Peripheral Nerve Endoscopy: a cadaveric study

Ralph Mobbs

A thesis submitted in fulfilment of the requirements for the degree of Master of Surgery

Faculty of Medicine
University of New South Wales

March 2004
Abstract

Peripheral nerve problems are common and encompass a wide spectrum of diseases, traumatic injuries and mass lesions. There have been few major technical advances in peripheral nerve surgery over the last three decades with exception of endoscopic carpal tunnel release, intraoperative nerve action potential recording and nerve grafting. Certain nerves in the upper and lower extremities are vulnerable to entrapment at specific anatomic locations by virtue of there being superficial, fixed in position, or coursing across a joint. Peripheral nerve surgeons often encounter patients who suffer from these entrapment syndromes, the most common being carpal tunnel syndrome, for which endoscopic techniques have been discussed in the literature since the early 1980’s. Otherwise there have been few reports in the literature that discuss the utility of endoscopic surgery for the treatment of peripheral nerve problems. Endoscopy has however been alluded to as a possible future less invasive technique for the exploration and treatment of nerve pathologies.

Endoscopic surgery along subcutaneous and facial planes is not a new concept. Balloon dissectors have been used to create an optical cavity by separating fascial layers of a constant anatomic plane. This cavity can be maintained with either carbon dioxide insufflation or manual retraction. These fascial planes can be accessed quickly to facilitate endoscopic procedures such as bone grafting, mastectomy, cosmetic procedures and tissue expansion for reconstructive surgery to name a few. Although there have been few reports of endoscopic techniques for peripheral nerve surgery, no attempt has been made to define rules for or against an approach. The
Peripheral nerve endoscopy  
Dr Ralph Mobbs

research hypothesis of this cadaveric study is that using standard equipment available in most hospitals, and using principles of subcutaneous fascial dissection and expansion, that a select range of peripheral nerve problems can be dealt with using endoscopy.

A study using both embalmed cadaveric specimens and fresh cadavers was used to evaluate potential endoscopic techniques. From 15 potential cadavers, 12 were suitable for examination of these techniques. A set of rules was developed to decide if a nerve exposure was possible. Nerve pathology must be in expandable and “safe” planes. A safe plane is a plane that can be expanded using techniques described where there is little chance of damaging adjacent neurovascular structures. Example of a dangerous plane would include the endoscopic evaluation of the posterior interosseous nerve. Along its path proximal to the arcade of Frosche, many nerves and vessels cross its path superficially and these would be at risk in this exposure. Therefore, nerves that are applicable to the technique include those that: can be reliably located via a minimal incision, the nerve trunk lies in an expandable and safe plane and are of a suitable diameter.

To develop the techniques to a suitable technical level may be difficult with inadequate patient turnover. Also, the time and additional risk may sway the decision making for a surgeon to initially attempt these techniques. For these reasons, I cannot see wide acceptance of the techniques detailed here. However, for the surgeon who develops a busy peripheral nerve practice and who is willing to learn these techniques,
they may have a limited role for patients who request a more limited/ minimally invasive approach to their peripheral nerve problem.
Acknowledgements

I am very grateful to Dr Bartek Szandera and Marcus Cremorsce for excellent assistance with schematic illustrations and the Medical Illustration Unit at the Prince of Wales Hospital, Randwick. Line illustration production was also performed at Medici Graphics, St Vincents Hospital, Sydney.

I thank Dr Charles Teo and the instrument company M.Stenning Australia for providing endoscopic and general theatre equipment that was used to establish an operating theatre environment in the morgue at the University of New South Wales.

This work was generously supported by a foundation scholarship from the Royal Australasian College of Surgeons. Thank you to my supervisors Dr Peter Blum who initiated my interest in peripheral nerve surgery and Dr Dzung Vu who has a sincere interest in teaching and a passion for anatomy that is rarely seen.

Thanks to family and friends who have helped out during the production of this thesis. Finally, a special thanks to Lisa, Redmond, Clementine and my parents Drs Gale and Tony Mobbs.
# Table of Contents

Abstract.................................................................................................................................................................................................................. ii
Acknowledgements .............................................................................................................................................................................................. v
Table of Contents ........................................................................................................................................................................................................ vi
Table of Figures............................................................................................................................................................................................................. ix

**Chapter 1: Introduction.** ................................................................................................................................................................................................. 1
- Evolution of Neuroendoscopy ........................................................................................................................................................................ 3
- Equipment for neuroendoscopy ...................................................................................................................................................................... 8
- Surgical methods to view anatomy ................................................................................................................................................................. 16

**Chapter 2: Equipment and new instrumentation** ............................................................................................................................................. 19
- Aims for instrumentation .................................................................................................................................................................................. 20
- Equipment for this project .............................................................................................................................................................................. 21
- Balloons used for dissections ........................................................................................................................................................................ 22
- New Instrumentation ..................................................................................................................................................................................... 23

**Chapter 3: Technical considerations** ............................................................................................................................................................... 26
- Develop a plane of dissection ........................................................................................................................................................................ 28
- Maintain the plane of dissection ..................................................................................................................................................................... 29
- Endoscopy ........................................................................................................................................................................................................ 31
- Visualization/ inspection within the plane: discussion .................................................................................................................................. 32

**Chapter 4: Sciatic nerve endoscopy** ............................................................................................................................................................... 34
- Surgical objectives ............................................................................................................................................................................................ 36
- Cadaveric Approach ........................................................................................................................................................................................ 37
- Technical Report ................................................................................................................................................................................................ 40
- Discussion ....................................................................................................................................................................................................... 47

**Chapter 5: Suprascapular nerve endoscopy** ...................................................................................................................................................... 49
- Technical Report ............................................................................................................................................................................................. 51
- Methods ........................................................................................................................................................................................................... 53
- Operative technique .................................................................................................................................................................................... 54
- Discussion ....................................................................................................................................................................................................... 62
# Table of Contents

- **Chapter 6: Ulnar nerve endoscopy** .......................................................... 64  
  - Single Portal Exposure ............................................................................ 66  
  - Methods .................................................................................................. 66  
  - Discussion ............................................................................................... 69

- **Chapter 7: Sural nerve harvest via endoscopy** ...................................... 70  
  - Surgical anatomy .................................................................................... 71  
  - Advantages of Technique ....................................................................... 72  
  - Surgical approach .................................................................................. 74

- **Chapter 8: Tarsal tunnel endoscopy** ....................................................... 78  
  - Tarsal tunnel syndrome .......................................................................... 80  
  - Operative Technique ............................................................................. 81

- **Chapter 9: Other nerves attempted** ....................................................... 84  
  - Median nerve .......................................................................................... 85  
  - Brachial plexus ....................................................................................... 86  
  - Posterior Interosseous Nerve ................................................................. 87  
  - Lateral Femoral Cutaneous Nerve ......................................................... 89  
  - Peroneal ................................................................................................. 95

- **Chapter 10: Feasibility of the minimally invasive technique** .................. 96  
  - Inspection of anatomy on predissected cadavers .................................... 98  
  - Attempting exposures on the fresh cadaver ......................................... 101  
  - Rules for suitability ............................................................................... 101

- **Chapter 11: Analysis of Clinical Application** ......................................... 103  
  - What are the potential advantages of the technique? ............................. 104  
  - What are the disadvantages of the technique? ....................................... 104  
  - What pathologies are suitable for the technique? ................................. 105  
  - Who should perform peripheral nerve endoscopy? ............................. 105

- **Chapter 12: Conclusion** ......................................................................... 106  
  - Conclusion ............................................................................................. 107  
  - Where to from here? ............................................................................... 107  
  - Will this change the future of peripheral nerve surgery? ...................... 107
Table of Figures

