

SEP as a sensory pathway integrity check

Method: SEP as a sensory pathway integrity check in patients undergoing lumbar endoscopic spine surgery using the Yeung Endoscopic Spine System

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Sensory pathway data from 400 somatosensory evoked potential tests.

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Abstract

Over the past two decades, intraoperative spinal cord monitoring has matured into a widely used clinical tool. It is used when the spinal cord is at risk for damage during a surgery. This includes orthopedic, neurosurgical, and certain cardiothoracic procedures ⁽⁴⁾.

Endoscopic spine surgery is technically feasible, and often produces excellent clinical and neurological results. ^(3, 5, 11, 13) Somatosensory Evoked Potential (SEP) testing has been used in surgery as a measure of peripheral and central nervous system integrity in humans ^(1, 2, 4, 7, 8, 9, 14, 15) and animals ⁽¹⁰⁾. SEP baseline and post-operative measurements may document both preexisting conditions and operative outcomes when elements of the central and peripheral nervous system are at risk for compromise ^(5, 6).

Compared with alternative techniques such as dermatomal SEP ^(2, 9, 11) and Motor evoked potentials ⁽⁸⁾, SEP techniques are used most widely and generally accepted. SEP studies have also been shown to reduce surgical morbidity. A large multicenter study has shown that continuous intraoperative SEP monitoring reduces postoperative paraplegia by more than 50-60% ⁽⁴⁾.

Method for SEP collection is presented, results are discussed, and clinical correlation is provided in 100 patients.

Method

100 patients undergoing Selective Endoscopic Discectomy (SED) with the Yeung Endoscopic Spine System (Y.E.S.S.) were monitored with bilateral SEP tests both pre and post operatively. 400 SEP tests were analyzed at the Squaw Peak Surgical Facility under the direction of Anthony Yeung M.D. and John Porter M.D. Palm OS-based Handspring VisorTM hardware and HandBaseTM software were used to acquire data and produce statistics.

Patients scheduled to undergo SED surgery were monitored pre and post operatively with bilateral tibial nerve SEP testing. Four tests were performed, with analgesic/sedative agents: Bilateral SEP Pre-operative baseline, Local 0.5% lidocaine, and Bilateral Post operative SEP with sedation of approximately 2-16cc Versed, and 2-16 cc IV Fentanyl. Study demographic: 38 Females, 62 males avg age 42.

1. SEP Baseline

After positioning the patient on the operating table without sedation, a baseline SEP on the affected leg was averaged, marked and printed on the TECA (Oxford Instruments) SEP machine according to the programmed protocol. A qualified physician was available real-time and on-line for supervision of the technologist and interpretation of the waveforms.

2. SEP Post Procedure Survey:

The SEP on the affected leg was averaged, marked and printed according to the programmed protocol. A comparison was interpreted based on five categories, and correlated with reported transient dysesthesia post operatively. Transient Dysesthesia: pain, tingling, or numbness requiring increased medication post-operatively, or a transforaminal block until the temporary dysesthesia subsided. 100 patients were followed from two to six months post operatively.

SEP Generators and Waveform Legend

Fig. 1 Stimulator to Output



Fig. 2 Normal Bilateral SEP



Tibial nerve somatosensory evoked potentials are averaged over a period of time, approximately 250-500 sweeps. The patient feels mild stimulation at the ankle, and is asked to relax while the waveform develops. The waveform is averaged, marked and printed. Peaks are chosen and based on waveform quality and reproducibility. Possible waveform complications include: technical 60Hz noise, twilight anesthetic effects, local anesthetic effects, and sympathetic skin response (diaphoresis).
SEP Values-What is "Normal"?

