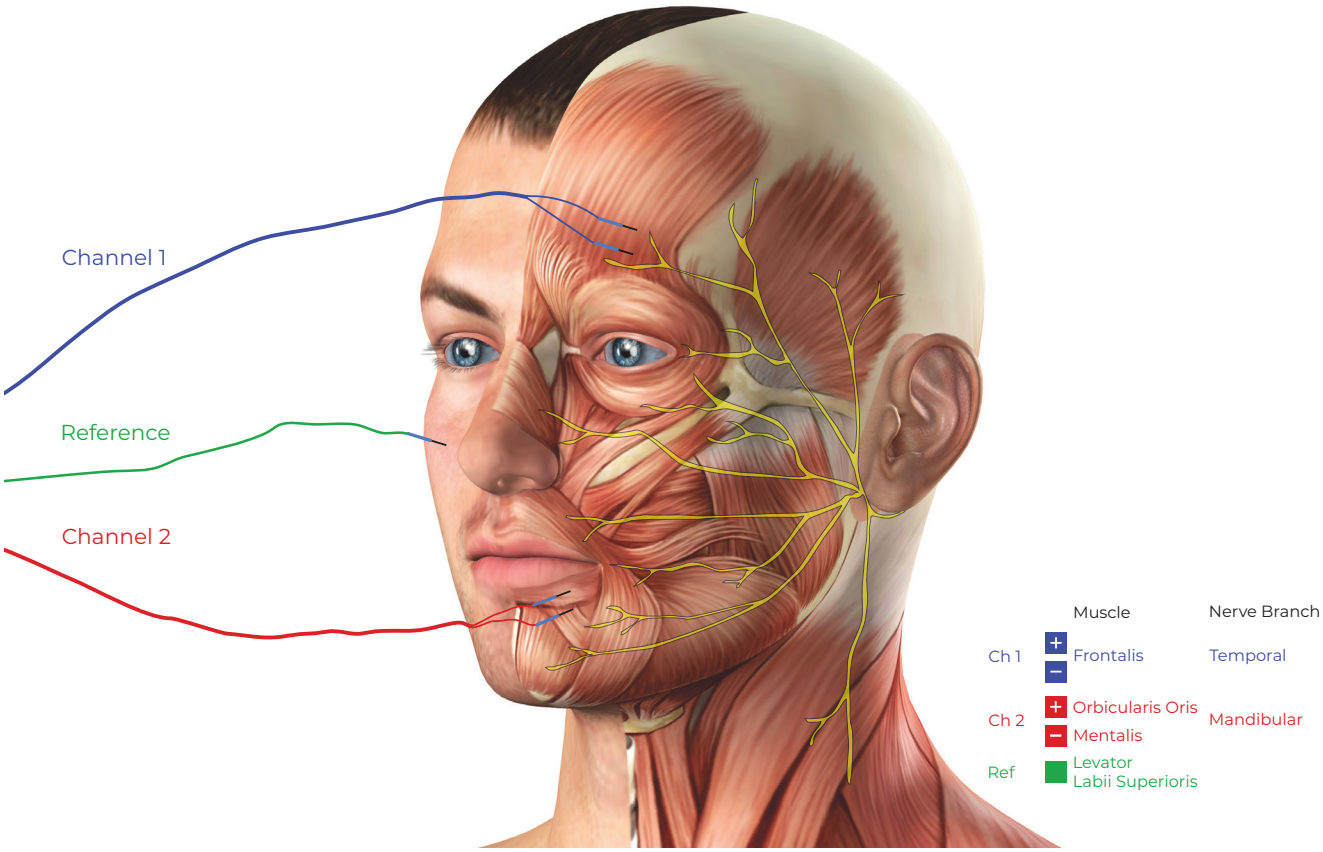


Figure 8.1: Suggested electrode placement during a cochlear implant.

SURGICAL PROCEDURE INFORMATION

A cochlear implant comprises two distinct phases; drilling the mastoid process in order to seat the transceiver and obtaining access to the cochlea so that the Subdermal Needle Electrodes can be inserted. It is in the second stage that the Neurosign® V4 Intraoperative Nerve Monitor is important. The facial nerve may be anomalous, or it is possible to injure it during the drilling of the middle ear.

The facial nerve runs within a canal on the edge of the mastoid process. It is important that the surgeon does not drill through the canal and the nerve.

Vibration from the drilling is often heard and can serve as an early warning that the nerve is nearby. A high-pitched whining indicates that either the nerve is affected by the drilling, or that the frontalis electrodes are touching bone and picking up the vibration. Check the bargraphs or waveform, equal amplitude indicates that the nerve is being affected, whereas signals only from channel 1 indicate vibration transferred by the bone and can be ignored.

The Precision Bipolar Probe will stimulate through bone if sufficient current is used. It is recommended that the nerve is stimulated to determine that the Neurosign® V4 Intraoperative Nerve Monitor and Subdermal Needle Electrodes are functioning correctly. If the nerve is dehiscent, a response will be gained with a stimulator current close to 0.2mA. If the nerve is not dehiscent. 0.5mA - 5.0mA will be required in order to gain a response, depending on the thickness of intervening bone. An initial stimulator current of 0.5mA is recommended, which can then be increased or decreased until a response is gained.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 1.1 (page 1) and observe where the facial nerve lies in relation to the muscles used to monitor the various branches.
2. Insert each pair of Subdermal Needle Electrodes into the appropriate muscles indicated in Figure 8.1 (page 15), with the wires leading away from the surgical site. Ensure that the needles of each electrode are inserted adequately into the muscle and not simply under the skin.
3. Secure the Subdermal Needle Electrodes with tape.
4. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
5. Plug the Subdermal Needle Electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
6. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
7. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
8. Begin monitoring the procedure and set up a patient report (if applicable).
9. Set the stimulator current to 0.5mA (using the left stimulator control dial).

Note:
A higher current may be necessary because the surgeon will be stimulating through bone; 0.5mA is a safe value to start. If there is no response at 0.5mA, increase the current until a response is heard. If the anatomy is normal, it may require 5.0mA to stimulate through the bone. If the nerve is dehiscent, only 0.2mA will be necessary - hence the starting value of 0.5mA.

The use of a Precision Bipolar Probe (PN 3604-00-TE) is recommended. The Precision Bipolar Probe can give an indication of depth of bone between the Precision Bipolar Probe and nerve. The blue tip of the Precision Bipolar Probe is the stimulator, the white tip is the return. Stimulate with the blue tip over the nerve or on overlying bone. The white tip must also make contact with the bone to act as the return.

Note:
Stimulation at 0.2mA represents exposed nerve, and 5.0mA denotes normal anatomy, as the drill is used the stimulation current can be reduced and early warning given when there is very little bone remaining.

9. MONITORING OF CRANIAL NERVE VII

Suggested Probe: Concentric Probe, PN: 3600-00-TE
Suggested Electrodes: 4 Channel Electrode Set, PN 4470-00