Figure 1.1: Single portal endoscopic procedure (a) .......................................................4
Figure 1.2: Single portal endoscopic procedure (b) .......................................................5
Figure 1.3: Single portal endoscopic procedure (c) .......................................................5
Figure 1.4: Single portal endoscopic procedure (d) .......................................................5
Figure 1.5: Single portal endoscopic procedure (e) .......................................................6
Figure 1.6: Single portal endoscopic procedure (f) .......................................................6
Figure 1.7: Single portal endoscopic procedure (g) .......................................................6
Figure 1.8: Surgical Setup ..............................................................................................7
Figure 1.9: Interoperative picture ..................................................................................7
Figure 1.10: Rigid endoscope .......................................................................................10
Figure 1.11: Pen scope .................................................................................................11
Figure 1.12: Light source .............................................................................................12
Figure 1.13: Video printer .............................................................................................12
Figure 1.14: Television .................................................................................................13
Figure 1.15: Video recorder ..........................................................................................14
Figure 1.16: Advantages and disadvantages of the four viewing methods ............17
Figure 1.17: Loupe magnification – Designs for vision: x2.5 with headlight ..........18
Figure 1.18: Microscope – Carl Ziess v OPMI .............................................................18
Figure 1.19: Endoscope – Karl Storz, 0 and 30 degree .............................................18
Figure 2.1: Endoscopic setup in the morgue at University of New South Wales ....21
Figure 2.2: Expanding planes along the ulnar nerve .................................................22
Figure 2.3: Preperitoneal structural balloon ..............................................................23
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4</td>
<td>Dual-Dissector instrument for endoscopic nerve surgery</td>
<td>24</td>
</tr>
<tr>
<td>2.5</td>
<td>Proposed balloon that expands laterally to avoid damage</td>
<td>25</td>
</tr>
<tr>
<td>3.1</td>
<td>Developing a plane of dissection</td>
<td>28</td>
</tr>
<tr>
<td>3.2</td>
<td>Lateral dissecting balloons to dissect along subcutaneous planes</td>
<td>28</td>
</tr>
<tr>
<td>3.3</td>
<td>Maintain the plane of dissection (a)</td>
<td>29</td>
</tr>
<tr>
<td>3.4</td>
<td>Maintain the plane of dissection (b)</td>
<td>29</td>
</tr>
<tr>
<td>3.5</td>
<td>Maintain the plane of dissection (c)</td>
<td>30</td>
</tr>
<tr>
<td>3.6</td>
<td>Maintain the plane of dissection (d)</td>
<td>30</td>
</tr>
<tr>
<td>3.7</td>
<td>Endoscopy (a)</td>
<td>31</td>
</tr>
<tr>
<td>3.8</td>
<td>Endoscopy (b)</td>
<td>31</td>
</tr>
<tr>
<td>3.9</td>
<td>Endoscopy (c)</td>
<td>31</td>
</tr>
<tr>
<td>4.1</td>
<td>Piriformis and the sciatic nerve emerging from its inferior angles</td>
<td>38</td>
</tr>
<tr>
<td>4.2</td>
<td>View of the inferior gluteal neurovascular bundle</td>
<td>38</td>
</tr>
<tr>
<td>4.3</td>
<td>Variation of the sciatic nerve</td>
<td>39</td>
</tr>
<tr>
<td>4.4</td>
<td>Sciatic nerve lesion</td>
<td>41</td>
</tr>
<tr>
<td>4.5</td>
<td>Incision lengthened at either pole to provide greater exposure</td>
<td>42</td>
</tr>
<tr>
<td>4.6</td>
<td>Create the necessary working space</td>
<td>43</td>
</tr>
<tr>
<td>4.7</td>
<td>The proximal segment of the sciatic nerve</td>
<td>44</td>
</tr>
<tr>
<td>4.8</td>
<td>The sciatic nerve on view at the base of the exposure</td>
<td>45</td>
</tr>
<tr>
<td>4.9</td>
<td>A distal view of the sciatic nerve</td>
<td>46</td>
</tr>
<tr>
<td>5.1</td>
<td>Incision on cadaver</td>
<td>55</td>
</tr>
<tr>
<td>5.2</td>
<td>Expanded endoscopic view of operative region</td>
<td>56</td>
</tr>
<tr>
<td>5.3</td>
<td>Corresponding endoscopic view of Figure 5.2</td>
<td>57</td>
</tr>
</tbody>
</table>
Figure 5.4: Division of the ligament with a micro scissor...........................................58
Figure 5.5: The divided ligament.................................................................................59
Figure 5.6: Where to cut the transverse scapular ligament..........................................60
Figure 5.7: Before more detailed dissection ................................................................61
Figure 6.1: Exposure of the ulnar nerve at the elbow ..................................................68
Figure 7.1: Sequence of sural graft harvest .................................................................73
Figure 7.2: Incision posterior to the lateral malleolus and the sural nerve ...............75
Figure 7.3: After the nerve dissection.......................................................................76
Figure 7.4: Four incisions extending from the ankle to the political fossa..............77
Figure 8.1: Endoscopic decompression of the tarsal tunnel: right foot ..............81
Figure 8.2: Prosected specimen demonstrating the path of the posterior tibial nerve .83
Figure 9.1: Proximal forearm, right side.  Path of PIN nerve...................................88
Figure 9.2: Note the LFCN piercing the “leaves” of the inguinal ligament ............93
Figure 10.1: Median nerve at the elbow .................................................................98
Figure 10.2: Suprascapular nerve at the suprascapular notch...............................98
Figure 10.3: Gluteal specimen demonstrating piriformis muscle and sciatic nerve ....99
Figure 10.4: Ulnar nerve at the elbow .................................................................99
Figure 10.5: Radial, PIN and SSRN nerves............................................................100
Figure 10.6: List of nerve dissections attempted on the fresh cadaver..............102
Chapter 1: Introduction.

Outline of chapter:

- Evolution of neuroendoscopy.
- Equipment for neuroendoscopy.
- Methods to view anatomy.
Neuroendoscopy has developed into its own subspecialty in Neurosurgery over the last 10-15 years though the works of Hopf,1 Pernesky,1 Jones,2 Teo,3 Fukushima,4 Jho5 and many others. The general goals of neuroendoscopy are to treat diseases of the central and peripheral nervous system with minimal trauma to normal tissues and planes of dissection and therefore reduce postoperative pain, scarring, morbidity and hospital stay. The delay in development of the technique was more a reflection on the technological limitations rather than interest. Endoscopy is now commonplace in the neurosurgeons armourmanterium for intracranial and spinal pathologies.

Surgery on the peripheral nervous system using the endoscopic technique has been largely overlooked except for a few procedures such as endoscopic carpal tunnel release and thoracoscopic sympathectomy.

The research hypothesis of this cadaveric study is that, by usage of standard equipment available in most hospitals, and using principles of subcutaneous fascial dissection and expansion, a select range of peripheral nerve problems can be dealt with using endoscopy.
Evolution of Neuroendoscopy

The urologist L’Espinasse performed the first endoscopic procedure on the brain in 1910. He placed a rigid endoscope into the dilated ventricular system of a hydrocephalic patient and attempted to remove the choroid plexus. Unfortunately the patient died soon after the procedure. The famous neurosurgeon Walter Dandy performed a similar procedure on four infants of which one survived.

The technique did not develop for many decades due to the lack of suitable equipment available for safe navigation through the ventricular system. During the 1970’s there were several major advancements to the technique. Griffith and Hopkins designed the first endoscope dedicated to neurosurgery and published on the definitive treatment of hydrocephalus by choroid plexectomy. Fukushima attempted intraventricular biopsy and endoscopic surgery of the subarachnoid space. Although the concept of third ventriculostomy was advocated in 1935 by Scarff, the procedure was popularized by Vries in the 1970’s. With the evolution of improved technology, intracranial endoscopy has become a mainstay of treatment of hydrocephalus and an important adjunct to treatment of tumours and vascular lesions to name a few indications. Once a tumour is removed, the surgeon can use the endoscope to assess the degree of resection. Often, the same surgery can be carried out through a smaller craniotomy by using the endoscope, in keeping with the concept of minimally invasive, yet maximally effective surgery.
Spinal endoscopy has received an ever-increasing presence in the scientific literature with its genesis in the treatment of lumbar spine disc herniation. Endoscopic spinal techniques have the advantage of reducing the "approach-related trauma" that is problematic with spinal surgery. The indications have rapidly evolved to include both posterior and anterior approaches to the spine at all levels. Degenerative spinal disease and disc herniation are not the only pathologies treated with endoscopy with malignant cord compression benefiting from endoscopic techniques.

Decompression of the cranio-cervical junction for a type 1 Chiari malformation has also been attempted endoscopically.

Endoscopic carpal tunnel release is one of the few applications of endoscopic technology to surgery of the peripheral nervous system. Carpal tunnel syndrome was a term first used in the 1930’s to describe an entrapment neuropathy of the median nerve at the wrist. The first open carpal tunnel release was described in 1947 with little change in the technique for 50 years until the advent of the endoscopic procedure in 1990. A summary of a single portal endoscopic procedure is included here (Figures 1.1 - 1.7):

Figure 1.1: Single portal endoscopic procedure (a)

The single portal technique starts with a small transverse incision proximal to the palmer crease.
When the surgeon is confident that instruments can be placed into the carpal tunnel, a cannula (open on one side) is placed into the carpal tunnel.

The endoscope is placed into the cannula to look at the undersurface of the Transverse Carpal Ligament - to make sure that nerves and arteries are safely out of the way.

Through the cannula a special knife is inserted. This knife has a hook on the end that cuts backwards as the knife is pulled back out of the cannula.
Figure 1.5: Single portal endoscopic procedure (e)

The slot in the cannula allows the hook to cut only in the direction the slot is facing. The nerves in the carpal tunnel are protected by the tube.

Figure 1.6: Single portal endoscopic procedure (f)

Once the knife is pulled all the way back, the Transverse Carpal Ligament is divided - without making an incision in the palmar skin.

Figure 1.7: Single portal endoscopic procedure (g)

Intraoperative picture of endoscopic carpal tunnel release.
Advances in minimally invasive endoscopic techniques with significantly reduced morbidity and mortality rates has established thoracoscopic sympathectomy as a safe and effective treatment for palmer hyperhidrosis. The technique has its origins in the 1970’s \(^{20}\), and is now considered a standard procedure for this indication. High technical success and patient satisfaction rates have paralleled the increased application of this procedure in the treatment of palmer hyperhidrosis \(^{21}\). Although predominantly the domain of thoracic surgeons as the procedure involves thoracoscopy, neurosurgeons are usually involved in the dissection and division of the sympathetic chain. Figure 1.8 summarizes the surgical setup for the procedure and Figure 1.9 an intraoperative picture.

**Figure 1.8: Surgical Setup**

Intraoperative setup for thoracoscopic sympathectomy.

**Figure 1.9: Interoperative picture**

Intraoperative view of thoracic cavity prior to sympathectomy.
Equipment for neuroendoscopy

The focus for any surgeon is on the procedure rather than the equipment 22. The focus for the procedure begins with understanding the anatomy, and to appreciate the anatomy a clear view is essential. Thus the limitation for the endoscopic surgeon is not only the experience of the surgeon, but also his/her tools. Poor instrumentation will lead to poor visualization, which will lead to poor appreciation of the anatomy, which will ultimately lead to complications. Various studies have warned of the dangers of neuroendoscopy 23, so to minimize complications the neuroendoscopist must be well trained, understand the “chain” of equipment and have adequate resources backup support.

The medium and viewing cavity.

Although clear CSF and Ringer’s irrigation is the ideal working medium for intraventricular surgery, no fluid is best for surgery involving other body cavities such as the thoracic and peritoneal cavity. Intermittent irrigation and suction is usually helpful to maintain a clear view while in other cavities such as the subarachnoid space, where blood products may contaminate the endoscope lens.

The viewing cavity may already be in existence such as ventricles of the brain, or be a potential space that can be enlarged with irrigation or insufflation. Other cavities may be created with the gradual removal or retraction of normal or pathological tissues. For instance, with the removal of disc material during a percutaneous discectomy, the surgeons’ working cavity is gradually enlarged as more disc material is removed.
Rigid endoscopes.

The rigid endoscope with glass optics offers a superior view of the operative field with the benefit of additional channels to operate additional instruments. Rigid endoscope design includes (Figure 1.10):

1. Proximal end interface point with the eye or video equipment.
2. Distal end furthest point from the proximal end or users eye.
3. Insertion diameter - the diameter quoted as the actual diameter inserted into the anatomy of an endoscope sheath.
4. Instrument axis - the axis of the instrument relative to the instrument axis.
5. Optical axis - the axis of the optical path which is displaced to the instrument axis.
6. Angle of view - the angular value of displacement to the optical axis.
7. Optical field of view - the area which the conical system covers is as a cone.
8. Fibre illumination - the area which the fiber illumination covers as a cone and is greater than the optical field of view.
9. Working length - the actual length embodying the insertion diameter, which can be applied.
10. Light post input - point of the illumination when connected to a light guide and source.
11. Eye shield - used as a cup for the eye or a diameter for the attachment of video camera equipment.
Flexible Endoscopes.