Fig. 3

*Dr. Yeung, et. al. 2001						
	Pre-operative n=100			Post-operative n=100		
	Affected	Control	Diff.	Affected	Control	Diff.
N1	21.65	21.36	(.29)	21.59	21.39	(.20)
P1	43.30	42.12	(1.12)	41.80	41.36	(.44)
N2	51.37	50.28	(1.09)	50.18	49.48	(.70)
P2	60.35	59.21	(1.14)	59.60	58.67	(.93)
A1	-1.08	-0.76	(.32)	-0.75	-0.69	(.06)
A2	1.06	1.28	(.22)	0.94	1.48	(.54)

	Chiappa, et. al. Normals			**Deblke, et. al. Normals			*Sлимп, et. al. Normals	
	Normal	(+/-)	S2S	Normal	(+/-)	S2S	Left	Right
N1								
P1	38.5	(2.8)	.45-3.05	39.4	(4.6)	.74-6.14	40.4 (2.5)	41.0 (2.2)
N2	48.1	(4.1)	.67-5.92	53.7	(5.9)	1.62-12.91	49.3 (2.7)	49.5 (2.9)
P2	61.2	(6.5)	1.59-12.1	72.4	(9.8)	3.76-14.31	60.4 (3.6)	60.6 (3.5)
A1	-1.4	(.5)	.19-1.42	2.1	(.5)	.27-1.76		
A2	1.8	(.4)	.35-1.58	2.8	(.8)	.47-2.52		

Pre and post-operative patients in Dr. Yeung's study are compared to Delbke, Chiappa and Slimp's "Normal" data. Values listed are considered within normal limits for somatosensory conduction latencies and amplitudes. Average SD of three 'normal' studies is 2.95 milliseconds. Dr. Yeung's affected leg data shows normalizing trend post operatively; the control leg remains within normal limits on average.

Control	Control Leg, Contralateral to site of operation, possibly symptomatic
S2S	Side-to-side latency or amplitude variation
()	Plus Minus statistic
Post	Post Operative SEP
Diff	Side-to-side difference between legs. Note: pre-op and post-op studies included.
*Dr. Yeung's study followed one hundred patients from two to six months post SED surgery 2001 (18)	
**Dr. Chiappa et.al paper, Posterior Tibial nerve at ankle stimulation, Cortical SEP data 1998 (20)	
***Dr. Deblke et.al paper, Popliteal Fossa stimulation, Cortical SEP data (21)	
****Dr. Slimp et.al paper, Posterior Tibial Nerve at ankle stimulation, Cortical SEP data (15)	

Why Monitor SEP's before and after surgery? SEP testing measures the gross somatosensory pathway signal from peripheral nerve to central nervous system ^(19,20,21). When stimulated at the posterior tibial nerves at the ankle, the electrical signal transmits from the Peripheral to the Central nervous system. (Fig.4). The waveform peaks are recorded at the somatosensory cortex of the brain. 92% of the maximal distribution from tibial nerve stimulation occurs in the central midline Cz'area of the somatosensory cortex, when referenced to the frontal midline Fz ⁽¹⁵⁾ as in our study.

Fig. 4 Origins of SEP (4)

Fig. 5 Abnormal SEP: Latency delay pre-operatively



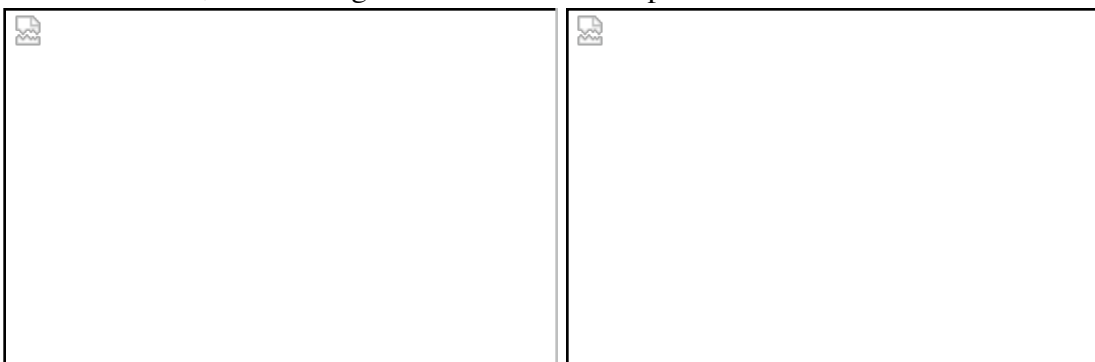
Pathology affecting structures along this pathway may manifest themselves as latency delays or depressed amplitudes in the SEP waveform. Radiculopathy, neuropathy, peripheral nerve or spinal cord impingements along the recorded pathway may show asymmetries between limbs (Fig.5). Note the cortical waveform in the top channel occurs approximately 10 milliseconds after the control leg waveform in channel 15.