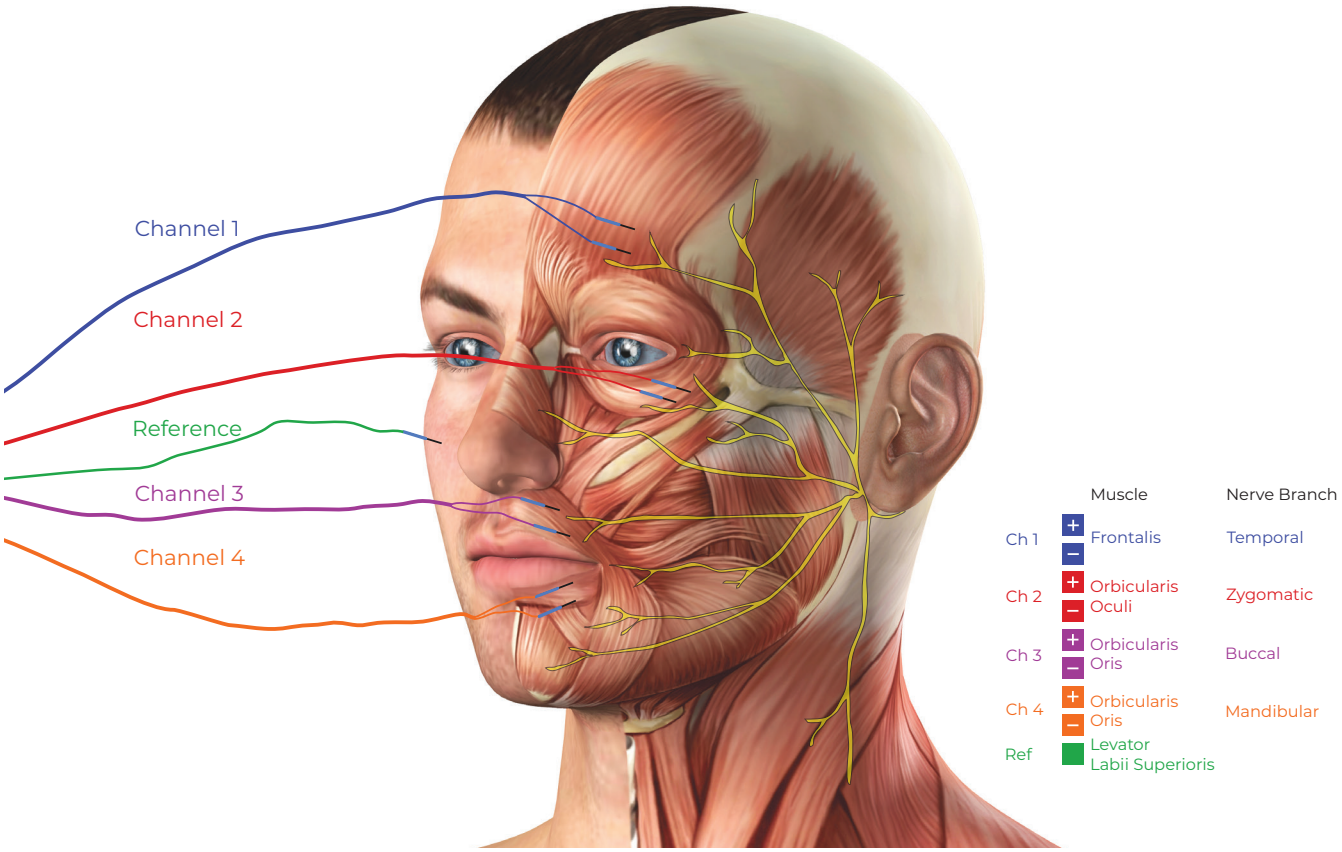


Figure 9.1: Suggested electrode placement for monitoring of the facial nerve (VII).

SURGICAL PROCEDURE INFORMATION

The surgery is normally an acoustic schwannoma, where the tumor lies on top of the facial nerve. However, micro-vascular decompression, facial nerve tumors, meningiomas and epidermoid tumors can all lie in the same location and require monitoring of cranial nerve VII.

The surgeon will identify the facial nerve at the internal auditory meatus and at the brainstem. It is worth measuring the latency of stimulation at these two points as an increase indicates nerve fatigue and may influence the surgeon's decision making.

The use of a Concentric Probe set to 0.05mA to locate the nerve trunk; once located, reduce the current to 0.03mA and ultimately to 0.01mA if the response remains strong. If the current has to be increased above 0.05mA, this indicates the possibility of nerve fatigue.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 1.1 (page 1) and observe where the facial nerve lies in relation to the muscles used to monitor the various branches.
2. Insert each pair of Subdermal Needle Electrodes into the appropriate muscles indicated in Figure 9.1 (page 17), with the wires leading away from the surgical site. Ensure that the needles of each electrode are inserted adequately into the muscle and not simply under the skin.
3. Secure the Subdermal Needle Electrodes with tape.
4. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
5. Plug the Subdermal Needle Electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
6. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
7. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
8. Begin monitoring the procedure and set up a patient report (if applicable).
9. Set the stimulator current to 0.05mA (using the left stimulator control dial). This current setting is used to stimulate the nerve initially at the internal auditory meatus and then at the brainstem. Reduce the current if required.

Note:
The use of a Concentric Probe (PN 3600-00-TE) is recommended. It is very accurate, does not stimulate through tissue, and is excellent for stimulating the small interconnecting fibres between the nerve branches.

10. MONITORING OF CRANIAL NERVES VII & V

Suggested Probe: Concentric Probe, PN: 3600-00-TE
Suggested Electrodes: 4 Channel Electrode Set, PN 4470-00

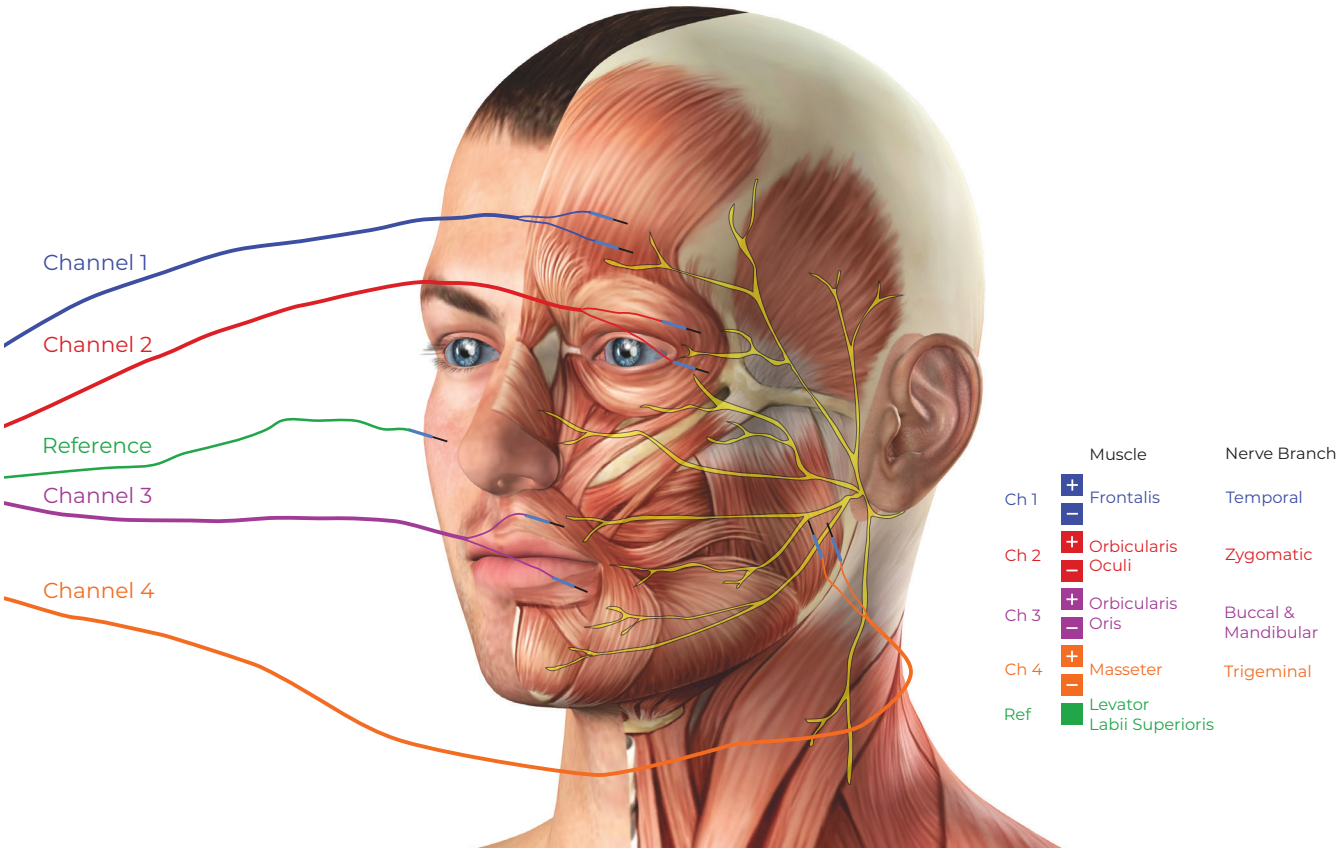


Figure 10.1: Suggested electrode placement for monitoring of cranial nerves VII & V.

SURGICAL PROCEDURE INFORMATION

The surgery is normally an acoustic schwannoma, where the tumor lies on top of the facial nerve. However, micro-vascular decompression, facial nerve tumors, meningiomas and epidermoid tumors can all lie in the same location and require monitoring of cranial nerve VII.

The surgeon will identify the facial nerve at the internal auditory meatus and at the brainstem. It is worth measuring the latency of stimulation at these two points as an increase indicates nerve fatigue and may influence the surgeon's decision making.

The use of a Concentric Probe set to 0.05mA to locate the nerve trunk; once located, reduce the current to 0.03mA and ultimately to 0.01mA if the response remains strong. If the current has to be increased above 0.05mA, this indicates the possibility of nerve fatigue.