The advantages of the flexible endoscope include movement and navigation in body cavities that is not possible with the rigid endoscope. Disadvantages include the reduced optical resolution, with most scopes providing 10,000 pixels up to 30,000. Also for the novice endoscopist, the difficulty to maintain orientation during a procedure remains a challenge.
**Pen scopes**

The penscope is lightweight and easy to use. Shown here (Figure 1.11) is a Murphy Scope – an endoscope designed specifically for visualization of small and difficult-to-access surgical compartments. It is a single-use, disposable product minimizes the risk of cross contamination and simplifies set-up time. The endoscope tip includes a non-traumatic rounded end to minimize trauma to surrounding tissue. The endoscopes are designed with 10,000 pixel fibers for a high-resolution image. The malleable tip of the bayonet and curved models can be reshaped per the surgeon's preference. An irrigation channel is included to maintain a clear field of view.

![Pen scope]

Figure 1.11: Pen scope
**Light source**

A xenon light source (Figure 1.12) provides superior brightness, which is important as this affects the picture quality. Most units have an automatic iris that reduces output when the scope gets close to an object to minimise potential glare.

![Light source](image)

**Figure 1.12: Light source**

**Video printer**

Pictured is a Sony Colour Video Printer - Figure 1.13. They are full-featured small format printers designed for medical and scientific applications. They provide high-resolution prints in seconds and are ideal for image creation, patient record files and patient referring copies. High quality performance is possible from almost any standard video signal.

![Video printer](image)

**Figure 1.13: Video printer**
Monitor

Designed specifically for use in medical applications, monitors must provide exceptional clarity and colour fidelity required for endoscopy, ultrasound, surgical and laboratory microscopy. Pictured is a medical monitor that offers a High Resolution picture tube, in addition to compatibility with NTSC and PAL colour systems (Figure 1.14). The design incorporates knob controls, splash guards and on-screen menus and provides flexibility and easier access to monitor setup.

Figure 1.14: Television
Video recorder

The video recorder should be designed for medical applications with digital frame memory that provides a noiseless, crystal clear "freeze" and fully compatibility with other S-VHS (or VHS) tape recordings (Figure 1.15). A compact design and optional control via RS-232C or 34-pin interface should provide convenient integration with ultrasound, endoscopy and pathology systems.

Figure 1.15: Video recorder
**Equipment in Development**

There are a variety of new instruments to assist the endoscopic surgeon. An endoscopic positioning stand that takes weight off a surgeon's hand, reduces operating room crowding, gives more precise control, and allows position locking is being trailed. Often when performing endoscopic surgery, the surgeon must maintain very demanding postures while holding various tools and graspers. The prototype passive assistive mechanism ("SFU Laparoscopic Stand") offers the surgeon a fixed structure for manipulating and holding tools in any desired configuration.

Stereotactic guidance systems for endoscopic surgeons are already in use that combines precise tool-position information from sensors. Developments in both flexible and rigid endoscopy have centred around reducing the diameter of the part of the endoscope that is inserted into the operative cavity. With flexible endoscopes, applications are being pursued to image the interiors of arteries for visualizing potential targets for laser angioplasty. Gradient-index objective lenses with diameters down to 0.25 mm are commercially available for these applications.

Larger diameter flexible fibre endoscopes are being replaced by solid-state video devices, which can provide excellent resolution in the same package size. These video chips provide colour imaging and can be made arbitrarily long. If these video devices can be reduced in size to less than 3 mm, they could even be used in place of some rigid endoscope relay lens systems.
Surgical methods to view anatomy

Although anatomy does not change, the technique by which you view anatomy does and this may provide alternative information from which the surgeon may alter his/her approach to a procedure. The surgeon has at their disposal essentially four methods to view anatomy (Figures 1.17-1.19):

i. Naked eye.

ii. Loupe magnification (x2.0 to x5.5)

iii. Operating microscope.

iv. Endoscope (0, 30 and 70 degree).

Surgeons have long recognized the value of magnification and illumination \(^{24}\). Neurosurgery was revolutionised with the introduction of the operating microscope by Yasargil.\(^{25}\) With the superior magnification of deep structures, the indications for neurosurgery were broadened and the specialty became safer. Many authors state the introduction of the endoscope will have a similar effect in the specialty of neurosurgery.

The author conducted a study of 17 surgeons who use loupe magnification, microscope and endoscopy to review the potential benefits of the microscope and endoscope as compared with loupe magnification and naked eye vision \(^{26}\). The superior illumination and variable magnification of the endoscope and microscope was seen as a major benefit. As a teaching tool, the microscope was seen as considerable benefit over loupes and the endoscope was again seen as a benefit over
the microscope as the assistant is involved in the procedure to either manipulate the endoscope or endoscopic instruments. See Figure 1.16 to summarize the advantages and disadvantages of the four viewing methods.

Figure 1.16: Advantages and disadvantages of the four viewing methods

<table>
<thead>
<tr>
<th>Feature</th>
<th>Naked eye</th>
<th>Loupes</th>
<th>Microscope</th>
<th>Endoscope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnification</td>
<td>Nil</td>
<td>Fixed</td>
<td>Variable</td>
<td>Variable</td>
</tr>
<tr>
<td>Illumination</td>
<td>Nil +/- head lamp</td>
<td>Nil +/- head lamp</td>
<td>Superior</td>
<td>Superior</td>
</tr>
<tr>
<td>Incision</td>
<td>Big patient = big incision.</td>
<td>Big patient = big incision.</td>
<td>Optics determine size of incision</td>
<td>Potentially minimal incision</td>
</tr>
<tr>
<td>Surgeon neck fatigue</td>
<td>Yes</td>
<td>Yes</td>
<td>Reduced</td>
<td>Minimal</td>
</tr>
<tr>
<td>Look “around corners”</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes (30 and 70 degree scope)</td>
</tr>
<tr>
<td>Teaching</td>
<td>Assistant excluded</td>
<td>Assistant excluded</td>
<td>Assistant included</td>
<td>Assistant integral to procedure</td>
</tr>
<tr>
<td>Infection risk</td>
<td>Increased with larger incision</td>
<td>Increased with surgeons bumping heads.</td>
<td>Potentially reduced</td>
<td>Reduced due to limited incision and minimal tissue trauma.</td>
</tr>
<tr>
<td>Cost</td>
<td>Nil</td>
<td>Minimal</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Time to setup</td>
<td>Nil</td>
<td>Minimal</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Figure 1.17: Loupe magnification – Designs for vision: x2.5 with headlight

Figure 1.18: Microscope – Carl Zeiss v OPMI

Figure 1.19: Endoscope – Karl Storz, 0 and 30 degree
Chapter 2: Equipment and new instrumentation

Outline of chapter:

- Aims for instrumentation.
- Equipment for this project.
- Balloons used for dissection.
- New instrumentation.
As carpenters rely on their tools, so do surgeons rely on their instruments. Evolution of neurosurgery as a specialty in the last 50 years can be partly attributed to advancements in magnification and illumination. Pioneers such as Yasargil during the 1970’s further refined the surgical adjuncts available with advances such as a balanced microscope stand, mouthpiece and hand controls. Along with naked eye vision, the modalities for illumination and magnification at the neurosurgeons disposal now include the loupe/ headlight combination, the microscope and the endoscope. Combinations of these tools have been reported and their combined use will likely increase in the future. With new operative techniques, it follows that new instrumentation will be necessary to aid the proposed technical advances. New instrumentation will either help with the initial exposure or dissection during the operation.27

**Aims for instrumentation**

1. Development of instruments that reduce the number of times that instruments change hands between the surgeon and scrub nurse. Advantages include minimization of time as considerable time is lost with slow or inaccurate instrument transfer in the OR and reduction of infection as increased instrument handling increases infection.

2. Develop tools that aid in the initial exposure of the operative field in a safe and technically easy manner.

3. Minimize the time a surgeon has to remove his/her vision from the video screen28, and thus time reduction with refocus on the screen and insertion of new instruments.
Equipment for this project

Laboratory

The cadaveric work was performed in the mortuary located at the University of New South Wales, School of Anatomy (Figure 2.1). The fresh cadavers were paid for by a grant from the Royal Australian College of Surgeons.

![Endoscopic setup in the morgue at University of New South Wales](image)

*Figure 2.1: Endoscopic setup in the morgue at University of New South Wales*
Endoscopic equipment

Endoscopes, light source, leads and video camera equipment was provided by N.Stenning Australia (174 Parramatta Rd, Camperdown, Australia) and Dr C.Teo (Director, Centre for Minimally Invasive Neurosurgery, Randwick, Australia).

Balloons used for dissections.

1. Standard catheter balloons were used for subcutaneous tissue expansion, as they are cheap and easy to use (Figure 2.2). A standard 5cc urine catheter used to expand planes along the ulnar nerve.

![Figure 2.2: Expanding planes along the ulnar nerve](image)

2. Structural balloons (Figure 2.3) used for abdominal surgery were initially tried however damage to neurovascular structures with the initial insertion rendered the use of this device as unsafe and was discontinued early in the study.
New Instrumentation

Dissector / Hook

The role of a blunt nerve hook in peripheral nerve surgery (PNS) is indispensable. The addition of a blunt dissector at one pole of an instrument and a blunt nerve hook at the other pole is a valuable addition that gives the operating endoscopic surgeon additional dissecting power without the change of instruments.

Dual Blunt Dissector / Sharp Dissector

The “Dual-Dissector”:

If the surgeon can blunt dissect in one direction (say distal to the operator), then sharp dissect in the reverse direction (say towards the operator), this will be a major advantage in PNS as entrapment neuropathies usually require the blunt dissection of the pathology prior to division of the constricting band or point of entrapment (Figure 2.4).
Figure 2.4: Dual-Dissector instrument for endoscopic nerve surgery

Enables the surgeon to blunt dissect away from the endoscope and sharp dissect towards the instrument. Designed by Dr RJ Mobbs, made by Eve instrument makers, Randwick, Australia.

**Structural Balloon**

A standard structural dissecting balloon will expand in all planes. A pre peritoneal balloon will expand in a longitudinal plane to develop the pre peritoneal plane. These balloons have been used in a variety of subcutaneous tissue expansion studies (plastic/axillary space dissection).\(^{29}\)

The goal of a structural balloon for EPNS (endoscopic peripheral nerve surgery) is to develop a plane while limiting the pressure exerted on the nerve.
I propose a new type of balloon (Figure 2.5) that will inflate sideways, so that minimal pressure is exerted on the nerve.

