Electronic Poster Abstracts

EP1. Time To Surgery And Travel Distances For Brachial Plexus Surgery: A Population-Based Perspective

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Introduction: Despite the importance of timely evaluation and treatment of patients with brachial plexus injuries, we have noted delays in referral. Because the majority of published experience with treatment of brachial plexus injuries is from individual centers, we used a population-based approach to better evaluate the referral patterns associated with these patients.

Materials and Methods: We used statewide administrative databases from California (2007-2011), Florida (2007-2013), New York (2008-2012) and North Carolina (2009-2010) to create a cohort of patients who underwent surgical treatment of brachial plexus injuries, as identified by CPT codes. These states and years were selected based on data availability for the initial injury, surgical treatment, and ZIP code of patient residence. Emergency department and operative records were used to determine the time interval between the injury and surgical treatment. The distances between the treating hospitals and between the patient's home ZIP code and the surgical hospital were recorded. Chi-square testing was used to analyze the relationships among patient demographics, hospital characteristics, time-to-surgery, and travel distances.

Results: There were 231 patients included in our cohort (mean age 46 years; 42% female). The mean time from injury to surgery was 9.8 months (min 2 days, max 24 months). Time from injury to surgery exceeded 12 months in 33% of cases. Predictors for delay to surgery over 12 months included initial treatment at a rural hospital (p=0.02), initial treatment at a non-teaching hospital (p=0.008), initial treatment at a hospital with less than 400 beds (p=0.01), and changing insurance types between the injury and surgery (p=0.02). Neither distance between the two treating hospitals nor changing hospitals between the injury and surgery significantly influenced time to surgery. For the 134 patients with available home ZIP code data, the median distance from the patient's home ZIP code to the surgical hospital was 14.7 miles (interquartile range: 7.3, 39), with 19% and 11% of patients traveled more than 50 miles and 100 miles for surgery, respectively. Increased travel distance for surgery was not associated with delay in time to surgery.

Conclusions: Our population-based analysis demonstrates distinct risk factors (mainly associated with the characteristics of the initial treating hospital) for delay to surgery over 12 months. These findings can be used to inform administrative and policy efforts to expedite the timely referral of patients with brachial plexus injuries to centers experienced in their care.

EP2. Revision Decompression of Ulnar Nerve at the Elbow

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Introduction: The failure rate after cubital tunnel release has been reported to be from 0 up to 80 percent. We sought to determine the success and the need for revision after primary cubital tunnel at our institution.

Materials and Methods: A retrospective chart review of all patients undergoing ulnar nerve surgery at the elbow from February 1989 to May 2009 was performed. Forty-one randomly selected consecutive patients treated from May 2008 to October 2008 were selected as controls.

Results: A total of 1279 ulnar nerve surgeries at the elbow from February 1989 to May 2009 was performed on 1232 adult patients aged from 20 to 94 years old (52 ± 17 years). There were a total of 768 males (62.4%) and 464 females (37.6%). All patients had minimum of four years after index surgery with an average follow up of 23.36±29.14 months. Only 17 patients (19 procedures) met the inclusion criteria. All patients had their primary nerve decompression surgery at our institution with a rate of 2.1 % recurrence rate requiring revision decompression. The average age of patients undergoing revision was 49.8±15.9 years at index surgery. The revision surgery was performed at average age of 52.12±16.3 years. Six cases (31.57%) had persistent symptoms and 13 cases (68.42%) had recurrent symptoms after index surgery. During revision surgeries, 9 (50%) patients had isolated neurolysis, 5 (27.8%) subcutaneous transpositions, and 4 (22.2%) submuscular transpositions. There were no complications in this group. Revision ulnar nerve decompression at the elbow had a success rate of 94.7% in improving associated symptoms. Comparative study to the controls, did not demonstrate any effect of sex, handedness, affected side, preoperative grip, apposition, and opposition strengths, preoperative static two-point discrimination and the incidence of revision nerve decompression. Younger age at presentation (49.73±15.03 compared to 58.02±13.28 years), a greater static two-point discrimination of 10.07±2.99 mm compared to 8.44±3.44 after decompression, and a greater likelihood of diabetes were associated with cubital tunnel requiring revision surgery.

Conclusion: Ulnar nerve compression neuropathy at the elbow has an incidence of 1.5% failure rate after primary decompression at the elbow with 89.4% improvement in symptoms. Sex, preoperative provocative test, electrophysiology findings and McGowan classification did not demonstrate any correlation to recurrence. Patients requiring revision surgery were on average 8.4 years younger, and more likely to have diabetes. Additionally pain was a more common presenting symptom compared to weakness and paresthesia in controls (odds ratio of 2.39).

EP3. The Vascularized Vastus Lateralis Nerve Graft Based on the Descending Branch of the LFCA for Immediate Facial Nerve Reconstruction

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Introduction: In the setting of ablative head and neck surgery in the periauricular area the resulting defect often requires a combined reconstruction of soft-tissue and facial nerve. In this study we investigate the vascular anatomy of the vastus lateralis nerve to be use as a vascularized nerve graft in combination with an ALT-flap and present its application in a clinical case.

Methods: In five cadavers the vastus lateralis motoric nerve (VLMN) and its vascular pedicle were dissected and measured. In two vascularized VLMN a radiopaque contrast was injected, CT-angiography with three-dimensional reconstructions was performed to visualize nerve's vascular supply. The VLMN graft has then been applied in a clinical case in combination with an ALT flap for immediate facial nerve reconstruction and the outcomes are described.