The trigeminal nerve (V) is mainly sensory with a small motor component. Therefore, the motor fibres may lie on the opposite side of the nerve from the stimulator; for this reason, set the stimulator current to 0.4mA and reduce if the nerve stimulates well. Set the cursor to the take-off point - expect a latency of 3.2ms. Leave the cursor on. When stimulating the facial or the trigeminal nerves, expect to see all channels display a waveform; if the take-off point on Channel 4 is 3.2ms, it is the trigeminal nerve, if the take-off point is between 5ms and 9ms, it is the facial nerve. Stimulating the trigeminal nerve will cause the sensation of pain (toothache) and the face will twitch as a response to the stimulus.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 1.1 (page 1) and observe where the facial nerve lies in relation to the muscles used to monitor the various branches.
2. Insert each pair of Subdermal Needle Electrodes into the appropriate muscles indicated in Figure 10.1 (page 19), with the wires leading away from the surgical site. Ensure that the needles of each electrode are inserted adequately into the muscle and not simply under the skin.
3. Secure the Subdermal Needle Electrodes with tape.
4. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
5. Plug the Subdermal Needle Electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
6. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
7. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
8. Begin monitoring the procedure and set up a patient report (if applicable).
9. Set the stimulator current to 0.05mA (using the left stimulator control dial). This current setting is used to stimulate the nerve initially at the internal auditory meatus and then at the brainstem. Reduce the current if required.

Note:
The use of a Concentric Probe (PN 3600-00-TE) is recommended. It is very accurate, does not stimulate through tissue, and is excellent for stimulating the small interconnecting fibres between the branches.

11. MONITORING OF CRANIAL NERVES VII & IX, XI OR XII

Suggested Probe: Concentric Probe, PN: 3600-00-TE
Suggested Electrodes: 4 Channel Electrode Set, PN 4470-00

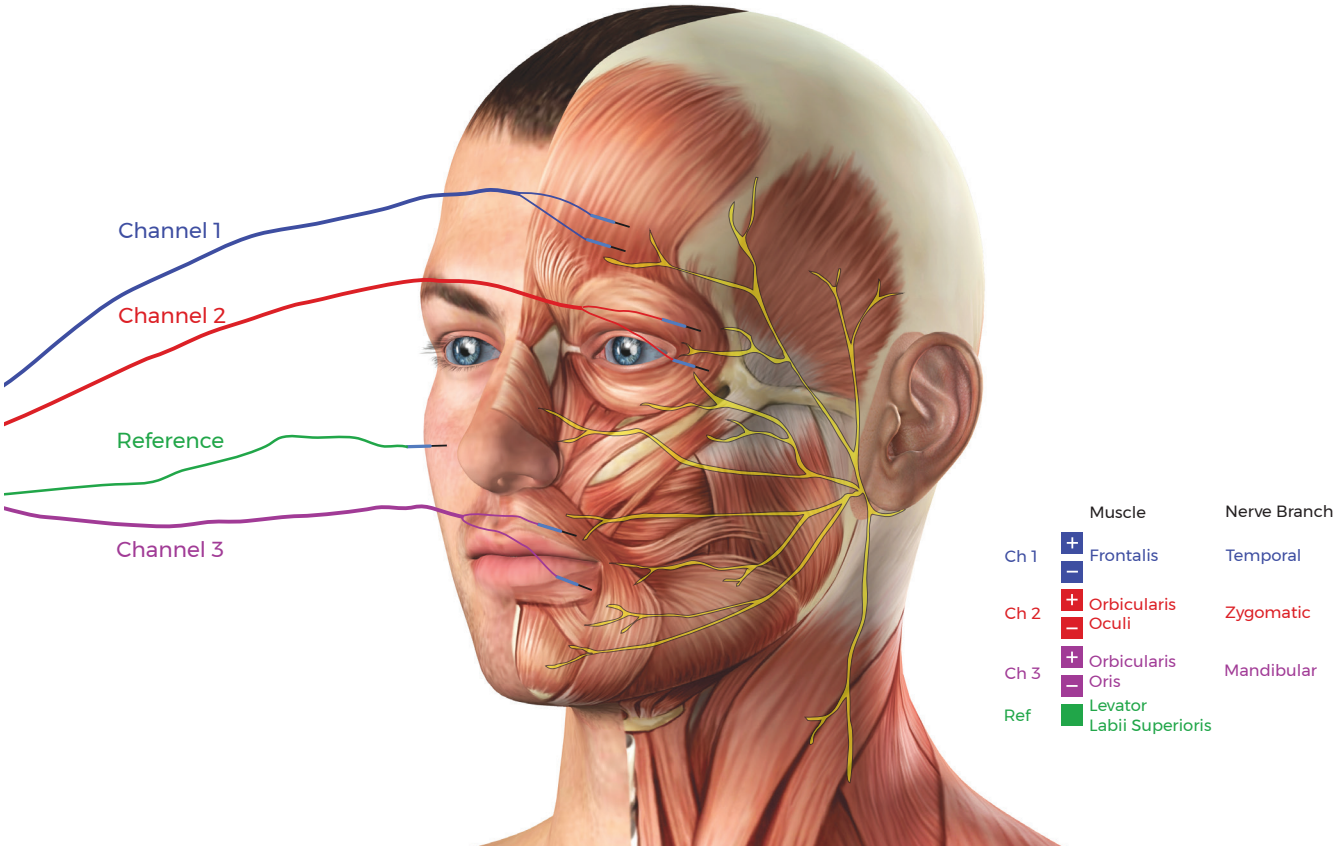


Figure 11.1: Suggested electrode placement for monitoring of cranial nerves VII & IX, XI or XII (cerebellopontine angle tumors).

SURGICAL PROCEDURE INFORMATION

The surgery is normally an acoustic schwannoma, where the tumor lies on top of the facial nerve. However, facial nerve tumors, meningiomas and epidermoid tumors can all lie in the same location and require monitoring of cranial nerve VII and IX.

The surgeon will identify the facial nerve at the internal auditory meatus and at the brainstem. It is worth measuring the latency of stimulation at these two points as an increase indicates nerve fatigue and may influence the surgeon's decision making.

The use of a Concentric Probe set to 0.05mA to locate the nerve trunk; once located, reduce the current to 0.03mA and ultimately to 0.01mA if the response remains strong. If the current has to be increased above 0.05mA, this indicates the possibility of nerve fatigue.

Cranial nerve XII is shown in the diagram only when the electrodes go in the pharynx. If the tumor extends down the brainstem, XII can be monitored in the same manner as other cranial nerves and using similar stimulating currents (0.05mA). At the end of surgery, check the patient's mouth for bleeding once the Subdermal Needle Electrodes are removed; apply gauze via mild pressure in the event of bleeding. Confirm that bleeding has stopped until the patient has fully regained consciousness in case bleeding recommences after extubating.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 1.1 (page 1) and observe where the facial nerve lies in relation to the muscles used to monitor the various branches.
2. Insert each pair of Subdermal Needle Electrodes (for channels 1 - 3) into each muscle as shown in Figure 11.1 (page 21), with the wires leading away from the surgical site. Ensure that the needles of the electrodes are inserted adequately into the muscle and not simply under the skin.
3. Secure the Subdermal Needle Electrodes with tape.
4. Look at Figure 11.2 to see where to insert the Subdermal Needle Electrodes for cranial nerves IX or XII. Subdermal Needle Electrodes should be inserted after the patient is intubated. Use Magill forceps to insert both needles at once, either on the ipsilateral side of the uvula into the soft palate (IX), or to the tongue on the ipsilateral side (XII).
5. Once needles are inserted, use a cotton gauze mouth pack to ensure the needles cannot come out during surgery.