**Figure 2.5: Proposed balloon that expands laterally to avoid damage**
Chapter 3: Technical considerations.

Outline of chapter:

- Develop a plane of dissection.
- Maintain the plane of dissection.
- Visualization/ inspection within the plane: discussion.
If initial consideration of anatomy on the prosected specimen deems a nerve suitable for the endoscopic technique, technical details must be considered. For each nerve the initial exposure is detailed and a plane of dissection developed. A variety of techniques were used in an attempt to maintain a subcutaneous plane. Difficulties encountered were mainly due to availability of an assistant. Endoscopes of different angulations were trailed to review which scope was most appropriate for each indication.
Develop a plane of dissection.

Once a nerve has been located via a minimally invasive exposure, developing a plane is performed using balloon dissection (Figures 3.1 and 3.2). Urinary catheter balloons were used for this purpose with 5, 10 and 20ml capacity balloons.

Figure 3.1: Developing a plane of dissection

Figure 3.2: Lateral dissecting balloons to dissect along subcutaneous planes
The author is developing a range of dissecting balloons to dissect along subcutaneous planes. As the line drawing demonstrates (Figure 3.2), the balloon should preferentially dissect longitudinally to avoid pressure on the nerve.

**Maintain the plane of dissection.**

*Figure 3.3: Maintain the plane of dissection*  
(a) Using an airtight portal, gas insufflation can be used to elevate a plane. The difficulty with this approach is the high risk of damaging the nerve when inserting the port “blind”. This approach was abandoned after several failed attempts.

*Figure 3.4: Maintain the plane of dissection*  
(b) Suture elevation can be helpful when the surgeon has no assistant! The difficulty with this technique is that once a suture is elevating a plane, to make minor adjustments may take time and slow a procedure down.
Figure 3.5: Maintain the plane of dissection (c)
Retractors are readily available in a variety of sizes as blade lengths. Depending upon the skill/patience of the surgeons’ assistant, the retractor can prove to be the most useful instrument to elevate planes of dissection.

Figure 3.6: Maintain the plane of dissection (d)
“Span” Elevators: a novel invention of the author. To maintain a maximal elevation of a subcutaneous plane, a disposable device that expands on application was devised. Unfortunately no instrument company was interested in development of the concept at this stage.
Endoscopy

Figure 3.7: Endoscopy (a)
The 0 degree endoscope is useful for straight ahead or “line of sight” view. Most useful when looking directly down on an object (suprascapular nerve). Not useful when looking along the shaft of a nerve.

Figure 3.8: Endoscopy (b)
The 30 degree endoscope is the most useful scope for a variety of applications. The slight angulation of the viewing angle lends itself to vision along the path of a nerve trunk.

Figure 3.9: Endoscopy (c)
The 70 degree scope has little to offer in endoscopy of the subcutaneous planes. Although it is maximally of use when “looking around a corner”, it was not routinely used in this study due to difficulty of appreciating anatomy at such a sharp angle.
Visualization/inspection within the plane: discussion

The purpose of reviewing the technical details was to discuss the minimally invasive endoscopic techniques used and how performed. An attempt to use carbon dioxide gas insufflation to perform nerve exposures within the subcutaneous and fascial tissue planes was performed, based on the previous work of aesthetic plastic surgeons\textsuperscript{30}, however the risk was considered too high for damage to a nerve trunk with the initial use of a blunt trocar introducer.

Specific instrumentation was gradually adapted to the techniques discussed, more out of need than for any other reason (Figures 3.1 – 3.9). A standard setup was utilized to dissect within the subcutaneous and fascial planes of the cadaver. An ultrasonic scalpel would improve visualization by avoiding electrocautery smoke, however it was not available for this study.

Numerous problems encountered from a technical perspective include:

1. Creation of a tent-shaped cavity with the use of mechanical retractors.
2. One of the hands of the surgeon is necessary for retraction if an assistant is not available
3. Instrument crowding
4. External supporting devices may be necessary if no assistant available
5. The skin's intrinsic elasticity may be lost if the cadaver is too old
6. Carbon dioxide insufflation may have numerous advantages but was too
difficult to use and the risk too great in the opinion of the author.

Similar approaches to facial plane surgery are being used by a variety of other
specialties:

1. Cardiothoracic,\textsuperscript{31}
2. Plastic/aesthetic,\textsuperscript{32}
3. Head and neck,\textsuperscript{33}
Chapter 4: Sciatic nerve endoscopy

Outline of chapter:

- Surgical objectives.
- Cadaveric approach.
- Technical report based on an operative case.
- Discussion of technical report.
A sciatic nerve lesion is uncommon. In this chapter we review the approach used for endoscopy on the sciatic nerve on the cadaver, then report the utility of the endoscope in an 18-year-old female with multiple lesions of her sciatic nerve. We describe a simple technique of endoscopic exploration of the sciatic nerve to assist intraoperative decision making. The case report is based on cadaveric work on sciatic nerve endoscopy, which is discussed.
Surgical objectives

Injuries to the sciatic nerve cause neurologic deficit to the peroneal and tibial nerve distributions, with more severe deficits to the peroneal division compared to the tibial. The long course of the sciatic nerve leaves it vulnerable to nerve injury from a variety of causes including misguided injection, hip arthroplasty, fracture or dislocation, and from prolonged compression, such as during coma. Sciatic nerve neuropathies caused by mass lesions or by the piriformis muscle are rare.34,35

Surgical approaches to the sciatic nerve for exploration involve long incisions and extensive dissection to visualize an appropriate length of nerve.36 Long incisions with substantial dissection result in more pain and prolonged postoperative recovery. If the gluteus maximus muscle bulk is divided to expose the superior aspect of the nerve adjacent to the sciatic notch or piriformis muscle, this results in significant postoperative morbidity. There is little information in the literature that reviews approaches to the sciatic nerve for exploration. For proximal sciatic nerve tumour and trauma however, wide exposure for adequate visualization may be necessary.37

An alternative novel minimally invasive approach that may be used for sciatic nerve inspection and exploration was developed.
Cadaveric Approach

The sciatic nerve is potentially a useful nerve for endoscopy due to the favourable anatomy of this structure at the inferior border of the gluteus maximus. Based on the cadaveric dissections, the nerve is located with relative ease between the biceps femoris and semi memb/tendinosus muscle groups. If there was a high content of adipose tissue in the cadaver, this could make the depth of dissection very deep and render the technique impossible.

Developing a plane superficial to the sciatic nerve in the cadaver was performed with ease. Even in the thin specimen, there was a well-defined fat plane around the nerve that could be developed with blunt ended dissecting scissors. Elevating the planes that had been developed either in a proximal or distal direction was performed with a hand held retractor and a good assistant! A 30 degree endoscope was of most benefit as the operator can visualize along the path of the nerve and then rotate the scope 180 degrees to visualize the superficial tissues (Figures 4.1 and 4.2). As the anatomy of the sciatic nerve is variable (Figure 4.3), a potential additional use of the technique could be for inspection of the nerve prior to lengthening the incision. The light source from the 30-degree endoscope highlights the region of the piriformis muscle and the sciatic nerve emerging from its inferior edge. The gluteus muscle has been deflected to demonstrate the anatomy (Figure 4.1).
Figure 4.1: Piriformis and the sciatic nerve emerging from its inferior angles

The endoscope has now been rotated 180 degrees. The operator would now have a view of the inferior gluteal neurovascular bundle, not of the sciatic nerve. The 30 degree endoscope can therefore be used to give the operator a greater appreciation of the anatomy than a “straight shot” 0 degree endoscope (Figure 4.2).

Figure 4.2: View of the inferior gluteal neurovascular bundle
Figure 4.3: Variation of the sciatic nerve
Technical Report

An 18 year old female presented with pain on the posterior aspect of her thigh, leg and the base of her foot. She also had moderate weakness of ankle dorsi flexion with disturbance of gait. Lumbar spine imaging was negative, however pelvic/thigh MR demonstrated multiple lesions of her right sciatic nerve (Figure 4.4). A decision to explore the sciatic nerve was made to remove a lesion that presented to the surface of the nerve for biopsy.

The patient was placed in the prone position on a Wilson frame in a similar posture for spinal surgery. A limited incision was made to locate the sciatic nerve just inferior to the gluteus maximus muscle bulk (Figure 4.5). The sciatic nerve was located between the lateral biceps and medial semi-tendinosus muscle bulk by finger palpation. A long blade retractor (Figure 4.6) was used to ‘lift’ the gluteus muscle bulk so that an endoscope could be introduced for visualizing the proximal section of the sciatic nerve (Figure 4.7). The plane of dissection for introduction of the retractor blade is made easily as the nerve is enveloped in a fat along a fascial plane. The plane can be created with either finger dissection or blunt dissection using the scissors superficial to the nerve. The retractor creates a working space for the endoscope and instruments. A view as far as the piriformis muscle was possible using a 30-degree endoscope with detailed observation of the nerve lesions. Although the nerve was in view at the base of the wound, the endoscope was used to document a single snapshot of the nerve for later study (Figure 4.8). The distal aspect of the nerve could also be
explored using the same technique of retractor elevation of the superficial tissues (Figure 4.9).

A single lesion was taken for biopsy following exploration of the nerve. Histopathology revealed schwannoma of the nerve.

The arrow points toward the sciatic nerve lesion. Note the marked wasting of the gluteal muscles, likely due to entrapment of the gluteal neurovascular bundle by a lesion.

Figure 4.4: Sciatic nerve lesion
The incision can be lengthened at either pole to provide greater exposure if necessary.

Figure 4.5: Incision lengthened at either pole to provide greater exposure
Retractors are used to access areas to create the necessary working space.

Figure 4.6: Create the necessary working space
The proximal segment of the sciatic nerve is clearly visible using the endoscope. Note the retractor blade in the superior aspect of the picture lifting the gluteal bulk so as to create a working space. The white arrows outline the inferior aspect of the piriformis muscle. The black arrows demonstrate the medial aspect of the nerve. The two-tone arrow points toward a nerve tumour presenting to the surface.

Figure 4.7: The proximal segment of the sciatic nerve
The black arrow points superiorly toward the piriformis muscle, the white arrow inferiorly. Note the incision in the inferior aspect of the nerve from where a large encapsulated tumour was removed.

Figure 4.8: The sciatic nerve on view at the base of the exposure
The black arrow points toward another lesion. The white arrow is the border of the semitendinosus muscle.