Results: The VLMN showed a division into an oblique proximal and a descending distal branch in 70% of the dissections. Mean maximal length of 8.4 ± 4.5 cm for the oblique division and 15.03 ± 3.87 cm for the descending division. The mean pedicle length was 2.93 ± 1.69 cm until crossing the oblique and 3.27 ± 1.49 cm until the descending division respectively. Three-dimensional CT-angiography documented that the entire VLMN perfusion is provided by branches from the descending branch of the lateral femoral circumflex artery. The clinical case was performed in a 67 year-old patient diagnosed of a squamous cell cancer in the external auditory canal required resection of sternocleidomastoid muscle, mastoid bone, external ear, parotid gland, 7 cm of facial nerve and neck dissection. The vascularized VLMN along with an ALT-flap were applied. Nerve coaptation by interposition oft he VLMN between facial nerve stump and distal marginal and buccal nerve branches. Selective masseter nerve transfer to a nerve branch to the zigomaticus major muscle was also performed. Vascular anastomoses were performed to the facial artery, facial and external jugular vein. Follow-ups at 3 months showed increase tonicity of the facial muscles and at 6 months smile restoration was observed.

Conclusion: The vascularized vastus lateralis nerve in combination with the ALT-flap is a technical reliable alternative in immediate reconstruction of composite defects in the periauricular area including the facial nerve.

Figure 1. Photograph of the cadaveric dissection oft eh VLMN showing the two main nerve branches, oblique and descending with its corresponding vascular pedicles

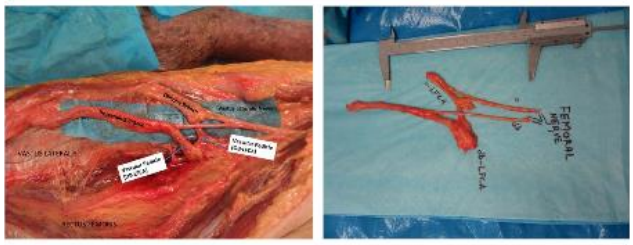
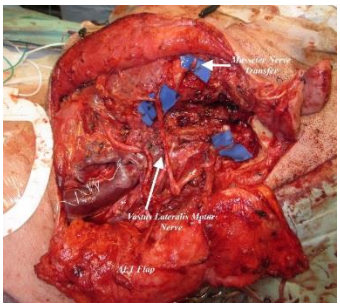


Figure 2. Intraoperative image oft he clinical case showing the reconstruction of the facial nerve with the VLMN and Masseter nerve transfer



EP4. Normal And Abnormal Paraneurial Tissues Create Strain Gradients In Rat Sciatic Nerves

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Introduction: Peripheral nerves stretch during joint movement, and demonstrate heterogeneous tensile properties along their length. Elevated strains can play a role in the progression of entrapment neuropathies, such as carpal tunnel syndrome. Surgical management of entrapment syndromes often require decompression of soft tissues surrounding the nerve, including natural adhesions referred to as the paraneurium. However, the effect that these surrounding tissues have on nerve kinematics is unknown. In this study we use a rat sciatic nerve model to determine the role of normal and surgically-induced paraneurial adhesions on regulating the distribution of peripheral nerve strain.

Materials & Methods: The sciatic nerve was exposed from the sciatic notch to its trifurcation in 10-week-old male Lewis rats (n=12). A tissue marking pen was used to draw five epineurial surface markers at 3-4mm increments along the nerve. The nerve was divided into proximal and distal regions relative to the central marker. The nerve was imaged with the knee flexed to 90° and ankle neutral (nerve relaxed), and with the knee fully extended and ankle maximally dorsiflexed (nerve stretched). Strains were measured using ImageJ (NIH) based on marker-to-marker distances in the stretched position relative to the relaxed position. Paraneurial tissues were then released from the nerve and imaging and kinematic analysis was repeated. After six weeks of monitoring, the sciatic nerve was again exposed, and strains measured as above before and after decompression of newly formed adhesions. Mean strains were compared using 2-way ANOVA (factors: time(0 or 6 weeks) and surgical intervention (exposure, decompression)). At each time point, frozen cross-sectional slices of proximal and distal regions were assessed using trichrome labeling (connective tissue) and immunolabeling with anti-laminin and anti-neurofilament antibodies.

Results: At 6 weeks, changes in nerve course through its bed and extra-epineuriual connective tissue were observed. Distal strain was significantly higher than proximal strain prior to decompression of either normal paraneurial tissues (0 weeks) as well as newly formed adhesions (6 weeks) (11.5% +/-6.5, $P<0.001$, and 8.3% +/-7.6, $P<0.05$, respectively). After decompression of either normal or newly formed adhesions, there was no significant difference in strain between proximal and distal regions.

Conclusion: Both normal and surgically-induced adhesions created a similar strain gradient in the rat sciatic nerve, despite differences in anatomical nerve course and fibrosis. Surgical decompression of both normal and surgically-induced paraneurium eliminated this strain gradient. Further studies are needed to determine the effect of paraneurial tissues on nerve function.

EP5. The Effect of Roflumilast, a Clinically Available Phosphodiesterase-4. Inhibitor, on Axonal Regeneration in a Rat Model of Peripheral Nerve Injury

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Introduction: The debilitating nature of peripheral nerve injuries and the limited success of surgical repair make it important to explore pharmacological means to enhance nerve regeneration. We have recently shown that rolipram, a phosphodiesterase-4 inhibitor that elevates cAMP, promotes peripheral nerve regeneration and significantly increases the numbers of motor and sensory neurons that regenerated axons after nerve transection and repair in rats. However, rolipram is only used for research purposes; it is not indicated for clinical use. With the development of roflumilast, a phosphodiesterase-4 inhibitor currently being used clinically for the treatment of chronic obstructive pulmonary disease, there is interest in investigating its potential role in human peripheral nerve regeneration.

Methods and Materials: Using aseptic technique and inhalation anesthesia, acutely axotomized common peroneal (CP) nerves were sutured to a freshly cut CP nerves in 20 male Wistar rats. The animals were then treated daily for 14 days with roflumilast (dose 1.0mg/kg/day) or vehicle (Methocel suspension only) orally by gavage. Fourteen days after nerve anastomosis, Fluororuby was applied to the distal stump of the CP nerve 10mm from the repair site for enumeration of motor and sensory neurons that regenerated their axons.