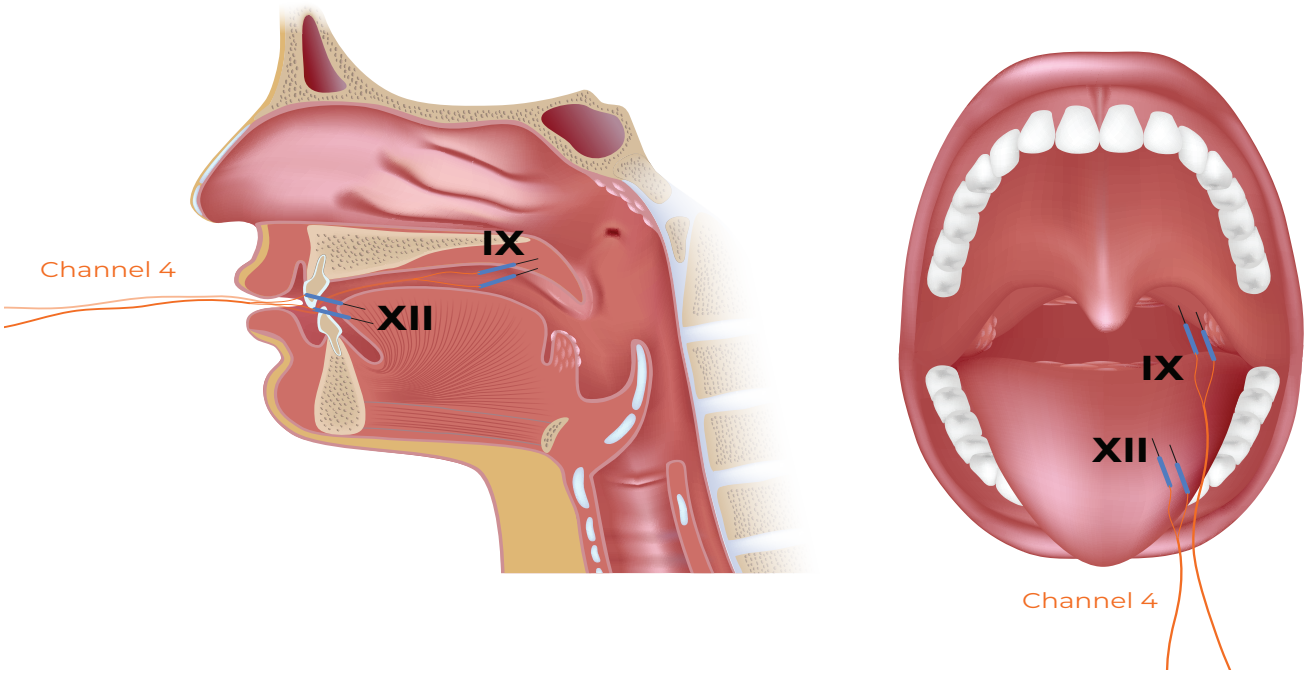


Figure 11.2: Differing options for monitoring of cranial nerves XI & XII.

6. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
7. Plug the Subdermal Needle Electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
8. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).

Step 9-11 continued on next page.

NERVE MONITORING - THE PROCEDURE

9. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
10. Begin monitoring the procedure and set up a patient report (if applicable).
11. Set the stimulator current to 0.5mA (using the left stimulator control dial). This current is used to stimulate the nerve initially at the internal auditory meatus and then at the brainstem. Reduce the current if required.

Note:
The use of a Concentric Probe (PN 3600-00-TE) is recommended. It is very accurate, does not stimulate through tissue, and is excellent for stimulating the small interconnecting fibres between the branches.

12. MONITORING OF SELECTIVE NECK DISSECTIONS

Suggested Probe: Concentric Probe, PN: 3600-00-TE
Suggested Electrodes: 8 Channel Electrode Set, PN 4472-00

NERVE	MUSCLE
Hypoglossal (XII)	Lateral aspect of tongue; genioglossus, styloglossus
Facial (VII) (mandibular branch)	Orbicularis oris, mentalis
Facial (cervical branch)	Platysma
Nerve to Mylohyoid (V)	Mylohyoid
Glossopharyngeal (IX)	Soft palate; stylopharyngeus
Mandibular branch of (V)	Digastric - anterior belly' masseter
Facial (on exit from stylomastoid foramen)	Digastric - posterior belly
Vagus (X)	Vocal cords via recurrent laryngeal nerve
Accessory and C2, C3	Sternocleidomastoid
Accessory (XI) and C3, C4	Trapezius
Ansa cervicalis C1 to C3	Omohyoid, sternohyoid, sternothyroid
Ansa cervicalis C1 to C2 and descending hypoglossal	Thyrohyoid
Phrenic	Diaphragm (laterally below lowest rib)

Figure 12.1: Selective Neck Dissection - monitoring multiple cranial nerves.

SURGICAL PROCEDURE INFORMATION

Neck dissections are performed to remove benign and malignant tumors growing in this area. Benign tumors allow any associated nerves to be preserved; malignant tumors suggest that nerves directly associated with the tumor are likely to be sacrificed. Therefore, this should be considered when deciding what needs to be monitored.

If the tumor involves the recurrent laryngeal nerve, the vagus can be stimulated to confirm continuity throughout the length of the RLN by exposing the vagus within the carotid sheath.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 2.1 (page 2) and observe where the nerves lie in relation to the muscles used to monitor the various branches.
2. These procedures vary in their potential nerve involvement, and nerves may need to be sacrificed if the tumor is malignant. Consider the table Figure 12.1 (page 24) in respect of the patient. Usually, the mandibular branch of the facial nerve, the recurrent laryngeal nerve, and the accessory are involved; but other nerves can be added according to the table.
3. If Subdermal Needle electrodes are inserted orally, use a cotton gauze mouth pack to ensure the Subdermal Needle Electrodes cannot come out during surgery.
4. Cranial nerve XI can be monitored using the trapezius muscle. Insert the Subdermal Needle electrodes where the neck meets the shoulder.
5. The phrenic can be monitored by inserting 2 Subdermal Needle electrodes just below the bottom rib laterally. The waveform is unusual as it follows the patient's breathing.
6. Secure the Subdermal Needle Electrodes with tape.
7. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
8. Plug the Subdermal Needle electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
9. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
10. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
11. Begin monitoring the procedure and set up a patient report (if applicable).
12. Set the stimulator current to 0.5mA (using the left stimulator control dial). Adjust the current as required.

Note:
The use of a Concentric Probe (PN 3600-00-TE) is recommended. It is very accurate, does not stimulate through tissue, and is excellent for stimulating the small interconnecting fibres between the branches. Alternatively, use the Stimulating Dissectors (PN 4013-00) to dissect and stimulate as you operate. If the Stimulating Dissectors are used, then place the white return needle into the edge of the wound and go to the Neurosign V4 UI and select: Procedure Settings – Select Filter Settings tab – Adjust the Stimulator Artefact Rejection (SAR) to 3ms.

SPINAL NERVE ROOTS

13. MONITORING OF RELEASE OF A TETHERED CORD

Suggested Probe: Concentric Probe, PN: 3600-00-TE
Suggested Electrodes: 8 Channel Electrode Set, PN 4472-00

LEVEL	MUSCLE
L2/3	Adductors
L4	Quadriceps
L5	Peroneus longus
S1	Medial gastrocnemius
S2	Abductor digiti minimi
S3	Puborectalis, levator ani, monitor via anal sphincter
S4	Puborectalis, levator ani, monitor via anal sphincter
S5	Coccygeus, monitor via anal sphincter

Figure 13.1: Monitoring of nerve roots.

SURGICAL PROCEDURE INFORMATION

At birth, the bottom of the spinal cord - the conus - extends to L3. During the growth spurt following puberty, the spinal cord should move up the spinal canal since the skeleton grows faster than the spinal cord, until in the adult it reaches L1. In a small proportion of children, the filum terminale, a non-nervous fiber extending from the conus to provide longitudinal support to the spinal cord, is 'tethered', often to a lipoma. This prevents the spinal cord from moving up the canal, so the cord is stretched. Eventually, this stretching has neurological effects, and ultimately will prevent any nerve conduction below the conus, and possibly higher.

Symptoms are likely to be pain and/or numbness in the lower limbs, muscle wastage in the lower limbs, and incontinence.

The surgeon will perform a laminectomy at L1/2/¾ and clear any lipoma or other growth which is tethering the nerve roots or filum terminale.

The surgeon will identify the filum terminale and cut it, allowing the spinal cord to move up the canal. Monitoring is very important in order to positively identify the filum terminale (it will not produce any EMG response). For this reason, it is important to ensure that all the nerve roots are monitored, either by the Neurosign® V4 Intraoperative Nerve Monitor or visually.

The sooner this procedure is carried out, the better. A severely neurologically compromised patient will benefit but may not regain normal function even if the operation is successful.

Note:
The use of a Concentric Probe (PN 3600-00-TE) is recommended. It is very accurate, does not stimulate through tissue, and is excellent for stimulating the nerve roots when using the microscope.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 2.1 (page 2) and observe where the nerves lie in relation to the muscles used to monitor the various branches.
2. Look at Figure 13.1 (page 27) to decide which nerve roots are to be monitored. Because there are only 8 channels, some compromise is necessary.
3. Below Figure 13.2 gives a workable solution, which can be varied given individual patient's needs.

   Note:
   Where 'left, right' is shown, this means 1 Subdermal Needle electrode in the left side of the body, 1 Subdermal Needle electrode in the right side of the body, thereby using just 1 channel.

LEVEL	CHANNEL L/R	MUSCLE MONITORED
L2/3	Left, right	Adductors
L4	Left	Quadriceps
L5	Left	Peroneus longus
S1	Left	Medial gastrocnemius
S5	Left. right	Anal sphincter
L4	Right	Quadriceps
L5	Right	Peroneus longus
S1	Right	Medial gastrocnemius

Figure 13.2: Suggested solution for electrode placement.

4. Secure the Subdermal Needle Electrodes with tape.
5. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
6. Plug the Subdermal Needle electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
7. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up your procedure (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
8. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
9. Begin monitoring the procedure and set up a patient report (if applicable).
10. Set the stimulator current to 1.0mA (using the left stimulator control dial). This current is safe to stimulate nerve roots directly. Adjust the current if necessary.