When SEP's Improve Fig.6 is an example of an abnormal SEP. Affected leg baseline shows initial waveform components are depressed, but return once surgery is over.

Fig. 6

Poor waveform, affected leg

Post-operative restoration of initial waveform



Overall, decreased latency and increased amplitude changes reflect measurable recordable improvement of the central and peripheral nervous system pathways when comparing pre-op and post-op values ^(1, 4). This cortical SEP changed with initial components decreasing from 52.3 msec to 36.6 msec. The control leg was 33.2 pre-op, and 34.7 post op. Although baseline SEP's are not a valid indicator of outcome ⁽¹⁾, the testing may serve as the control for post-operative SEP. The measured increase or decrease in latency and amplitude may predict the pathway's integrity and the patient's clinical outcome ^(4, 11, 16, 17).

Results

In 100 patients studied at our facility, there was no relationship between SEP's performed before surgery and surgical outcome⁽¹⁷⁾. Similar results were seen in 120 patients at another facility using the open-spine method (2).

When Post-operative testing showed a decrease in latency of the affected leg, often the patient symptoms of pain, tingling, and numbness decreased immediately post-op. However, it was not a predictor of dysesthesia outcome.

In another study where open lumbar surgery was performed on 41 patients, SEP was used to determine the adequacy of lumbar nerve root decompression and for the prediction of the successful relief of symptoms ⁽¹⁾.

Fig. 7	Pre-op Aff.	Post-op Aff.	Change	Pre-op Control	Post-op Control	Change
N1 Cervical	21.65	21.36	-0.29	21.59	21.39	-0.20
P1 Cortical	43.24	42.12	-1.12	41.80	41.36	-0.44
N2 Cortical	51.37	50.28	-1.09	50.18	49.48	-0.70
P2 Cortical	60.35	59.21	-1.11	59.60	58.67	-0.93
Amp 1	-1.08	-.76	-0.32	-0.76	-.69	-0.07
Amp 2	1.06	1.28	+0.22	0.94	1.48	+0.54

Pre operative latencies and amplitudes are compared with post-operative studies. In each measure, decreases in latency were found in the affected and control legs. Affected leg latency decreased a total average of 3.61 msec in the aggregate, while the control leg decreased by 2.27 msec. A 3 msec change in SEP latency is considered above normal variability ^(13, 15, 21, 20).

SEP and Outcomes Fig. 8 Types of SEP outcomes:

Type of outcome (100)	No TP-D (76)		TPD (24)	
Anesthesia affecting waveform	4	5%	4	16%
No change in amplitude/latency	4	5%	2	8%
Change in Latency - Decrease	46	60%	10	41%
Change in Latency - Increase	24	30%	8	33%
Change in Amplitude	Increase: 19% - Same: 1% - Decrease: 80%			



SEP outcome was not a predictor in transient postoperative dysesthesia post operatively.

Changes in SEP latency occurred more often in non-symptomatic patients than in the TPD population.

Autonomic nerve testing is planned for Phase II of our study.

Dramatic SEP Changes
 Of 100 patients, 21 experienced a latency decrease in the cortical SEP of 3 milliseconds or

more. Average standard deviation in three 'normal' studies suggests 2.95 milliseconds is a normal range of variability ^(19, 20).

Breakdown of millisecond drop in cortical latency:	No. of patients:
3 msec	7
3-5 msec	12
5-10 msec	2
>10 msec	0

Clinical Correlation:

Most of the 14 patients who had dramatic drops in SEP latency (above 3 milliseconds) had compressive nerve root lesions, extruded fragments that compressed nerve roots, or other impinging or compressive types of lesions. Some patients were missing initial components of the SEP pre-operatively. Patient waveforms may change post operatively based on the change in physiology that occurs during surgery to the somatosensory pathway (Fig.6).

Pie graph shows all patients, and those with dramatic SEP outcomes (in milliseconds) measured by comparison of pre and post op values.