Results: No significant difference was found in the peripheral nerve regeneration following axotomy and repair between the vehicle group and the roflumilast-treated group of rats. The number of motoneurons that regenerated in rats treated with roflumilast was 132 +/- 16 (mean +/- standard error), compared to 167 +/- 11 treated with vehicle. The number of sensory neurons that regenerated after treatment with roflumilast was 414 +/- 38, compared to 474 +/- 53 with vehicle. Neither the motoneurons nor the sensory neurons showed a significant difference in axon regeneration between the two groups using an independent t-test.

No toxicity was noted in the animals treated with roflumilast.

Conclusions: Given as a daily oral dose, roflumilast was ineffective. Perhaps more localized and more frequent administration of the drug would result in improved nerve regeneration. In previous studies showing the benefit of the phosphodiesterase-4 inhibitor rolipram, the drug was delivered at a continuous rate over 7, 14, or 21 days through a subcutaneously implanted pump on the back of the rat.

Further study is needed to investigate the use of pharmacological means to enhance peripheral nerve regeneration, using a clinically available drug.

EP6. Calcium and Calcium-ATPase Levels During Peripheral Nerve Regeneration

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Peripheral nerve injury can have devastating effects on daily life. The increase in calcium concentration after nerve injury can negatively impact neurite growth and activate downstream processes leading to neuron death. Schwann cells play a key role in axon regeneration and is a source of calcium ion storage in the peripheral nervous system. Our previous studies have shown that calcium modulating agents can decrease calcium accumulation in peripheral nerve tissues and improve the speed of functional recovery, however the effective therapeutic window has not yet been identified. Here we show that after rat sciatic nerve injury, calcium accumulation remained at peak elevation until 8 weeks after which it decreased over the course of 24 weeks back toward baseline. At the same time, compound muscle action potential (CMAP) measurements from the extensor digitorum longus muscle recovered to near normal. Unexpectedly, qPCR results showed that upregulation of sarco/endoplasmic reticulum calcium-ATPase (SERCA; pumps cytosolic calcium into intracellular stores found in neurons and Schwann cells) mRNA remained only minimally elevated until 12 weeks when a near 200 fold increase was observed in the crushed nerve segment followed by return to baseline by 24 weeks. These results taken together suggest that up-regulation of SERCA may account for the decrease in calcium accumulation, however the reason for the peak at 12 weeks will require further investigation. These results may also imply that in order to achieve maximal benefit after peripheral nerve injury, therapies to decrease calcium accumulation should likely be initiated as soon as possible but may still be beneficial if started before the natural course of calcium decline at 8 weeks.

EP7. Pelvic Pain with Sitting: Diagnostic Algorithm & Surgical Approaches

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Purpose: Painful sitting is a common complaint of both male and female patients with pelvic pain. The most common peripheral nerve implicated in this problem is the pudendal nerve. Patients with painful sitting often prefer to stand or lie down during work or daytime at home, or in the doctor's office. Understanding the etiology of painful sitting, should offer a diagnostic approach, including nerve blocks, and surgical peripheral nerve approaches.

Methods: Anatomic pathways related to the nerves surrounding the pelvis were reviewed. Clinical experience with more than 50 pelvic pain patients who complain of painful sitting are reviewed. A model of chronic nerve compression for the pelvis, is constructed. These anatomic pathways and the CT- or MRI- guided approach to the nerve blocks is analyzed.

Results: The posterior femoral cutaneous nerve (PFC), through its inferior cluneal (IC) nerve and distal branches innervates the lower buttocks and posterior thigh skin, regions in which the pain of sitting is perceived. The pudendal nerve (PN), sciatic nerve (SN), obturator nerve (ON), ilioinguinal (II), iliohypogastric (IH) and genitofemoral (GF) nerves cannot transmit information about sitting that is interpreted as pain. *The PFC nerve innervates the region about the ischial tuberosity*.

Pudendal nerve compression causes symptoms in the distribution of its branches; anus, perineum, labia/scrotum, vestibule, vagina, clitoris/penis, but not true pain in the ischial tuberosity region, because the PN does not innervate this region.

PFC nerve is the most common cause of pain with sitting. PFC is usually injured in sports (hamstring tear) or as a complication of previous PN or SN surgery.

Nerve blocks of the PN and PFC are the best way to distinguish the etiology of pain with sitting.

Conclusion: Through an understanding of pelvic peripheral nerve regional anatomy, and analysis of clinical presentations of pelvic pain, an algorithm for diagnosis of the etiology of painful sitting is possible. Use of this algorithm may facilitate research and clinical care of pelvic pain patients with painful sitting.

EP8. Obstetrical Brachial Plexus Injury: A National Clinical Practice Guideline

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Introduction: The objective of this study was to establish an evidence-based clinical practice guideline for the primary management of obstetrical brachial plexus injury (OBPI). Four gaps are identified for management of OBPI in Canada: 1) The historic poor use of evidence, 2) Timing of referral to multidisciplinary care, 3) Indications and timing of operative nerve repair, and 4) Distribution of expertise in Canada.

Materials & Methods: The guideline is intended for all providers delivering perinatal care, and all specialists delivering care to OBPI patients. The consensus group was composed of clinicians representing each of Canada's ten multidisciplinary centres. An original meta-analysis comparing the effectiveness of primary nerve repair versus nonoperative management was completed. An analysis of OBPI burden, epidemiology, and referral patterns at all 10 Canadian was completed. Quality indicators for referral to a multidisciplinary centre were established. Recommendations were based on best evidence, and interpretation of this evidence by clinical experts. An electronic modified Delphi approach was used for consensus, with agreement criteria defined a priori following RAND procedures.