Figure 4.9: A distal view of the sciatic nerve
Discussion

The presented case demonstrates that endoscopic techniques may reduce the need for extensive open surgical dissections, as discussed by previous authors.\textsuperscript{38} Although the schwannoma was removed from the sciatic nerve at the base of our exposure using loupe magnification, the endoscope added value to the procedure by documenting the gross appearance of the nerve and aiding in decision making for the most appropriate lesion to remove. The trend in neurosurgery of treating disease with minimally invasive techniques to reduce approach related trauma is also applicable to peripheral nerve surgery.

Issues of safety require discussion. If the operator is not confident of the anatomy or pathology, then a more open exposure is necessary as damage to the sciatic nerve can leave the patient with markedly reduced function of the lower limb. The incision that we propose is for proximal sciatic nerve pathology only. In addition, our approach enables the surgeon to lengthen the incision in both directions to expose a greater length of nerve if the need arises. Following exploration, the surgeon may need to extend only one pole of the incision, thereby reducing the amount of approach related trauma. The issues of safety will be answered by a prospective clinical series.

Body habitus is a major factor that may render the technique impossible. If the patient has a high degree of adiposity, the sciatic nerve may be very deep and difficult to find in a limited exposure. The angle of approach made by the endoscope into the wound (Figure 4.5) may be difficult if the distance between the skin surface and the
nerve is too long. The length of the endoscope would be a factor as a short shaft may not reach the depth of the wound. The type of endoscope (i.e.: 0, 30 or 70 degree) is a factor as the endoscope shaft is not able to be introduced in parallel with the nerve, and thus a 30 or 70 degree endoscope may be necessary to “look around the corner” of the subcutaneous retracted edge to visualize the nerve. Retraction of the subcutaneous tissues to create a working space is also challenging if these tissues have a high adipose content and the retractor blade is very deep, or the assistant is incapable of the necessary retraction. Fixed retractor blades similar to cranial endoscopy is not an option, as the limb cannot be “fixed in space” as with the cranial vault with 3-point pin fixation.

Each surgeon must decide if they will accept a new technique given the limitations on the learning curve involved. The author believes however that the techniques outlined in this chapter are not difficult to conceptualise or perform, and that morbidity would be minimal.
Chapter 5: Suprascapular nerve endoscopy

Outline of chapter:

- Technical report based on an operative case.
- Methods.
- Operative technique.
- Discussion.
The suprascapular nerve (SScN) is derived from the upper trunk of the brachial plexus from C5,6. The nerve traverses the floor of the posterior triangle and passes beneath the superior transverse scapular ligament \(^{40}\). The function of this ligament in the human is uncertain.\(^{41}\) The nerve then supplies supraspinatus, infraspinatus and the posterior aspect of the capsule of the shoulder joint. The nerve has also been described to have cutaneous branches \(^{42}\).

Suprascapular neuropathy is an uncommon cause of shoulder pain and weakness and therefore may be overlooked as an etiologic factor \(^{43}\). Entrapment of the SScN was first reported in the literature in 1932.\(^{44}\) Interestingly, humans are not the only mammals that are affected by this entrapment neuropathy,\(^{45}\) with the canine entrapment syndrome treated by partial osteotomy of the notch.\(^{46}\) The diagnosis of suprascapular neuropathy is based on clinical findings and abnormal electrodiagnostic test results, however magnetic resonance imaging can reach a positive, topographic and etiologic diagnosis of SScN entrapment.\(^{47}\) The suprascapular nerve is susceptible to compression at the suprascapular notch, and more rarely at the spinoglenoid notch. Causes of suprascapular neuropathy include traction injury at the level of the superior transverse scapular ligament or the spinoglenoid ligament, ganglion cysts, nerve tumours\(^{48}\), ligamentous calcification\(^{49}\) and direct trauma to the nerve.

The syndrome often afflicts athletes, particularly those in basketball, volleyball, weight lifting, and gymnastics. The chief complaint is the insidious onset of a deep, dull aching pain in the posterior part of the shoulder and upper periscapular region.
The pain is noncircumscribed and does not involve the neck or radiate down the arm. Weakness is confined to the supraspinatus (i.e., in the initiation of shoulder abduction) and to the infraspinatus, the only muscle responsible for external rotation of the humerus. Atrophy of these muscles causes hollowing of the infraspinous fossa and prominence of the scapular spine. (Atrophy of the supraspinatus is not obvious due to the overlying trapezius.) Deep pressure over the midpoint of the superior scapular border may produce discomfort.

Operations for decompression of the suprascapular notch have been described from the anterior and posterior aspect. Advantage of the anterior approach includes identification of the superior trunk of the brachial plexus and subsequent accurate localization of the suprascapular nerve, which can then be followed to the scapular notch. The posterior approach is a more direct route to the notch, however the difficulty is that the depth of the exposure makes operating around the suprascapular artery and nerve challenging.

**Technical Report**

A 41-year-old healthy female presented with a 14-month history of left shoulder weakness following a low speed motorbike accident. There was no associated pain. Shoulder external rotation was weak at 3 out of 5. The weakness resulted in significant morbidity with daily duties. Investigations included somatosensory evoked potentials of the SSrN and demonstrated response differences consistent with
neuropathy at the level of the superior transverse scapular ligament. MRI was unhelpful.

The author has trailed various endoscopic techniques on the cadaveric model including anterior and posterior approaches to the suprascapular notch. A posterior approach is described here as this was considered the most safe. Following general anaesthesia, the patient was positioned supine with a large sandbag under the ipsilateral shoulder. A 3cm incision was made medial to the suprascapular notch (Figure 5.1) and blunt dissection performed until the superior border of the scapulae was reached. To avoid damaging the suprascapular artery, the initial approach was purposely made medial to this structure. After the superior border of the scapula is reached, dissection is performed laterally along the superior border until the palpating finger could feel the superior transverse scapular ligament. At this stage the endoscope was inserted and the superior transverse scapular ligament visualized (Figures 5.2 and 5.3). A dissector was used to delineate the full extent of the ligament. A nerve stimulator was used at this point to verify the SScN.

Following clear visualization of the boundaries of the ligament, a straight micro scissors was used to divide the ligament under direct vision (Figure 5.4). After division of the ligament (Figure 5.5), the nerve is inspected with a blunt nerve hook to verify that no further compressive elements are present. The patient was discharged within 24 hours of surgery. At 12 months follow-up, her shoulder pain has settled and external rotation power is now 4+/5. Restoration of muscle wasting is incomplete,
however previous authors have commented on this finding following SScN decomposition.\textsuperscript{51}

**Methods**

Of 15 cadavers operated on, 12 were suitable for examination. On the first cadaver, the incision and approach was made directly over the suprascapular notch, and as a consequence the suprascapular artery was damaged with the approach. On the living patient, this complication would be disastrous, as the operative field would be blocked out with arterial blood. In addition the two ends of the artery may retract proving haemostasis very difficult. A further two cadavers had calcified superior transverse scapular ligaments that were unable to be divided and the procedure abandoned.

These two patients would have either a type V or VI suprascapular notch as based on the classification of Rengachary et al.\textsuperscript{52}

Retraction down the narrow corridor can be prepared with either a nasal speculum or versa-trak\textsuperscript{TM} system. The retraction also aids in haemostasis as the muscle bulk is placed under stretch. Haemostasis is also aided by initial infiltration with a vasoconstricting agent.
Operative technique

General anaesthesia with the patient positioned supine. A large sandbag should be placed under the midscapular region to lift the superior scapula region into view. A linear incision is made medial to the notch. Image-intensification may be used to check that the approach is medial to the notch. This is an important point, as you do not want to approach the notch from directly above, and risk damaging the artery, which lies superior to the transverse scapular ligament.

Blunt dissection through the muscle bulk of trapezius and supraspinatus until the superior border of the scapular is reached.

An appropriate retractor system is used to create the corridor necessary to introduce instruments.

With endoscopic view, blunt dissect in a lateral direction along the superior border of the scapular until the medial insertion of the ligament is reached.

Using a blunt hook, palpate around the ligament and identify the nerve. From the cadaveric experience, the nerve is located laterally in the suprascapular notch and therefore the operator should divide the ligament as medial as possible.

To confirm the suprascapular nerve, a nerve stimulator can be used.

Haemostasis can be achieved with bipolar cautery and care should be taken when removing the retractor to localize any bleeding points.

Normal arm movement should commence the following day from surgery to help minimize scar entrapment of the nerve.

Discharge could be either the same day or the next day depending on patient co-morbidities.
The incision is made medial to a vertical line made by the coracoid process.

Figure 5.1: Incision on cadaver
Figure 5.2: Expanded endoscopic view of operative region
The black arrows (x4) outline the superior transverse scapula ligament. The white arrows (x2) outline the suprascapular nerve. Note that to the left of the white arrows, the artery can be seen passing superficial to the ligament.

Figure 5.3: Corresponding endoscopic view of Figure 5.2
Note that the endoscope was retracted from the operative field to make the introduction of the sharp scissor safer.

Figure 5.4: Division of the ligament with a micro scissor
The divided ligament (black arrows) and the released nerve (white arrows). Note the indentation of the suprascapular nerve due to the compressing ligament.

Figure 5.5: The divided ligament
Following the dissection of multiple cadavers, the suprascapular nerve was consistently seen to be running in the lateral aspect of the notch (star). The arrows point to the medial aspect of the notch where the ligament has a broad attachment (Figure 5.6). The ligament can be safely divided in this location.

Figure 5.6: Where to cut the transverse scapular ligament
The Figure 5.7 demonstrates the Figure 5.6 before more detailed dissection. The white arrows delineate the notch. The black arrow points toward the suprascapular nerve.

Figure 5.7: Before more detailed dissection


**Discussion**

Neuroendoscopy follows a general trend in neurosurgery of treating disease with minimally invasive techniques to reduce approach related trauma of normal tissues and to improve visualization of intraoperative pathology. Although peripheral nerve surgery does not lend itself well to minimally invasive techniques, authors have proposed that “improved imaging combined with evolving endoscopic techniques may reduce the need for extensive open surgical dissections”\(^{53}\). A standard approach and exposure of the SScN involves extensive muscle dissection and therefore results in a painful incision and prolonged postoperative recovery. The endoscope allows superior illumination and magnification at depth making possible a narrow corridor to the pathology. This narrow corridor can be made with minimal muscle dissection and maintained with adequate retraction.