Conclusion

SEP testing may be used as a gross somatosensory pathway integrity check. From a medical legal standpoint, it may document pre-existing pathology affecting the somatosensory pathway prior to surgery. Data collected during the study is subjectively interpreted, each patient served as their own control.

Documented development of waveform components missing pre-operatively is considered an improvement, and was correlated clinically with a satisfactory outcome for the patient. Dramatic SEP latency changes often were related to compressive nerve root lesions with an onset of less than 1 year.

Anecdotal evidence of transient postoperative dysesthesia (TPD) from 2 to 6 months post operatively were reported as transient in nature. Of approximately 70,000 lumbar fusion surgeries in the US, 7-11% regularly produce surgically related dysesthesias ⁽¹⁵⁾. SEP baselines did not predict dysesthesia; nor did SEP post-operative studies. Further research

involving autonomic nervous system testing is currently being implemented into the study protocol.

SEP monitoring documented the decrease in latency of the initial cervical and cortical responses post operatively. Decreased SEP latency may be correlated with improvement in the patient's physical symptoms. Decreases of 3 milliseconds or more were considered dramatic. Amplitude increase of the initial slope of the cortical waveform was noted, as well as significant increase in 2nd slope amplitude, which may reflect the anesthetic effect on the central nervous system as the cortical response (most sensitive amplitude changes from anesthesia) on the affected and control legs responded similarly.

Clinical Trials Planned Large, multicenter clinical trials are in development in the US⁽²³⁾ to detect small group differences involving surgeons of comparable skill implementing the Yeung Endoscopic Spine System. Neuromonitoring equipment purchased from Oxford Instruments will include multichannel EMG with interleaving SEP and autonomic nerve testing to the protocol. Digital video integration of neuromonitoring may be viewed via uplink to OEC imaging systems. Data monitoring in conjunction with Patrick Zhu, Ph.D. and contributing physicians.

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Equipment: Oxford Instruments. Booth located in Technical Exhibitors area of the Monte Carlo Hotel.

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Fig. 1 Stimulator to Output

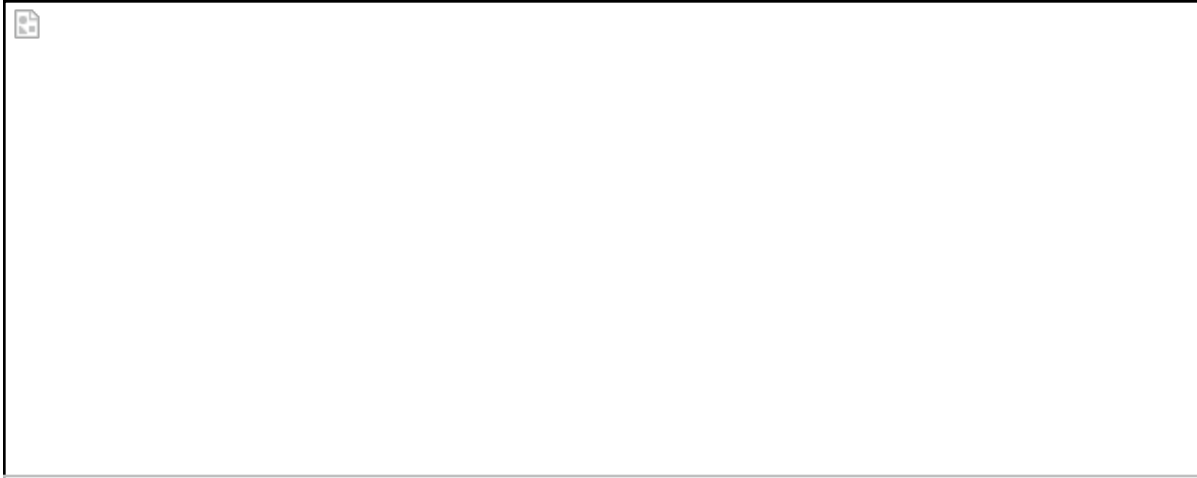


Fig. 2 Normal Bilateral SEP



Ch 1. Cortical
response -
Affected Leg

Ch 2. Spinal
response -
Affected Leg

Ch. 3. Cortical
response -
Control Leg

Ch. 4. Spinal
response -
Control Leg

Fig. 4 Origins of SEP (4)