Results: Nerve repair significantly reduces functional impairment, RR 0.58, 95%CI 0.43-0.79, $p<0.001$, $I2=0\%$. With operative management, death was not reported. Major adverse events were reported in 1.5% of cases and minor in 5.0%. The quality of evidence was low. Residual impairment is underestimated and uncharacterized in nonoperative literature; among demographic (all severities) samples managed nonoperatively, residual impairment remains in 27% (19-36%). OBPI incidence was at least 1.24 per 1000 births in Canada in the last decade, and consistent over the study period. Very strong risk factors (odds ratio>30) were comorbid humerus fracture, shoulder dystocia, and comorbid clavicle fracture. The majority (55-60%) of identified cases were not referred to a multidisciplinary centre. Among those referred, timing was "good" in 28%, "satisfactory" in 66%, and "poor" in 34%. The guideline group approved seven recommendations for management.

Conclusions: Seven recommendations address the identified gaps in care, and guide identification, referral, treatment, and outcome assessment for OBPI. The process established a new network of opinion leaders and researchers for further guideline development, and multicentre research. The next step is to facilitate the implementation of the recommendations on a national scale. Application of a clinical practice guideline has the potential to improve knowledge among clinicians, improve educated referral, influence care processes at tertiary care centers, minimize practice variation, inform policy, and establish criteria for evaluation/quality review for OBPI.

EP9. Safety and Efficacy of AmnioMatrix Amniotic Membrane for Use in Peripheral Neurolysis

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Purpose: To evaluate the effect of the use of amnion-based biologic materials in the outcomes of patients after neurolysis.

Methods: The charts of eight patients who had undergone neurolysis with amnion-based biologic augmentation were reviewed. Patient demographics, pertinent medical and surgical history, treatment course and clinical outcomes were recorded. In addition, any complications and/or need for revision surgery were noted.

Results: Eight cases of neurolysis were performed in 7 patients for: recurrent cubital tunnel syndrome (4), dorsal radial sensory nerve neuritis (3) and recurrent carpal tunnel syndrome (1). Six patients were female and one was male. At mean follow-up duration of 16.8 months, 87.5 % of cases resulted in improvement of symptoms and 12.5 % noted no improvement. There were no complications or adverse reactions in our series. No patient reported worsening of their initial presenting symptomatology, and there was one patient, who despite initial symptomatic improvement in her cubital tunnel symptoms, who was revised using a nerve conduit at greater than 2.5 years from amnion placement.

Conclusions: The use of amnion-based biologic augmentation after neurolysis is a safe and effective procedure. We believe that the inherent anti-inflammatory, anti-microbial, and stimulatory properties of the amnion have a legitimate role in improving patient outcomes after the aforementioned scar removal procedures.

EP10. Perineural Spread of Endometriosis

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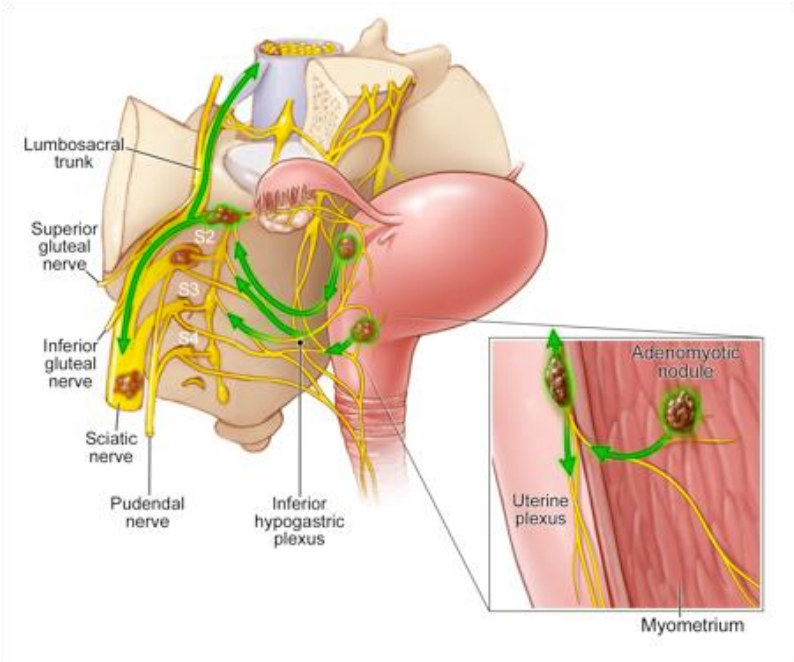
Sciatic nerve endometriosis is a rare presentation of retroperitoneal endometriosis. We present two cases of catamenial sciatica concluded as sciatic nerve endometriosis. We propose that both cases can be explained by perineural spread of endometriosis from the uterus to the sacral plexus along the pelvic autonomic nerves and then further distally to the sciatic nerve or proximally to the spinal nerves (Fig. 1,©) similarly as has been proposed in pelvic (cervical) cancer. This explanation is supported by magnetic resonance imaging (MRI) studies in both cases. As a proof of concept, we retrieved and analyzed the original MRIs of a case reported in the literature and found a similar pattern of spread. We believe that the imaging evidence of our institutional cases together with the outside case is very compelling for perineural spread as a mechanism of endometriosis of nerve.

Figure 1:



EP11. 3D Digitized Nerve Anatomy: Contributions to Clinical Treatment Challenges

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Introduction: The data generated by Microscribe™ 3D digitizers facilitates the exploration of extra- and intramuscular innervation patterns throughout the muscle volume in cadaveric specimens. The digitized data can be visualized as in-situ 3D representations of nerves in and near other anatomical structures using Autodesk® Maya®. The purpose of this presentation is to demonstrate clinical applications of the digitized nerve data.

Materials, Methods and Results: Muscle Transfers

1a Pedicled: e.g temporalis muscle

The innervation of temporalis was digitized in 10 hemisected cadaveric heads. Each nerve branch was digitized extramuscularly from the foramen ovale to the muscle belly and intramuscularly until no longer visible with a dissection microscope. The results suggest that the muscular territories of three main nerve branches may be transposed to a new orientation, while preserving temporalis function. Further clinical study is necessary.

1b Free Functioning Muscle Transfers e.g. gracilis

Innervation and blood supply of gracilis were digitized in 20 embalmed lower limbs. The results suggested that one to two compartments could potentially be split into two to three functional units.