14. MONITORING OF PEDICLE SCREWS AND RIGID FIXATION

Suggested Probe: Monopolar Ball Tip Probe, PN: 3603-00-TE
Suggested Electrodes: 8 Channel Electrode Set, PN 4472-00

LEVEL	CHANNEL L	CHANNEL R	MUSCLE MONITORED
L2, **L3**	1	5	**Adductors**
L3, **L4**	2	6	**Quadriceps**
L4, **L5**	3	7	**Peroneus longus**, Tibialis Anterior
L5, **S1**	4	8	**Medial gastrocnemius**, Biceps Femoris

Figure 14.1: Recommended levels and muscles in **bold**.

SURGICAL PROCEDURE INFORMATION

Ideally, levels above and below as well as the immediate area of surgery should be monitored - patients tend to be individual, with the degree of innervation from the different levels varying from person to person.

Use the Monopolar Ball Tip Probe to stimulate. If the nerve root is directly stimulated, use a lower current level (< 2.0mA); in order to stimulate through the pedicle wall, set the current level to 7.0mA.

Once the hole for the screw has been made, the stimulating Monopolar Ball Tip Probe can be run down it. The Monopolar Ball Tip Probe should be positioned at the thinnest part of the pedicle, about 1/3 from the top; this is the point of stimulation. If there is no response at 7.0mA, or the response is below 100µV as shown on the peak value display, the screw may be inserted. Listen carefully for any indication that the pedicle wall is being breached. the principle is that bone acts as an insulator, so if no current flows to the nerve root then the bone is intact; if current flows, it implies that the bone is very thin or that there is a crack in the bone.

If there is significant response at 7.0mA, maintain the Monopolar Ball Tip Probe in position and reduce the stimulating current. Note the level at which the response drops below 100µV. If this level is reached above 5.0mA, continue and insert the ball tip with caution, listening for any activity.

If there is significant response between 3.0mA and 5.0mA, consider repositioning the hole.

If there is significant response at 2.0mA, the pedicle wall is almost certainly breached.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 2.1 (page 2) and observe where the nerves lie in relation to the muscles used to monitor the various branches.
2. Surgery at the lumbar levels of the spine carries serious risks which the Neurosign® V4 Intraoperative Nerve Monitor can help reduce.
3. Follow Figure 14.1 (page 29) as a guide to electrode placement. The adductors can be found in the groin and the Subdermal Needle Electrodes are best inserted with the patient in supine position. The muscle can be felt as a ridge by pressing into the area firmly.
4. Tape the Subdermal Needle electrodes in position and tape the coiled wire temporarily to the inside leg so it can be retrieved once the patient is in the prone position.
5. Subdermal Needle Electrodes for the quadriceps can be inserted when the patient is either supine or prone.
6. Insert the remaining Subdermal Needle Electrodes and position the reference needle electrode on the opposite side to the electrocautery pad.
7. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
8. Plug the Subdermal Needle electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
9. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up the Pedicle Screw setup (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
10. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement until the impedance is green. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
11. Begin monitoring the procedure and set up a patient report (if applicable).

Note:
The use of a Monopolar Ball Tip Probe (PN 3603-00-TE) is recommended. If necessary, adjust the stimulator output to 7.0mA. The stimulator probe should be connected when required rather than at the start of the surgery. Insert the stimulator return needle in the buttock.

If using a Monopolar Ball Tip Probe, it may be necessary to counter stimulus artefact (clicking sound wherever the Monopolar Ball Tip Probe is touched). Go to Procedure Settings – Filter Settings tab – Adjust the Stimulator Artefact Rejection (SAR) up to 5ms.

15. MONITORING OF FUSION CAGES

Suggested Probe: Monopolar Probe, PN: 3602-00
Suggested Electrodes: 8 Channel Electrode Set, PN 4472-00

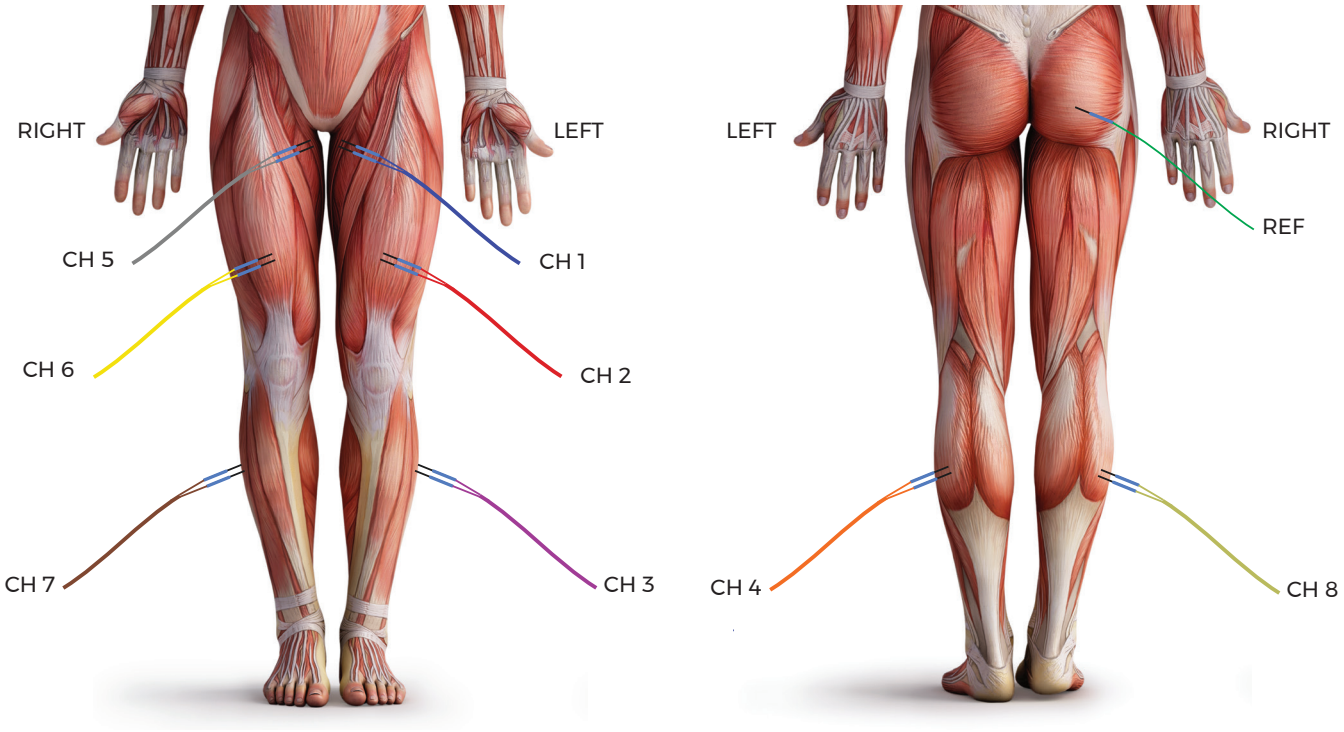


Figure 15.1: Suggested electrode placement for monitoring of fusion cages.

SURGICAL PROCEDURE INFORMATION

Fusion cages, to relieve a herniated intervertebral disc, are becoming increasingly popular since they are intrinsically stronger mechanically than just using pedicle screws and some form of rigid fixation. The herniated disc must be removed, an area of the body of the vertebra drilled out, and the cage inserted. The interior of the cage is filled with bone dust, and in time the cage and the two vertebrae fuse together.

Monitoring is helpful whilst the disc is being removed, as any pressure or disturbance on the nerve roots will be detected.

Once the cage has been put in place, the foramen through which the nerve root exits may need decompressing. The Neurosign® V4 Intraoperative Nerve Monitor will detect any disturbance of the nerve root.

If desired, the surgeon can use the Monopolar Probe to stimulate the relevant nerve roots. This shows that the Neurosign® V4 Intraoperative Nerve Monitor is working correctly, and that the particular nerve root is being monitored. The surgery to fit the cage and decompress the foramen can then proceed in confidence. A stimulating current of 1.0mA should be used. Insert the stimulator return needle in the buttock.

Otherwise, the surgeon is listening for any unexpected spontaneous activity.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 2.1 (page 2) and observe where the nerves lie in relation to the muscles used to monitor the various branches.
2. Look at Figure 15.1 (page 31) to decide which nerve roots are to be monitored.
3. Surgery at the lumbar levels of the spine carries serious risks which the Neurosign® V4 Intraoperative Nerve Monitor can help reduce.
4. Follow below Figure 15.2 as a guide to electrode placement. The adductors can be found in the groin and the Subdermal Needle Electrodes are best inserted with the patient in supine position. The muscle can be felt as a ridge by pressing into the area firmly.