The issue of safety is paramount. With all new proposed approaches, the operator must be comfortable with the anatomy and the equipment, in this case the endoscopy set-up. In our study there was one unintentional nerve division during the approach/exposure (\(1/15 = 6.7\%\)). In this case, while attempting to locate the ligament, vigorous dissection was performed with a scissor rather than the safer option of the surgeons’ finger. Over time, issues of safety will be answered by a prospective clinical series. Randomised Control Trials will not be possible due to the small number of these entrapment lesions that present to the peripheral nerve surgeon. To reach an adequate number of patients would require too lengthy a study. In conclusion, each surgeon must decide if they will accept a new technique given the
limitations of the learning curve. Compressive lesions attributable to suprascapular notch entrapment had the best improvement with surgical decompression\textsuperscript{54}. Endoscopy provides the venue for these improvements to be performed in a less invasive manner.
Chapter 6: Ulnar nerve endoscopy

Outline of chapter:

- Single Portal Exposure.
- Methods.
- Discussion.
Peripheral nerve endoscopy
Dr Ralph Mobbs

Ulnar neuropathy at the elbow (UNE) is the second most common entrapment neuropathy of the upper limb, next to carpal tunnel syndrome. Most frequently, UNE occurs in the region of the retroepicondylar (ulnar) groove due to various pathological processes.\(^{55}\) In 23\% of cases in one study, no specific cause could be identified.\(^{56}\) The remainder can be attributed a variety of aetiologies including: external pressure, intragroove pressure due to repetitive flexion, chronic stretch associated with valgus deformity, tight anatomical confines within the cubital canal, bony/scar impingement, anomalous muscles/bands and mass lesions.\(^{57,58}\)

The clearest way of classifying UNE is anatomically. Entrapment can occur at four locations about the elbow joint. From proximal to distal these are 1. The medial intramuscular septum/Arcade of Struthers, 2. The retroepicondylar groove, 3. The humeroulnar arcade (true cubital tunnel syndrome), 4. The exit point from the flexor carpi ulnaris through the deep flexor pronator aponeurosis.\(^{59}\) Traditionally, diagnosis of UNE has relied primarily on clinical and electrophysiologic evaluation with occasion use of roentgenography and thermography.\(^{60,61}\) Magnetic Resonance Imaging (MRI) is emerging as a potential addition to the assessment of UNE, allowing more precise anatomical localisation.\(^{62}\) To the author’s knowledge there have been three other studies reporting the utility of MRI for UNE.\(^{63,64,65}\)

In addition to MRI for assessment of UNE, the role of endoscopy has been discussed in the literature. Although not a major focus in this study, the author has attempted endoscopy on this nerve with potential benefits to the standard exposure.
Single Portal Exposure

Endoscopy as a new technique for endoscopic release of the ulnar nerve at the elbow has been designed for cubital tunnel syndrome and discussed by some authors. One group makes a series of three 5 mm incisions along the line of the ulnar nerve with the skin and subcutaneous tissue lifted to produce a provisional space. As discussed in Chapter 3, this would produce a “tent” shaped cavity. An endoscope was inserted through the one incision, and the constricting ligaments and fascia were released using a retrograde knife inserted through the other incision under endoscopic vision. This group has treated eight patients and successful results were achieved. Potential benefits include an earlier return to work and daily activity due to early healing of incisions and minimal post-operative pain.

The author has been attempting a “single portal” exposure to achieve the same goals on the cadaver.

Methods

The anatomy of the ulnar nerve at the region of the elbow lends it self to a minimally invasive exposure due to its relative superficial course and proximity to easily found structures, such as the medial epicondyle. Locating the nerve proximal to the epicondyle results in the most rapid and safe exposure, as the nerve is unlikely to be affected by pathologies at this level, as it is proximal to the cubital tunnel. After the nerve has been identified, dissection in a proximal and distal direction is usually not difficult due to the fat planes around the nerve (Figure 6.1).
After visualization of the nerve and adequate retraction to create a working space, the nerve can easily be dissected free using the endoscope in one hand and dissecting scissors in the other hand. From commencing the dissection proximal to the epicondyle, the nerve can be dissected until it reaches the level of the flexor carpi ulnaris (FCU), which is the endpoint of exposure in a standard dissection. Figure 6.1 represents a “standard” exposure of the ulnar nerve for surgery on an entrapment neuropathy. Using endoscopic inspection, the author believes this incision can be limited to one third of the incision shown.

This exposure of the ulnar nerve at the elbow demonstrates the usual site of entrapment at the cubital tunnel. To endoscopically expose the nerve, the nerve can be initially located proximal to the elbow (gray arrows) or distal (white arrows). The author initially exposed the nerve proximally, however due to technical difficulties now exposes the nerve at the region of the FCU (white arrows) and endoscopically dissects proximally.
Figure 6.1: Exposure of the ulnar nerve at the elbow
Discussion

The difficulties of utilizing this approach for patients however include:

The ulnar nerve in the region of the entrapment may well be scarred to surrounding tissues, such as the fibres than comprise the cubital tunnel. This could potentially make the exposure dangerous if the operator could not appreciate the anatomy of the nerve endoscopically.

If you dissect in a proximal to distal direction, you therefore have to introduce instruments from an axilla to hand direction. On the operating table, in practical terms, this requires the operator to be standing/sitting at the axilla of the patient and to be directing the instruments in an un-ergonomical direction with “crowding”.

For the reasons outlined above, it may well be easier to expose the nerve distal to the epicondyle and dissect in a proximal direction. This certainly makes the procedure easier for the surgeon who can now stand/sit in a more comfortable position and introduce instruments in an “uncrowded” fashion.
Chapter 7: Sural nerve harvest via endoscopy

Outline of chapter:

- Surgical anatomy.
- Advantages of minimally invasive harvest of sural nerve.
- Technique: Surgical approach.
Surgical anatomy

The sural nerve passes down the posterolateral side of leg and onto dorsal aspect of lateral side of foot, giving rise to lateral calcaneal branches (the medial branch supplied by tibial nerve). Its terminal branches consist of lateral dorsal cutaneous nerve and the lateral calcaneal branches. The sural nerve, which lies superficial to the deep fascia below knee, is used as guide to the tibial nerve as one can follow the sural nerve upwards to pierce deep fascia and lead to the tibial nerve which is its parent trunk.

Except for unmyelinated autonomic fibres, the sural is entirely sensory. It innervates lateral & posterior third of leg and lateral aspect of foot and heel & lateral portion of the ankle.

The main role of this nerve to the peripheral nerve surgeon is to provide cable grafts. Up to 25 cm of nerve graft may be harvested and used as a cable graft. The blood supply to the sural nerve usually comes thru the muscular perforating branches of the posterior tibial artery or cutaneous branches of the peroneal artery.
Advantages of Technique

The usual procedure to harvest a sural nerve graft requires a long incision that is essentially the same length as the length of graft that is required. Thus, if the surgeon requires a 20 cm graft to reconstruct a nerve, the incision will be at least 20cm. For many patients, a long incision simply adds to the overall trauma of the surgery which usually will have two or more incisions depending on the nerve reconstruction procedure.

There have been several reports in the literature outlining minimally invasive approaches to harvest the sural nerve. A recent report details the use of a vein harvesting technique using a sharp, round vein “stripper” to harvest the nerve. A problem with this technique is that the surgeon does not visualize the procedure and haemostasis is not secured at the time of harvest. The technique outlined by the author gives the operator the option of using bipolar diathermy during the harvest for haemostasis (Figure 7.1).

An additional long leg incision has many disadvantages:

1. Cosmetically poor, especially for young women.
2. Potentially a slow healing incision for patients with diabetes.
3. Patients will not mobilize in the postoperative period as rapidly with a long and potentially painful incision. This has follow-on effects with an increased risk of chest and DVT risk.
4. Psychologically a patient feels not as “damaged” by the surgery if a minimalist approach is adopted.

Figure 7.1: Sequence of sural graft harvest
Surgical approach

The above Figure 7.1 summarises the surgical approach to a minimally invasive harvest of the sural nerve:

1. **Part 1** demonstrates the outline of the sural nerve. It is essential that the surgeon has landmarks for the nerve and mark out on the skin this outline. The most reliable location to find the nerve however is at the classic spot for a “sural nerve biopsy”, being posterior to the lateral malleolus approximately half way between the malleolus and the tendo-achilles (Figure 7.2-7.3).

2. **Part 2** shows the introduction of an endoscope at the starting point. The surgeon has a variety of ways of dissecting the nerve. These include, but are not limited to, balloon dissection or simply using a dissecting scissor under endoscopic guidance, which is the preferred method of the author. When the length of the endoscope has been reached with the dissection, the surgeon has to make a further incision so that the process can be repeated again (Figure 7.4).

3. **Part 3** shows that 3 mini-incisions are usually all that is required to harvest a long length of nerve, say greater than 20 cm in length that would be suitable for most reconstructive procedures. Brachial plexus reconstruction may require longer grafts and it is commonplace to harvest 2 sural nerves. In this case the procedure could be repeated on the contra lateral leg. The incisions are quick to close and the usual pressure bandage that is used for a long incision may not be necessary.
A 1.5cm incision has been made posterior to the lateral malleolus and the sural nerve identified in a standard fashion. A Mollison retractor has been used to keep the exposure open. The direction that the endoscope is angled is demonstrated. If an assistant were present, a fixed blade type retractor would be inserted to create space for additional instruments.
Figure 7.3: After the nerve dissection

This figure demonstrates that after the nerve has been dissected for as long as possible given the length of the endoscope, a new incision can now be made using the light of the endoscope as a guide. Even if the cadaver has a relatively high level of adiposity, the intense light from the endoscope can still be seen through the skin to guide an incision. Most standard endoscopes have a length of 12-15 cm, therefore to harvest a length of nerve of 20-25 cm, three incisions is enough.
There are 4 incisions extending from the ankle to the political fossa. The distal three incisions would be adequate for most reconstructive procedures and the total length of the incision would be under 5cm, rather than 25+cm. The main difficulties encountered include the division of side branches and maintenance of haemostasis during the procedure. Issues of haemostasis were not a problem with the cadavers however! Another technical consideration is that the patient would have to be positioned prone for the nerve harvest as the supine position makes the procedure very difficult.
Chapter 8: Tarsal tunnel endoscopy

Outline of chapter:

- Tarsal tunnel syndrome.
- Operative technique.
- Figures.
Tarsal tunnel syndrome (TTS) is defined as an extrinsic or intrinsic compression neuropathy of the posterior tibial nerve or one of its branches \(^{67}\), first described in 1962 \(^{68}\). Although far less common, TTS is analogous to the carpal tunnel syndrome at the wrist \(^{69}\). Symptoms consist of longitudinal arch pain, plantar anaesthesia or paraesthesia, exacerbated with activity or after prolonged ambulation \(^{70}\).