Clinical control of symptomatic nerve behaviour

2a Control of Pain e.g. sacro-iliac joint

Following dissection/digitization of 25 cadaveric hemipelves, the location of the posterior sacral network that innervates the posterior aspect of the sacro-iliac joint was quantified relative to bony landmarks. The data could aid the development of better image guidance techniques for nerve ablation.

2b Control of Spasticity e.g. subscapularis

Post-stroke spasticity of the subscapularis poses a functional problem. The intramuscular innervation of subscapularis was established in 50 embalmed cadaveric specimens and each intramuscular innervation pattern was digitized. An injection strategy was proposed based on the anatomical findings.

3 Reassessing surgical landmarking of the facial nerve

Pitanguy's line, used to demarcate the frontotemporal branch of the facial nerve, was palpated and pinned by 4 independent raters in 10 intact midsagitally sectioned cadaveric specimens. The pins were digitized and the frontotemporal branch was exposed and digitized along with bony landmarks. The 3D models demonstrated that the frontotemporal branch had a variable relationship to Pitanguy's line, facilitating assessment of this line as a surgical landmark.

Conclusions: Digitized nerve data can be used to inform surgical planning, landmarking of incisions, defining patterns for innervated flap design, nerve ablation landmarking, and injection strategies.

EP12. Early Versus Late Brachial Plexus Reconstruction In Brachial Plexus Birth Palsy

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Introduction: Timing of surgical intervention for obstetric brachial plexus palsy is still a depadable issue for most microsurgeons. This study aims at ellucidating the results of surgical intervention before and after the age of one year.

Materials and Methods: From January 1998 to June 2006, 80 patients suffering from brachial plexus birth palsy were treated by surgical reconstruction of brachial plexus. Patients were evaluated for functional recovery by Toronto scale. Follow up period was 1-8 years.

Results: Functional results were compared as regards the age, type of lesion (rupture VS avulsion), type of reconstruction (neurolysis vs grafting vs neurotization).

Conclusion: The earlier the surgical intervention, the better results, however this was not statistically significant untill the age of one year.

EP13. Impact of Parity on Time to Diagnosis and Treatment of Brachial Plexus Birth Palsy

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Introduction: The purpose of this study was to evaluate the relationship between brachial plexus palsy at birth, parity and subsequent treatment.

Materials & Methods: A retrospective review of 158 patients who presented to our clinic between January 1, 2005 and January 1, 2015 for treatment of brachial plexus birth palsy. Data was collected regarding the birth history and subsequent surgical treatment for brachial plexus birth palsy.

Results:158 patients presented to a tertiary pediatric medical center between January 1, 2005 and January 1, 2015. 38% (60/158) of these patients were born to primiparous women while 62% (98/158) were born to multiparous women. There were no statistical differences between the primiparous or multiparous women for gestational diabetes (9 vs. 27, p=0.159) or preeclampsia (7 vs. 10, p=0.563). There were no statistical differences between the children of primiparous or multiparous women for gestational age (38.88 weeks vs. 38.98 weeks, p=0.7647), associated fractures at birth (8 vs. 17, p=0.502), dystocia (28/44 vs. 61/77, p=0.062), Horner's syndrome (4/45 vs. 10/80, p=0.539) or surgical treatment (25/60 vs. 45/98). Children born to multiparous women had a statistically significant higher birth weight (4158.48 vs. 3834.26, p=0.0020), earlier time to first presentation for treatment (3.45 months vs. 11.14 months, p=0.0239), and an earlier time to initial surgery (17.75 months vs. 21.71 months, p=0.004). While not statistically significant but trending towards significance was that children born to primiparous women on average had multiple surgeries for the treatment of their brachial plexus palsy compared to those of multiparous women (11/60 vs. 8/98, p=0.056).

Conclusions: Brachial plexus birth palsy is more common in multiparous women. Children born to multiparous women however are treated at a younger age, undergo surgery at a younger age, and are less likely to require multiple surgeries than children born with brachial plexus palsy to primiparous women.

EP14. Assessment of Sural Nerve-Originated Neuropathic Pain After Ankle Sugery; Comparison with a Healthy Population and a Normal Ankle Surgery Population

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Objective: Unstable ankle fractures require open reduction and internal fixation (ORIF) with plate and screws. Neurological complications following ankle surgery are reported, especially following operative reconstruction of WEBER B and C fractures. The sural nerve (SuN) is susceptible to local and iatrogenic trauma because of its suprafascial course. The objective of this study was to examine the prevalence of neuropathic pain in ORIF operated patients and to evaluate the morphological changes of sural nerves of ORIF operated patients using ultrasound and correlate them with clinical findings.

Method: In this observational retrospective survey; a cohort of 530 women and men, aged ≥18 years, undergoing ankle surgery in the period from January 2007 to January 2014, was invited to an online questionnaire. Pain symptoms were assessed using the MCGill Pain Questionnaire, the DN4 and the CISS. Descriptive statistics were used to present patient characteristics; risk factor analysis was performed through a logistic regression model. The completed questionnaires were used to select appropriate cases and controls to perform ultrasound measurements. The SuN was identified using 18 Mhz high-frequency ultrasound imaging. Cross-sectional area (CSA), diameter, echogenicity and vascularization of the nerves were measured in 15 symptomatic patients, 15 asymptomatic patients and 15 healthy volunteers matched on age and BMI.

Results: A total of 271 patients completed the questionnaire. The mean follow-up period was 4.5 years (±1.9) and overall pain symptoms were reported by 171 (63.5%) of the study population. In 129 (47.6%) of the total the symptoms were persistent and in 42 (15.5%) transient. The prevalence of neuropathic pain symptoms was 78 (28.8%). In univariate analysis, five parameters were significantly associated with neuropathic pain. In multivariate analysis, independent significant predictors of neuropathic pain were: radiating pain (OR = 2.39, 95% CI: 1.03 – 5.54) and a positive VAS-score (OR = 1.22, 95% CI: 1.04 – 1.44). The SuN's were clearly identified in all 45 participants; the results on the differences between cases and controls are still preliminary.