LEVEL	CHANNEL L	CHANNEL R	MUSCLE MONITORED
L2, **L3**	1	5	**Adductors**
L3, **L4**	2	6	**Quadriceps**
L4, **L5**	3	7	**Peroneus longus**, Tibialis Anterior
L5, **S1**	4	8	**Medial gastrocnemius**, Biceps Femoris
S2	Perenium		
S3			
S4			

Figure 15.2: Recommended levels and muscles in **bold**.

5. Tape the Subdermal Needle electrodess in position and tape the coiled wire temporarily to the inside leg so it can be retrieved once the patient is in the prone position.
6. Subdermal Needle Electrodes for the quadriceps can be inserted when the patient is either supine or prone.
7. Insert the remaining Subdermal Needle Electrodes and insert the reference needle electrodes into the buttocks or biceps femoris and tape down to secure.
8. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
9. Plug the Subdermal Needle electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod, and place the Pre-amplifier Pod on the side rail of the operating table.
10. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up the Pedicle Screw setup (refer to the Neurosign® V4 Reference Guide/User Manual for more information). Lower the stimulating current to 1.0mA.

Step 11-12 continued on next page.

NERVE MONITORING - THE PROCEDURE

11. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.

12. Begin monitoring the procedure and set up a patient report (if applicable).

Note:
The use of a Monopolar Probe (PN 3602-00-TE) is recommended. Insert the stimulator return needle in the buttock. Adjust the stimulator output to 1.0mA. The stimulator probe should be connected when required rather than at the start of the surgery.

If using a Monopolar Probe, it may be necessary to counter stimulus artefact (clicking sound wherever the probe is touched). Go to Procedure Settings – Filter Settings tab – Adjust the Stimulator Artefact Rejection (SAR) up to 5ms.

16. MONITORING OF NERVE ROOT DECOMPRESSION

Suggested Probe: Monopolar Probe, PN: 3602-00-TE
Suggested Electrodes: 8 Channel Electrode Set, PN 4472-00

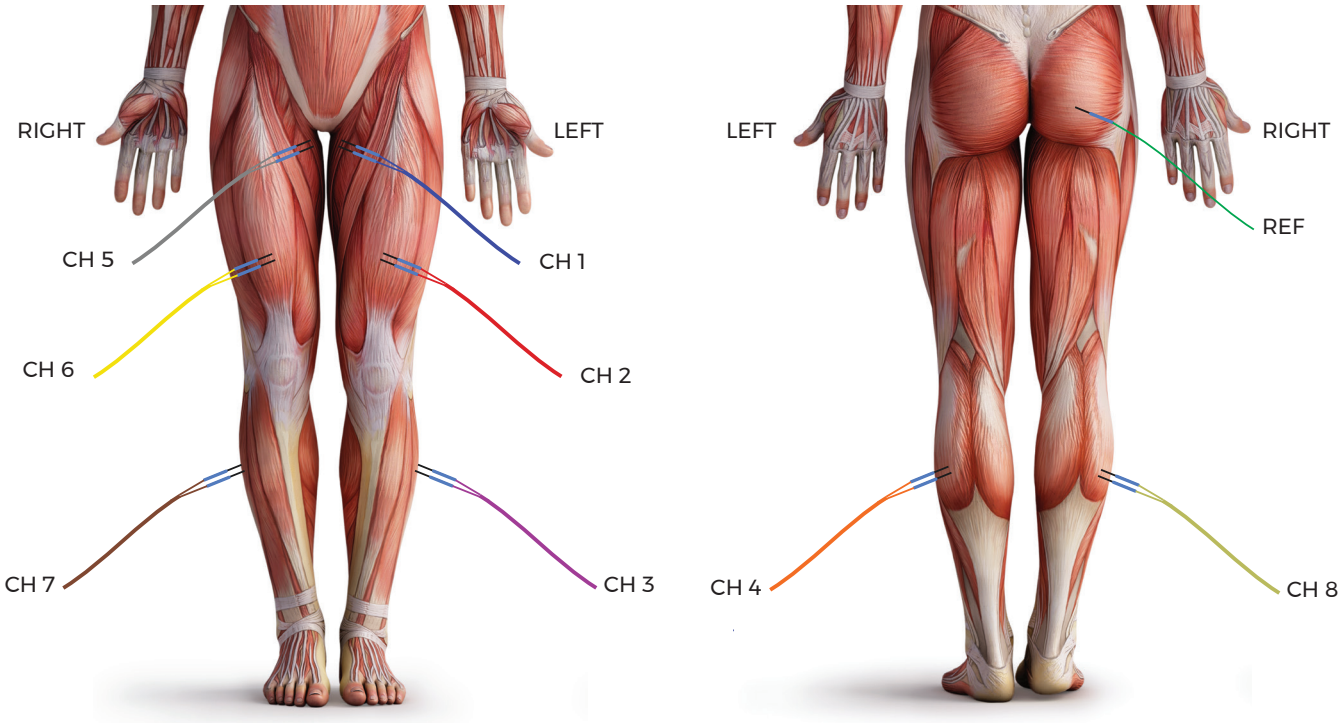


Figure 16.1: Suggested electrode placement for monitoring of nerve root decompression.

SURGICAL PROCEDURE INFORMATION

Nerve root decompression is often a necessary part of stabilizing the lower spine. Either the foramina, the holes through which the spinal nerve roots exit the spinal column on their way to the legs, have been reduced in size through bone growth, or the intervertebral disc has herniated or reduced in size so that the 2 vertebra are close together. This more frequently occurs at the lower end of the spine which carries the greatest load. Where instrumentation is being fitted, what may have taken years to develop is being corrected in a few hours. As the vertebrae are locked together, the foramina through which the nerve roots exit can alter their shape, possibly compressing the nerve roots. To correct this, some bone around the foramen is removed.

Because of the continuous nature of the monitoring, any pressure on the nerve root caused by either the decompression or by fragments of bone or dura remaining will be detected.

If desired, the surgeon can use the Monopolar Probe to stimulate the relevant nerve roots. This shows that the Neurosign® V4 Intraoperative Nerve Monitor is working correctly, and that the particular nerve root is being monitored. The surgery to fit the cage and decompress the foramen can then proceed in confidence. A stimulating current of 1.0mA should be used. Insert the stimulator return needle in the buttock.

Otherwise, the surgeon is listening for any unexpected spontaneous activity.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 2.1 (page 2) and observe where the nerves lie in relation to the muscles used to monitor the various branches.
2. Look at Figure 16.1 (page 34) to decide which nerve roots are to be monitored.
3. Surgery at the lumbar levels of the spine carries serious risks which the Neurosign® V4 Intraoperative Nerve Monitor can help reduce.
4. Follow below Figure 16.2 as a guide to electrode placement. The adductors can be found in the groin and the Subdermal Needle Electrodes are best inserted with the patient in supine position. The muscle can be felt as a ridge by pressing into the area firmly.

LEVEL	CHANNEL L	CHANNEL R	MUSCLE MONITORED
L2, **L3**	1	5	**Adductors**
L3, **L4**	2	6	**Quadriceps**
L4, **L5**	3	7	**Peroneus longus**, Tibialis Anterior
L5, **S1**	4	8	**Medial gastrocnemius**, Biceps Femoris
S2	Perenium		
S3			
S4			

Figure 16.2: Recommended levels and muscles in **bold**.