The roof of the tarsal tunnel is the flexor retinaculum and is formed by the deep fascia of the leg and the deep transverse fascia \(^{71}\). The proximal and distal borders of the tunnel are formed by the inferior and superior margins of the flexor retinaculum. As the tibial nerve passes behind the medial malleolus and through the tarsal tunnel it proceeds to bifurcate into cutaneous branches, articular branches and vascular branches. The main divisions of the posterior tibial nerve include the calcaneal, medial plantar nerve and lateral plantar nerve branches \(^{72}\).
Tarsal tunnel syndrome

There is a large range of aetiologies that have been associated with the TTS, including idiopathic, post-traumatic, neoplastic, inflammatory factors, varicosities, tenosynovitis, cysts and neurilemmoma. In addition there have been 7 reports in the literature of TTS related to an anomalous muscle.

Although electrodiagnostic studies are not an absolute diagnostic measure, radiography, computed tomography and magnetic resonance imaging have been successfully used to determine any bony or soft tissue aetiologies for TTS. Comparison to carpal tunnel syndrome can be made. Anomalous structures around the wrist have been documented as a possible causative factor for carpal tunnel syndrome, so it is no surprise that anomalous structures adjacent to the ankle have been documented.

Cadaveric studies have investigated tibial nerve tension as a potential causative factor for TTS and concluded that tibial nerve tension increases within a surgically created cadaveric pes planus foot.
Operative Technique

Figure 8.1: Endoscopic decompression of the tarsal tunnel: right foot

The operative sequence of endoscopic decompression of the tarsal tunnel: right foot exposure is demonstrated in Figure 8.1.

The aim of endoscopic division of the flexor retinaculum begins with the initial identification of the tibial nerve. If the nerve is always in the vision of the surgeon, the risk of damaging the nerve is reduced. The surgeon must initially position the patient so that the ankle landmarks can be appreciated and the path of the nerve (and its branches the medial plantar nerve, lateral plantar nerve and medial calcaneal nerve marked out on the skin. The initial incision involves a linear cut approximately 5cm superior to the medial malleolus in a line that is bisected by the medial malleolus and tendo-achilles.
Following identification of the neurovascular bundle, the nerve can be further identified by the use of a nerve stimulator to visualize the flexion of the plantar muscles of the foot that are supplied by the branches of the tibial nerve. Using blunt dissecting scissors, a plane of dissection can be initiated superficial to the nerve and the plane maintained by fixed blade retractors. The endoscope can be inserted to visualize the nerve and sequentially divide the fibres of the flexor retinaculum that are superficial to the nerve. If the tarsal tunnel is very “tight” and the constricting bands of the retinaculum are difficult to elevate from the tibial nerve, a blunt dissector should be first introduced to create a plane between the nerve and retinaculum prior to division of the retinacular fibres.

The extent of the decompression distally is not an exact science. The surgeon should evaluate how tight the tunnel created by the retinaculum is at each stage of division of this structure. If an anomalous muscle or a nerve sheath tumour is encountered, the surgeon should abandon the endoscopic technique and adopt an open approach and lengthen the incision to visualize the full extent of the pathology.
Figure 8.2: Prosected specimen demonstrating the path of the posterior tibial nerve

In Figure 8.2, the proximal blunt probe is well above the “tarsal tunnel” and may serve as an initial site for identifying the nerve. The middle probe is inserted within the tunnel, which has been partially opened proximal to the middle probe. The distal probe demonstrates the medial plantar nerve, well beyond the tarsal tunnel.
Chapter 9: Other nerves attempted

Outline of chapter:

- Median nerve at elbow.
- Brachial plexus.
- Posterior Interosseous Nerve.
- Lateral Femoral Cutaneous Nerve.
- Peroneal.
Median nerve

Problems affecting the median nerve at the level of the elbow include the pathologies: supracondylar spurs & ligaments (Struthers), fractures of the humerus (supracondylar) in children, elbow dislocation, injection injury and the pronator teres syndrome. Pain in the volar forearm exacerbated by repeated pronation is a classic sign, with little weakness or sensory loss.

The author initially considered that the median nerve at the elbow would offer itself to an endoscopic exposure due to the relative superficial course and the flexibility of the superficial structures such as the skin and subcutaneous fat planes. Using the biceps tendon at the elbow as a landmark, a small incision was made proximal to the elbow crease and the median nerve located with little effort.

Although technically possible, the procedure was abandoned for several reasons:

1. An entrapment at this location is very rare. For a surgeon to become comfortable with a new technique, there must be a minimum limit to the number of procedures performed to upkeep a particular skill. This nerve at this location would not support such numbers.

2. To reach the Anterior Interosseous Nerve would require elevation of planes that would not readily accept elevation, such at the flexor digitorum superficialis.

3. The brachial artery; the potential to damage this large vessel makes the procedure unappealing.
Brachial plexus

Exposures for brachial plexus surgery are usually extensive. A minimally invasive approach to the brachial plexus for pathologies such as cervical band/rib or reconstruction would be most welcomed. Unfortunately the complexity of anatomy in this region renders this an unworkable option. The complexity of the facial planes, branching patterns from the trunks and cords, vascular structures, bony structures and thoracic duct make any minimalist approach to this region far too dangerous. Although anatomy was reviewed on the cadavers, any serious attempt to explore this structure endoscopically was abandoned.


**Posterior Interroseous Nerve**

The posterior interoseous nerve (PIN) is the deep motor branch of radial nerve and supplies all of the extrinsic wrist extensors except for the extensor carpi radialis longus. The PIN passes through the supinator muscle in its course from anterior to the posterior surface of the forearm. The most common site for entrapment of the nerve is the arcade of Froche, this arcade being absent in full term foetuses but is present in 30% of adults and may develop in response to repeated rotary movement of forearm. Inciting causes for dysfunction of this nerve include; radiocapitellar joint ganglions and synovitis and congenital tightness of ligamentous arcade of Frohse.80,81

The technique for decompression of the PIN involves two approaches: Anterior and Posterior. The anterior approach is more advantageous since is allows decompression of all points of compression including fibrous bands, radial recurrent vessels, the arcade of Frohse and distal edge of the supinator at its exit. The posterior approach only allows decompression at the proximal and distal aspects of the supinator muscle.

A proposed incision on the anterolateral aspect of the arm just proximal to elbow flexion crease. Dissection was performed between brachialis & brachioradialis to locate the radial nerve in the distal aspect of the arm, just proximal to elbow flexion crease. The radial nerve was traced from proximal to distal. Difficulties were encountered however.
To elevate the muscle bulk that overlies the PIN was difficult. In addition there were numerous vessels encountered that were at a high risk of being damaged with the exposure (Figure 9.1). This approach was therefore abandoned.

Figure 9.1: Proximal forearm, right side. Path of PIN nerve

This specimen demonstrates the radial nerve dividing into the PIN and the SSRN. The probe is inserted into the arcade of Froche. If a surgeon attempts to identify the radial nerve at the elbow level, elevating the muscle/fat/skin planes would be too dangerous with potential to damage recurrent radial vessels and more superficial cutaneous nerves.
Lateral Femoral Cutaneous Nerve

Meralgia paresthetica (MP) is a syndrome of pain, an isolated disturbance of sensation, or both in the distribution of the lateral femoral cutaneous nerve (LFCN). It usually starts with numbness or a tingling, burning pain and evolves into hypeaesthesia, which is painful in the anterolateral thigh. The male to female ratio is 2.8:1 and the involved side is split evenly between the right - 36% and the left 38%. The remaining 22% of cases present with bilateral symptoms. The majority of patients experience a decrease of touch, pain and temperature but preserved pressure sensation in the LFCN distribution. There are multiple aetiologies for this condition but obesity is an important factor with 90.7% of patients being overweight (> 79.5 kg). A recent weight gain of 6.8 to 9 kg has been reported in up to 8% of patients with this condition. Operative treatment is by either neurolysis or transection. The question of the superior technique is unsettled, because no critical analysis comparing results of both techniques is available.

Werner Hager, a German surgeon gave the first description of an injury to the LFCN in 1885. His patient complained of thigh pain following a hip trauma on the dance floor! The name “meralgia parasthetica” was given 10 years later by Roth. The vunerable of the nerve has been investigated by many authors and a reflection of the unique course of the nerve.

The preferred surgical treatment for MP after more conservative management has failed remains controversial. In theory, the release of the presumed entrapment in the region of the anterosuperior spine of ileum should work and neurolysis, if properly performed, should relieve symptoms more often than it does. The high rate of
success of conservative treatment should be borne in mind when deciding whether to operate. In a study of 21 patients, neurolysis was successful in 3 out of 10 patients and transection in 9 out of 11. The authors concluded that neurolysis yielded a nonsignificant improvement, in comparison with previous conservative treatment, and transection resulted in a significant improvement.

**Surgical Anatomy:**

**Pelvis**

The LFCN has its origin in the lumbar plexus from the 2nd and 3rd lumbar segments. As its name suggests, it is purely a sensory nerve. The nerve travels downward lateral to the psoas muscle and crosses the iliacus muscle (deep to the iliac fascia – a dense layer of fascia). The deep circumflex iliac vessels which course parallel to the inguinal ligament beneath the iliac fascia, traverse the nerve, as it exists the abdomen.

**Thigh**

The LFCN then passes either through or underneath the lateral aspect of the inguinal ligament (Figure 9.2), and finally travels to innervate the lateral thigh. It divides into an anterior and posterior branch and supplies skin on lateral aspect of thigh.

**Variations**

The anatomy of the lateral femoral cutaneous nerve was investigated through dissection of 104 human anatomic specimens by Aszmann et al. The variability of
its course and locations as it exists the pelvis is described and related to soft-tissue and bony landmarks. They described five different types of LFCN:

i. type A, posterior to the anterior superior iliac spine, across the iliac crest (4 percent);

ii. type B, anterior to the anterior superior iliac spine and superficial to the origin of the sartorius muscle but within the substance of the inguinal ligament (27 percent);

iii. type C, medial to the anterior superior iliac spine, ensheathed in the tendinous origin of the sartorius muscle (23 percent);

iv. type D, medial to the origin of the sartorius muscle located in an interval between the tendon of the sartorius muscle and thick fascia of the iliopsoas muscle deep to the inguinal ligament (26 percent);

v. type E, most medial and embedded in loose connective tissue, deep to the inguinal ligament, overlying the thin fascia of the iliopsoas muscle, and contributing the femoral branch of the genitofemoral nerve (20 percent).