Conclusion: This study shows that over 28 % of the patients with moderate to severe pain, after ankle surgery, also suffer neuropathic pain symptoms. This causes increased interference with daily activities and health related quality of life. Most of these patients do not receive adjuvant analgesics. We identified two independent significant predictors of neuropathic pain. We strongly believe that the ultrasound findings will prove the usefulness in the evaluation of SuN complications after ankle stabilization surgery.

EP15. Endoscopy-Assisted Cubital Tunnel Release Under Carbon Dioxide Insufflation And Anterior Transposition

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Purpose: The optimal treatment for cubital tunnel syndrome is widely debated. The purpose of this study is to describe the technique of an endoscopic-assisted ulnar nerve decompression using carbon dioxide insufflation in association with subcutaneous anterior transposition and to assess the success or failure of the method of treatment.

Methods: In all, 8 male and 4 female patients with an average age of 42 years (range, 25-56) who presented signs, symptoms, and abnormal neurophysiological studies of cubital tunnel syndrome were recruited in the retrospective study. Between August 2008 and June 2009, they were operated on using a 0-degree lens endoscope. Preoperatively, they were classified according to the Dellon scale, and the Bishop rating system was used to evaluate the postoperative outcomes.

Results: Preoperatively, 5 patients were rated as mild, another 5 as moderate, and the remaining 2 as severe. The average length of the incision was 15 ± 3 mm, the mean length of the ulnar nerve decompression was 18 ± 2 cm, and the whole duration of surgery (skin to skin) lasted 30 ± 5 minutes. The endoscopic-assisted cubital tunnel release under carbon dioxide insufflation and subcutaneous anterior transposition surgeries in all patients were performed with no difficulty. All the patients had improvement in symptoms of cubital tunnel syndrome and 10 of 12 patients scored excellent according to the modified Bishop Rating System at a minimum of 1 year after surgery.

Conclusions: Endoscopy-assisted cubital tunnel release under carbon dioxide insufflation demonstrated similar results compared with conventional open surgeries, besides, it may avoid problems such as long incision, painful scarring, and have additional advantages of providing an extended endoscopic view, which is safe and mini-invasive with favorable results in a 12-month follow-up.

EP16. Grading the Loss of Sensation in Diabetics. A Mokken Scale Analysis. Results from the Rotterdam Diabetic Foot Study

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Introduction: Diabetic sensorimotor polyneuropathy (DSP) is the greatest risk factor for diabetic foot ulceration. In the Rotterdam Diabetic Foot Study we assess the sensation of the feet and varying symptoms of DSP, with several screening instruments. These instruments test different nerve fibers, which are progressively lost during the natural course of DSP. Until now, we estimated by expert opinion how these tests compare to each other and how they roughly reflect the stage of DSP. The aim of this study is develop a hierarchical scale of measures of DSP, in order to scale the patient in the natural history of DSP.

Methods: We determined the sensation of the feet of 418 patients included in the Rotterdam Diabetic Foot Study. The Rydel-Seiffer tuning fork tested the vibration threshold on two sites of both feet. Cutaneous threshold (one point static discrimination (S1PD) was tested on five locations of the foot with monofilaments ranging from 0,008 – 300 grams. Innervation density (two-point static and moving discrimination (S2PD, M2PD) was assessed on the same test sites. Hoffman-Tinel sign was tested at the tarsal tunnel. Cold/warmth perception was tested and subjective neuropathy complaints were assessed via the Michigan Neuropathy Screening Instrument (MNSI).

The test items were dichotomized per patient in a consensus meeting by the authors. For example, a patient had S2PD or not. Scalability of an item set implies that it can be used for the measurement of patients, whereas invariant item ordering implies that the hierarchical ordering of the items is the same for all patients. To investigate the scalability and the ordering of the items studied, we used Mokken scale analysis. This analysis can be viewed as a nonparametric approach to the item response theory.

Within the framework of Mokken scale analysis, the scalability of an item set is studied by investigating the fit of the monotone homogeneity (MH) model, whereas the invariant ordering of the items is studied by investigating the fit of the double monotonicity (DM) model.

Results: The main outcome measures will be:

(1) Fit of the HM, indicating whether items can be used for measuring patients

(2) Fit of the DM, indicating invariant (hierarchical) item ordering

Conclusions: This very promising method to grade the loss of sensation in diabetics might be the key to reliably monitor the diabetic at risk. Hence, we want to present the results of this analysis at the ASPN 2016.

EP17. WITHDRAWN

EP18. Athymic Rat Model for Studying Acellular Human Nerve Allograft

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Introduction: Although human acellular nerve allograft is a promising nerve repair tool, optimizing graft application and understanding effective graft dimensions has been hampered by lack of an appropriate animal model. Rodent nerve acellular allograft can be tested in the utilitarian rodent nerve repair model, but testing different size options is limited by the size of the rodent donor animal. Human acellular nerve allograft offers the variety of sizes desired for more complete study but poses a high risk of rejection as xenograft tissue in the rodent model. Athymic nude rats are less prone to reject xenograft tissue due to their immunocompromised state and may offer an animal model for testing human acellular allograft.

Materials and Methods: Fifteen athymic nude and 15 Sprague-Dawley rats underwent unilateral excision and repair of a 10mm tibial nerve segment using 10mm of human acellular nerve graft. Testing at three months consisted of muscle force measurements, wet muscle weight, and histological assessment from the middle of the nerve grafts.

Results: Athymic rats repaired with human acellular xenograft demonstrated higher reinnervated muscle weight. Gross inspection of the xenograft in euthymic rats revealed a brown and scarred center and histological inspection demonstrated larger axon diameters, and higher midgraft axon counts in the grafts of athymic rats.

Conclusion: This study is the first to test acellular human nerve allograft in an athymic rat. The nerve regeneration was better in human acellular nerve allograft implanted into immunocompromised athymic rats when compared to euthymic rats supporting a potential role of this model in studying acellular human nerve tissue.