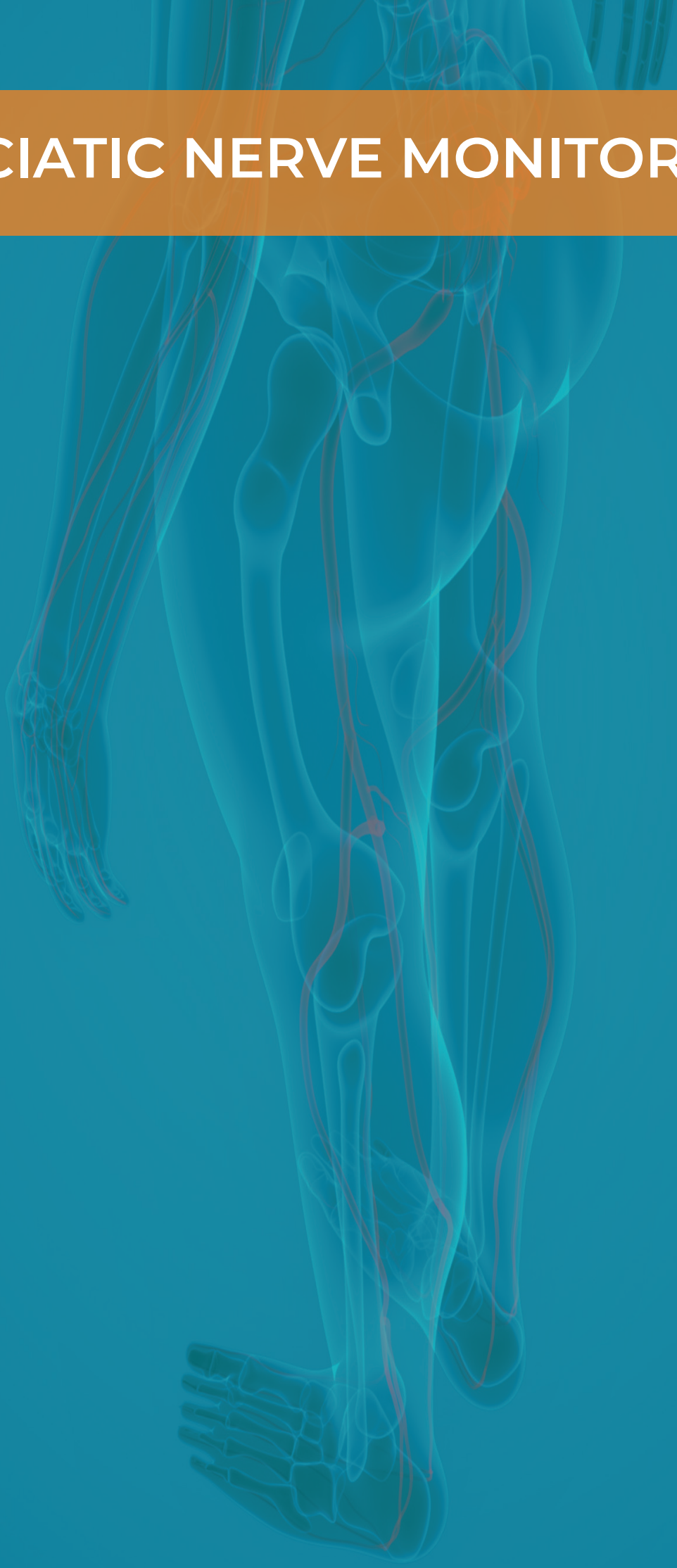
5. Tape the Subdermal Needle electrodes in position and tape the coiled wire temporarily to the inside leg so it can be retrieved once the patient is in the prone position.
6. Subdermal Needle Electrodes for the quadriceps can be inserted when the patient is either supine or prone.
7. Insert the remaining Subdermal Needle Electrodes and insert the reference needle electrodes into the buttocks or biceps femoris and tape down to secure.
8. Leave a 5cm length of cable, to accommodate movement, and then secure the cable with tape.
9. Plug the Subdermal Needle electrodes into the corresponding color-coded sockets on the Neurosign® V4 4 or 8 Channel Pre-amplifier Pod.
10. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and set up the Pedicle Screw setup (refer to the Neurosign® V4 Reference Guide/User Manual for more information). Reduce the default stimulating current to 1.0mA.
11. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
12. Begin monitoring the procedure and set up a patient report (if applicable).

NERVE MONITORING - THE PROCEDURE

Note:
The use of a Monopolar Probe (PN 3602-00-TE) is recommended, unless pedicle screws are being used, in which case use the Ball Tip Probe (PN 3603-00-TE). Insert the stimulator return needle in the buttock. Adjust the stimulator output to 1.0mA. The stimulator probe should be connected when required rather than at the start of the surgery.

If using a Monopolar Probe, it may be necessary to counter stimulus artefact (clicking sound wherever the probe is touched). Go to Procedure Settings – Filter Settings tab – Adjust the Stimulator Artefact Rejection (SAR) up to 5ms.

SCIATIC NERVE MONITORING



17. MONITORING OF HIP REPLACEMENT

Suggested Probe: Monopolar Probe, PN: 3602-00-TE
Suggested Electrodes: 8 Channel Electrode Set, PN 4472-00

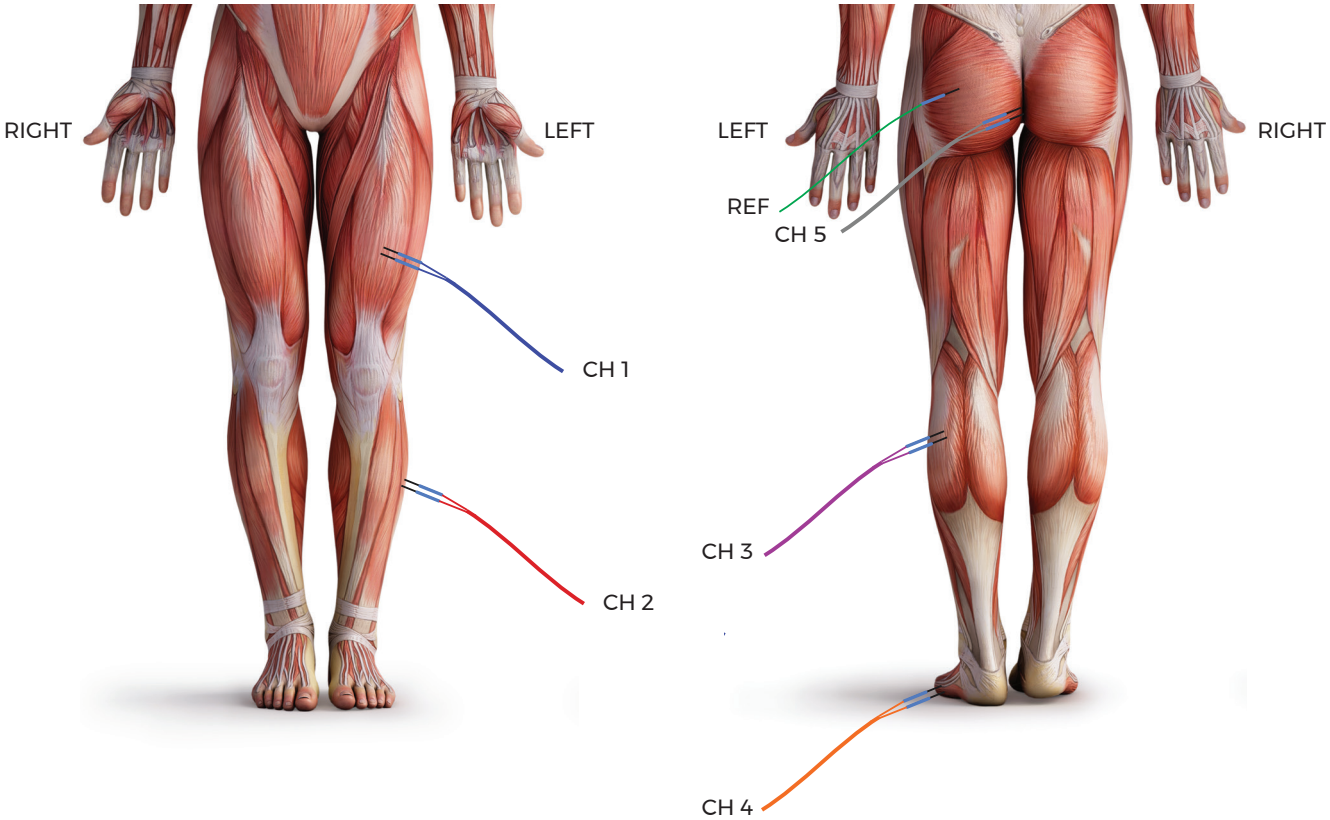


Figure 17.1: Suggested electrode placement for monitoring of hip replacement.

SURGICAL PROCEDURE INFORMATION

The sciatic nerve is at greatest risk of injury during a hip replacement. Hip replacements are routinely performed without monitoring, but there is a small but significant risk of nerve damage which rises considerably if there is scar tissue in the area, perhaps from a previous hip replacement.

Nerve damage can occur through compression, traction or physical trauma. Since the sciatic nerve is typically over 1.0cm in diameter near the pelvis, physical trauma is, perhaps, unlikely; but periods of compression or traction during the replacement of the joint is not unusual. The Neurosign® V4 Intraoperative Nerve Monitor can help to reduce these bursts of activity by alerting the surgeon to their existence!

If desired, the surgeon can use the Monopolar Probe to stimulate the relevant nerve roots, or more appropriately, the sciatic nerve itself. This shows that the Neurosign® V4 Intraoperative Nerve Monitor is working correctly, and that the sciatic nerve is being monitored via the chosen muscles. A stimulating current of 0.5mA - 1.0mA should be used. Careful stimulation of the sciatic nerve will result in responses from different muscles, and areas of the nerve may elicit no apparent response - these will be sensory fibres, otherwise, the surgeon is listening for any unexpected spontaneous activity. Insert the stimulator return needle in the buttock

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 2.1 (page 2) and observe where the nerves lie in relation to the muscles used to monitor the various branches.
2. Look at Figure 17.1 (page 38) to decide which nerve roots are to be monitored.
3. Only 1 hip is operated on at a time, therefore it is only necessary to monitor the affected leg.
4. Surgery involving the sciatic nerve involves nerve roots from both the lumbar plexus and the sacral plexus. Follow below Figure 17.2 as a guide to electrode placement.