The results of this study suggest that the lateral femoral cutaneous nerve is most susceptible to mechanical trauma when the nerve is type A, B, or C. In another study by Hospodar, the course of the nerve was variable, but was most commonly found at 10-15 mm from the ASIS and as far medially as 46 mm from the ASIS. In no prosection did the nerve pass lateral to the ASIS (even though historically the nerve is thought to pass lateral to the ASIS in 10% of population).
Two types of exposures of the LFCN have been described. In the first type, the incision for the infrainguinal approach is made 3 cm below and parallel to the inguinal ligament down to the fascia lata, which is incised in the same direction. The LFCN is exposed medially to the sartorius muscle by blunt dissection of the fascia lata. The nerve is then followed proximally toward the inguinal ligament. In the second type, the incision for the suprainguinal exposure runs 1 cm above and parallel to the inguinal ligament. The fascia is incised, and subsequently, the peritoneum is encountered by a muscle-splitting incision. The suprainguinal approach allows accurate identification of the LFCN in its intrapelvic retroperitoneal course. The nerve is followed distally to the inguinal ligament. Either type of exposure is suitable for neurolysis.
Sites of entrapment:

![Figure 9.2: Note the LFCN piercing the “leaves” of the inguinal ligament](image)

**Decision making re suitability:**

The question that first needs to be asked: is anatomy reliable enough to expose nerve with a minimally invasive exposure? As can be appreciated from the marked variability of this nerve in the thigh, we do not believe that the LFCN offers itself to a minimally invasive exposure and therefore not suitable for endoscopic techniques. The option of making an incision superior to the inguinal ligament, and then attempting to expose the nerve in a preperitoneal fashion was considered. The problem however is that if the operator uses a pre-peritoneal structural balloon (e.g.: EPS-400 SpaceSEAL® 10/11mm - Extraperitoneal Proximal Separator ) to expose the iliac fascia, the surgeon must be comfortable in intrabdominal surgery in addition to nerve surgery.
Recommendations for clinical application

At this point in time, I do not recommend an endoscopic visualization of the LFCN via either an abdominal or thigh based approach for the treatment of meralgia paresthetica for the following reasons:

1. Size of the nerve. As the nerve is a sensory nerve only, it has a small diameter and therefore can be very difficult to locate in a minimalist incision.

2. Variation of the anatomy of the nerve.

3. Inconsistent opinions in the literature in regards to the most suitable approach for this problem.
Peroneal

The common peroneal nerve is derived from L4-S2 as a part of the sciatic nerve. Entrapment of this nerve usually results in the clinical syndrome of “foot drop”.

Operative treatment involves external neurolysis of the common peroneal nerve at the level of the fibular head. The nerve is usually entrapped by thick fibrous bands which arch over the nerve as it crosses the fibular neck. The standard approach for decompression of this nerve requires a fairly small incision, so a decision was made early to abandon an endoscopic approach, as there was little to be gained in terms of limitation of incision and dissection.
Chapter 10: Feasibility of the minimally invasive technique

Outline of chapter:

- Inspection of anatomy on predissected cadavers.
- Attempting exposures on the fresh cadaver.
- “Rules” for suitability.
- List of nerve dissections attempted on the fresh cadaver.
Peripheral nerve endoscopy  
Dr Ralph Mobbs

Initial consideration must be given to whether a particular nerve is suitable for the endoscopic technique. Anatomy was first reviewed on prosected specimens with emphasis on potential expandable planes superficial to the nerve trunk. If a nerve was deemed suitable for the technique, an exposure was attempted on the fresh cadaver. This was important as the fresh cadaver retains some degree of tissue flexibility early after death. During this process, a set of rules was established to divide those nerves that are suitable and those that are not. Clinical application thus far has been attempted on a variety of nerves such as the suprascapular, sciatic and ulnar nerves.
Inspection of anatomy on predissected cadavers

Some examples of inspection of anatomy on prosected specimens.

Figure 10.1: Median nerve at the elbow

Figure 10.2: Suprascapular nerve at the suprascapular notch
Figure 10.3: Gluteal specimen demonstrating piriformis muscle and sciatic nerve

Figure 10.4: Ulnar nerve at the elbow
Figure 10.5: Radial, PIN and SSRN nerves
Attempting exposures on the fresh cadaver

Performing standard exposures of peripheral nerves on the cadaver is identical to exposing nerves on the living patient in the operating theatre. Most of the cadavers were “fresh” and therefore skin incisions and the use of retractor systems were very similar to normal conditions (Figure 10.1 – 10.5). After a standard incision was performed, an incision that exposed the nerve with as little tissue trauma was undertaken. The incision would also have to be an adequate size to introduce instruments.

Rules for suitability

1. Does the incision conform with a Line of Tension?
2. Does the nerve have reproducible anatomy at a specific location to permit a minimally invasive exposure.
3. Is patient to fat?
4. Is potential incision directly over a joint?
Figure 10.6: List of nerve dissections attempted on the fresh cadaver

List of nerves examined on each of the 15 cadavers, including initial suitability of the technique.

<table>
<thead>
<tr>
<th>Cadaver No.</th>
<th>Was cadaver suitable?</th>
<th>If Not – why not.</th>
<th>Brachial Plexus</th>
<th>Ulnar/AEL</th>
<th>Median/AEL</th>
<th>PIN/AEL</th>
<th>SScN/STSL</th>
<th>SScN/ITSL</th>
<th>Sciatic</th>
<th>Tibial/TTL</th>
<th>Sural/graft</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Y</td>
<td></td>
<td></td>
<td>B</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Y</td>
<td></td>
<td></td>
<td>B</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>N</td>
<td>Excessively fat – initial exposure impossible.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>N</td>
<td></td>
<td></td>
<td>U</td>
<td>B</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>N</td>
<td>Cadaver “too old” – no elasticity of subcutaneous planes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>B</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td>U</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Y</td>
<td></td>
<td></td>
<td>B</td>
<td>U</td>
<td>U</td>
<td>B</td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>U</td>
<td>B</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>N</td>
<td>Excessively fat – initial exposure impossible.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td>U</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

PIN = posterior interosseous nerve  
SScN = suprascapular nerve  
STSL = superior transverse scapular ligament.  
ITSL = inferior transverse scapular ligament.  
AEL = at elbow level.  
TTL = tarsal tunnel level  
U = Unilateral exposure of nerve.  
B = Bilateral exposure of nerve.
Chapter 11: Analysis of Clinical Application

Outline of chapter:

- What are the potential advantages of the technique?
- What are the disadvantages of the technique?
- What pathologies are suitable for the technique?
- Who should perform peripheral nerve endoscopy?
What are the potential advantages of the technique?

The advantages include:

1. Limitation of wound incision size.\textsuperscript{90}
2. Minimization of postoperative scar formation and complications such as progressive scar entrapment of peripheral nerves and scar contracture over joints.\textsuperscript{91}
3. Cosmesis.\textsuperscript{92}
4. Reduction of postoperative pain due to minimization of skin and subcutaneous tissue dissection.\textsuperscript{93}
5. Early return to work.\textsuperscript{94}

What are the disadvantages of the technique?

Disadvantages can be summarized under the two headings of safety and time constraints. If a surgeon suggests a new technique for an already established and safe procedure, they must be able to provide evidence that the new procedure is at least as safe as the previous. The issue of time constrains in the hospital system is an important one. There is no doubt the techniques discussed in this report would lengthen the time of any given procedure. The addition time and expense of setting up for endoscopy should be factored into the decision making process. Also, the surgeon would take longer using the endoscopic technique than an open and many surgeons would find the “fiddle factor” too annoying and revert to the open procedure.
What pathologies are suitable for the technique?

Nerve entrapment syndromes lend themselves to the technique as a decompressive procedure is usually simple and can be performed using endoscopic guidance. Nerve tumours may be suitable for inspection, however the author is not recommending endoscopy for removal of nerve sheath tumours at this stage. Trauma is an absolute contraindication to nerve endoscopy as the peripheral nerve is usually buried in scar tissue. Development of planes of dissection is difficult and not possible using the endoscopic approach as detailed here. Harvest of sural nerve graft however is a very promising advancement as these patients are usually left with long and painful scars.

Who should perform peripheral nerve endoscopy?

Surgeons who attempt peripheral nerve endoscopy should have at least the following credentials:

1. Well established in peripheral nerve surgery.
2. Can perform an open technique on a particular peripheral nerve with safety prior to attempting an endoscopic approach.
3. Have some background knowledge of endoscopy (IE: 2D vs. 3D).
Chapter 12: Conclusion

Outline of chapter:

- Conclusion.
- Where to from here?
- Will this change the future of peripheral nerve surgery?
Conclusion

The aim of the study was to determine whether peripheral nerve exposure can be achieved using minimally invasive endoscopy equipment available in most hospitals. The study has demonstrated that selective nerve exposures and pathologies are suitable for the novel minimally invasive techniques developed by the author.

Where to from here?

Any new technique should be tested by the rigors of a prospective clinical trial and time. The techniques proposed here are no different and the author is commencing a prospective series to examine the questions of suitability and safety.

Will this change the future of peripheral nerve surgery?

The author will continue to perform the conventional “open” procedures for most patients. In the prospective series, patients will be given the option of having an endoscopic procedure performed. An appropriate consent process will also be required as safety issues are not yet established.

The techniques developed have specialist application and the use would be indicated by patient interest following appropriate consultation and consent.
Appendix

Presentation at meetings

Presentations of the techniques described herein have been presented at:

2. The Australasian College of Surgeons (May 2003).

Video footage on CD-ROM

The attached CD ROM has two videos:

1. Intraoperative suprascapular nerve decompression.
2. Cadaveric peripheral nerve exposures.
References


14 Perneczky A, Muller-Forrell W, van Lindert E, Fries G. Keyhole Concept in Neurosurgery. Thieme, Stuttgart, Germany, 1999


86 Kline DG. Comment on “Operative Treatment of Meralgia Paresthetica: Transection versus Neurolysis” Neurosurgery 37(1); 1995: 63


88 Aszmann OC, Dellon ES, Dellon AL. Anatomical course of the lateral femoral cutaneous nerve and its susceptibility to compression and injury. Plast Reconstr Surg 1997 Sep;100(3):600-4

89 Hospodar PP. Anatomic study of the lateral femoral cutaneous nerve with respect to the ilioinguinal surgical dissection. Journal of Orthop Trauma. 13(1); 1999: 17-19.