EP19. Long-term Observation of Respiratory Function After Unilateral Phrenic Nerve and Multiple Intercostal Nerve Transfer for Avulsed Brachial Plexus Injury

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Objective: Either phrenic nerve transfer (PNT) or multiple intercostal nerves transfer (MIT) alone was reported having no significant impact upon pulmonary function in short or medium term. But it has rarely been reported whether the combination of PNT-MIT could influence respiratory function in the long term. In this study, pulmonary and diaphragmatic function were compared between PNT and PNT-MIT after 7 to 19 years (mean 10 years) postoperatively.

Methods: 23 adult patients with brachial plexus avulsion injuries (BPAI) underwent PNT-MIT were compared with 19 corresponding adult patients who underwent PNT only. Pulmonary function testing, phrenic nerve conduction study, chest fluoroscopy were performed to assess ventilation, diaphragmatic response and excursion. In the PNT-MIT group, further comparison was performed to investigate whether transferred intercostal nerves number and the timing of MIT would influence the results.

Results: In PNT-MIT group, forced vital capacity (FVC), forced expiratory volume in one second (FEV1) and total lung capacity (TLC) were 73.69%, 72.04% and 74.81% of predicted without significant differences from PNT group. Diaphragmatic paralysis permanently existed with hemidiaphragm elevation of 1 to 1.5 intercostal spaces (ICSs) and near one ICS reduced excursion. But no statistically significant difference was found between PNT and PNT-MIT groups. Furthermore, in the PNT-MIT group, three and four intercostal nerves transfer resulted in no further decrease in pulmonary function than two intercostal nerves. No significant difference was found when PNT-MIT was performed at the same stage or at an interval of 1 or 2 months.

Conclusion: In the long term observation, PNT-MIT didn't result in additional impairment in respiratory function in adult patients compared with PNT alone. Two to four intercostal nerves transfer performed for 1 to 2 months delay after PNT is a safe method for treating BPAI.

EP20. Interposition Graft Repair Of A Rat Facial Nerve Defect With And Without Donor Nerve Interfascicular Dissection

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Introduction: Interfascicular dissection (IFD) may be employed to obtain multiple interposition grafts from a single donor nerve, however a risk of increased axonal loss exists due to epineurial disruption. This study compares outcomes in a rat facial nerve model with and without IFD of the donor nerve.

Materials and Methods: Following calvarial titanium plate implantation to allow for head fixation, the left facial nerve was exposed in 28 Lewis rats. Following resection and proximal ligation of the marginal branch, a 1 cm segment of the buccal branch was resected and repaired with either a full thickness (N=14) or partial thickness by IFD (N=14) interposition sciatic nerve isograft.

Results: Using laser micrometers, whisking displacements were serially recorded until functional plateaus were achieved. Axon counts proximal and distal to the nerve grafts were obtained from resin-embedded, 1-μm thick, toluidine blue stained sections. Functional and histologic outcomes were compared between groups using unpaired t-tests.

Conclusions: This is the first study to objectively assess interposition grafting outcomes with and without IFD of the donor nerve. These findings are particularly relevant to situations where multiple long nerve grafts are required, such as cross-face nerve grafting.

EP21. Choosing a Set of Instruments to Point out the Diabetic at Risk for Foot Ulceration. Results from the Rotterdam Diabetic Foot Study

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Introduction: Diabetic sensorimotor polyneuropathy (DSP) is the greatest risk factor for diabetic foot ulceration. Several diagnostic tools can evaluate the presence of DSP. The aim of this study is to assess how the various diagnostic tools and sites discriminate between patients who had an ulcer in their medical history and patients that did not. Knowledge of these values may help to identify patients at risk for foot ulceration.

Methods: In a retrospective cohort study, we determined the sensation of the feet of 399 patients. We distinguished three groups: diabetic ulcer and amputation (DU+); diabetic ulcer without amputation (DU-) and no ulcer (controls). 55 patients (13.8%) had an ulcer in their history and 11 of them underwent an amputation. The tuning fork tested the vibration threshold on two sites of each feet (dorsal distal hallux and medial malleolus). Cutaneous threshold (one-point static discrimination, (S1PD) was tested on five locations (pulp of 1st and 5th toe, medial heel (above callus), first web and lateral foot) of each foot with monofilaments ranging from 0,008–300 grams. Innervation density (two-point static and moving discrimination (S2PD, M2PD) was assessed on the same test locations. Neuropathy complaints were assessed using the Michigan Neuropathy Screening Instrument (MNSI).

Results: S2PD in DU-: median 16 (range 3- >16, varying across feet and locations), DU+: median >15 (range 8- >15, idem) and controls: median 11-14 (range: 2- >15, idem). M2PD in DU-: median 13- >15 (range 2- >15, idem), DU+: median > 15 (range 4- >15, idem) and controls: median 8-10 (range 2- >15). The cutaneous threshold was 26-fold increased in the ulcer group and 209-fold increased in the amputation group vs. control. Vibration perception was diminished (DF-) group) or absent (DF+). Complaints (MNSI >7) were higher in the ulcer (40.9%) and amputation groups (54.4%) compared to controls (8,7%), with more negative symptoms (such as numbness) reported in the DF+ and DF- (81.8% vs. 54.5%), compared to controls (22.5%).

Conclusions: Patients with DF-/+ in their history more frequently have a S2PD >15, an increasing cutaneous threshold, a decreasing vibration sense and more negative and positive symptoms of DSP. Only one or two test locations need to be tested on one foot to make a statement about the contralateral foot, to make a proper risk assessment of the patient in general. The prognostic value of these test values will be studied in the follow-up in the Rotterdam Diabetic Foot Study.

EP22. Does Travel Distance Correlate with Outcomes in Revision Cubital Tunnel Surgery?