LEVEL	CHANNEL	MUSCLE MONITORED
L4	1	Quadriceps
L5	2	Peroneus longus
S1	3	Medial gastrocnemius
S2	4	Abductor digiti minimi
S3	5	Anal sphincter

Figure 17.2: Suggested solution for electrode placement.

5. Tape the Subdermal Needle electrodes in position and tape the coiled wire temporarily to the inside leg so it can be retrieved once the patient is in the prone position.
6. Subdermal Needle Electrodes for the quadriceps can be inserted when the patient is either supine or prone.
7. Insert the remaining Subdermal Needle Electrodes and position the reference needle electrode in the buttock and tape down.
8. Attach the Neurosign® V4 8 Channel Pre-amplifier Pod to the side rail of the operating table.
9. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and create a Procedure Setup using 5 channels (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
10. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
11. Begin monitoring the procedure and set up a patient report (if applicable).

Note:
The use of a Monopolar Probe (PN 3602-00-TE) is recommended. Insert the stimulator return needle in the buttock. Adjust the stimulator output to 1.0mA. The stimulator probe should be connected when required rather than at the start of the surgery.

If using a Monopolar Probe, it may be necessary to counter stimulus artefact (clicking sound wherever the probe is touched). Go to Procedure Settings – Filter Settings tab – Adjust the Stimulator Artefact Rejection (SAR) up to 5ms.

18. MONITORING OF PELVIC REPAIRS

Suggested Probe: Monopolar Probe, PN: 3602-00-TE
Suggested Electrodes: 8 Channel Electrode Set, PN 4472-00

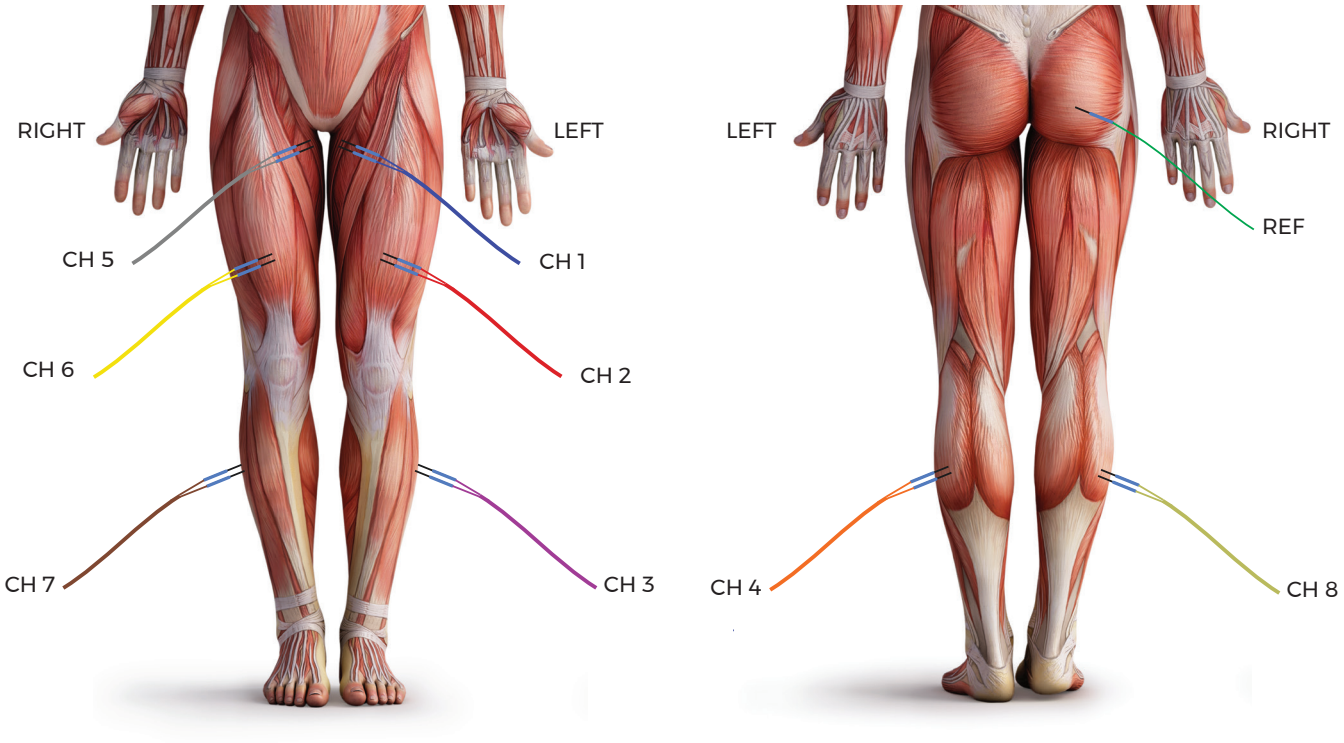


Figure 18.1: Suggested electrode placement for monitoring of pelvic repairs.

SURGICAL PROCEDURE INFORMATION

Pelvic repairs are often necessary as the result of accidents, typically involving motorcycles. The pelvis may need to be reconstructed using long screws; injury is possible from the initial trauma or from the repair itself. The Neurosign® V4 Intraoperative Nerve Monitor enables the surgeon to work knowing that any disturbance of a motor nerve being monitored will produce a warning. Because of the continuous nature of the monitoring, any pressure on a motor nerve caused by either the decompression, fragments of bone or the placement of a screw will be detected.

If desired, the surgeon can use the Monopolar Probe to stimulate the relevant nerve roots. This shows that the Neurosign® V4 Intraoperative Nerve Monitor is working correctly, and that the particular nerve root is being monitored. In the case of a trauma patient, it will also demonstrate that the motor nerve is still intact before the repair is undertaken. A stimulating current of 0.5mA - 1.0mA should be used. Otherwise, the surgeon is listening for any unexpected spontaneous activity.

NERVE MONITORING - THE PROCEDURE

1. Refer to Figure 2.1 (page 2) and observe where the nerves lie in relation to the muscles used to monitor the various branches.
2. Look at Figure 18.1 (page 40) to decide which nerve roots are to be monitored.
3. Surgery at the lumbar levels of the spine carries serious risks which the Neurosign® V4 Intraoperative Nerve Monitor can help reduce.
4. Follow below Figure 18.2 as a guide to electrode placement. The adductors can be found in the groin and the Subdermal Needle Electrodes are best inserted with the patient in supine position. The muscle can be felt as a ridge by pressing into the area firmly.

LEVEL	CHANNEL L	CHANNEL R	MUSCLE MONITORED
L2, **L3**	1	5	**Adductors**
L3, **L4**	2	6	**Quadriceps**
L4, **L5**	3	7	**Peroneus longus**, Tibialis Anterior
L5, **S1**	4	8	**Medial gastrocnemius**, Biceps Femoris
S2	Perenium		
S3			
S4			

Figure 18.2: Recommended levels and muscles in **bold**.

5. Tape the Subdermal Needle electrodes in position and tape the coiled wire temporarily to the inside leg so it can be retrieved once the patient is in the prone position.
6. Subdermal Needle Electrodes for the quadriceps can be inserted when the patient is either supine or prone.
7. Insert the remaining Subdermal Needle Electrodes and position the reference needle electrode into the buttock or biceps femoris and tape down.
8. To monitor the sacral levels S2-S4, and the pudendal nerve, insert Subdermal Needle electrodes into the perineum or anal sphincter.
9. Plug the Subdermal Needle electrodes into the corresponding color-coded sockets on the Neurosign® V4 8 Channel Pre-amplifier Pod.
10. Switch the Neurosign® V4 Intraoperative Nerve Monitor on and create a Procedure Setup using 8 channels or use the Pedicle Screw setup and reduce the stimulator current to 1.0mA (refer to the Neurosign® V4 Reference Guide/User Manual for more information).
11. Perform the electrode impedance check and ensure indicators for all channels in use display green. If not, check the electrode placement. Please note that Green impedance does not indicate that the correct muscle is being used. Green indicates that there is good impedance only.
12. Begin monitoring the procedure and set up a patient report (if applicable).

NERVE MONITORING - THE PROCEDURE

Note:
The use of a Monopolar Probe (PN 3602-00-TE) is recommended. Insert the stimulator return needle in the buttock. Adjust the stimulator output to 1.0mA. The stimultor probe should be connected when required rather than at the start of the surgery.

If using a Monopolar Probe, it may be necessary to counter stimulus artefact (clicking sound wherever the probe is touched). Go to Procedure Settings – Filter Settings tab – Adjust the Stimulator Artefact Rejection (SAR) up to 5ms.

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N-2020-001.01 EN