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Introduction: Even when properly performed, decompression of the ulnar nerve at the cubital tunnel may fail or result in recurrence, prompting the need for revision surgery. This may prompt referrals to a distant care center, and the association between the need for travel to reach a referral center and the outcomes in these surgeries has not been studied. We present a single surgeon's experience of revision cubital tunnel surgeries with a comparison of outcomes between local patients and those referred from out of town.

Materials and Methods: All consecutive revision cubital tunnel surgeries performed by the senior author from 2008-2011 were reviewed. Revision surgery included submuscular ulnar nerve transposition (SMUNT) in all cases, with some also including release of Guyon's canal, end-to-side transfer of the anterior interosseous nerve (AIN) to the ulnar nerve, or carpal tunnel release (CTR). Patients were divided into a local group (living within 50 miles) and a travel group (living greater than 50 miles away). Pre- and post-operative data were collected prospectively. Outcomes assessed included pain level as recorded using the visual analog scale (VAS).

Results: 40 patients underwent surgery during the study period; one was excluded for lack of follow up data. 18 of 39 (46.2%) also underwent decompression of Guyon's canal, 6 (15.4%) underwent AIN transfer, and 12 (30.8%) underwent CTR. 18 patients (46.2%) were from the local area, and 21 (53.8%) had traveled >50 miles. Average follow-up was 5 months for the local group and 6 months for the travel group. Average pre-operative VAS score was 7.1 in the local group and 6.6 in the travel group. Mean change in VAS was -2.8 in the local group and -0.9 in the travel group ($p=0.061$). Chi-squared analyses between local and travel patients of likelihood for improvement of ≥ 2 points or ≥ 3 points on the VAS were also not significant ($p =0.089$ and $p=0.087$, respectively). Regression models adjusted for age, sex, and follow-up also failed to show a significant difference between groups.

Conclusions: We present a large series of patients undergoing revision cubital tunnel procedures, many of which had traveled significant distances for surgery and follow-up. Although this study is limited by the length of follow-up and by VAS as a measure of outcome, we found no significant difference in the outcomes of revision cubital tunnel surgery between patients in our local area versus those traveling long distances to have surgery.

EP23. Evaluation of Functional Recovery Outcomes from Subjects with Peripheral Nerve Discontinuities Repaired with Processed Nerve Allograft

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Introduction: Functional outcomes following peripheral nerve reconstruction can be dependent upon the treatment option used to bridge the discontinuity. The use of processed nerve allograft (PNA) has steadily increased for the reconstruction of traumatic and iatrogenic peripheral nerve injuries. We report our experiences with processed nerve allograft from a single center participation in a registry study.

Methods: The RANGER® registry study is currently utilized to continuously monitor and incorporate injury, repair, safety and outcomes data using standardized case report forms. The database was queried for all nerve repairs occurring though our single center site. Subject demographics, nerve injury and repair, and outcomes data were reviewed and reported. Subjects divided into groups based on the level of available follow-up as insufficient follow-up or sufficient follow-up. Subjects with a minimum of 5 months follow-up were included in the sufficient follow-up group and were evaluated for functional recovery. Meaningful recovery was defined by the MRCC scale at S3/M3 or greater for sensory and motor function.

Results: Eighteen subjects with 30 nerve repairs between the ages of 18-64 were included in this study. There were 13 repairs (12 sensory and 1 mixed) with insufficient outcomes data, 9 repairs (5 sensory and 4 mixed) still in follow-up and 8 repairs (7 sensory, 1 mixed) with sufficient data to determine the outcome of the repair. The mean ±SD age was 52±26 years. The mean time to repair was 117±91 days with a mean gap length at 28±19mm. Recovery was reported in 7 of 8 nerve repairs. There were no reported nerve adverse events. Additionally, two subjects with digital nerve injuries required revision after the original repair. In both cases additional tissue resection was need at the original injury site to ensure healthy fascicular pattern prior to subsequent reconstruction with nerve allograft. One subject is still in follow-up and one is reporting meaningful sensory recovery at 260 days of follow up.

Conclusion: Current outcomes data from the RANGER® study showed that the processed nerve allograft used to repair peripheral nerve discontinuities demonstrated a meaningful recovery. The RANGER registry remains ongoing and additional data collected will allow for further data analysis.

EP24. Travel Distance And Demographics For Brachial Plexus Surgery At An Academic Referral Center

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Introduction: Due to the subspecialized nature of management of brachial plexus injuries (BPI), many patients travel substantial distances for evaluation and treatment. The extent of this travel and its potential impact on delivery of care for BPI are unclear. In the current study, we reviewed the travel distances and demographics associated with 15 years of BPI surgery at our academic referral center in the United States.

Materials and Methods: We evaluated predictors for traveling >200 or >500 miles for surgery, as well as the association between greater travel and complications within 30 days after surgery (ICU transfer, hospital readmission, BPI-related reoperation, cerebrovascular accident, pulmonary embolism, and myocardial infarction).

Results: From 1/1/01 to 5/29/15, 466 surgeries were performed in 337 patients for traumatic BPI. The median straight line distance traveled was 194.2 miles (min: 1.4, max 6232.6), with 48% and 21% of cases performed in patients traveling >200 and >500 miles, respectively. Women were more likely to travel >200 miles, while there were no differences for travel >200 miles based on age or race. Patients with Medicaid were less likely than those with private insurance to travel >200 miles ($p<0.001$). Patients with private insurance were also more likely than those with any other insurance type (all $p<0.05$) to travel >500 miles. The overall rate of major complications within 30 days of surgery was 5.8%, 80% of which were hospital re-admissions. After adjusting for age, sex, race, insurance type, and ASA score in multinomial regression modeling, neither travel distance >200 miles nor >500 miles was associated with increased risk of major complications.

Conclusions: Based on these data, the catchment area for BPI referral at our center is relatively large. This is particularly salient to the management of BPI given the importance of serial examination and timely intervention. Although our study demonstrates that patients at our center who traveled greater distances are not at increased risk for complications, further investigation at other centers in the United States is needed to determine the generalizability of these findings.

Figure 1: National heat map of patient travel

Figure 2: Regional heat map of patient travel