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SEP as A Sensory Pathway Integrity Check in Patients Undergoing Lumbar Endoscopic Spine Surgery Using the Yeung Endoscopic Spine System

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Abstract

Introduction: Sixteen (16) patients undergoing Lumbar Selective Endoscopic Discectomy (SED) using the Y.E.S.S. method was monitored intra operatively for SEP (Somatosensory Evoked Potentials) and EMG (Electromyography) activity. 18 cases were analyzed. ***Questions:*** Is Intraoperative Neuro monitoring of SEP and EMG safe, effective and useful in SED cases? What information does it yield, if any?

Results: ***SEP:*** On average, the patients experienced a decrease in N1 latency (Cervical, PNS response) of 2.53 msec. The P1 latency, (Cortical, CNS response) the first recordable scalp component of the waveform decreased 1.07 msec, comparing the pre-op values to the post-op studies. Amplitudes measuring the first cortical slope of P1-N2 decreased 0.01 milliamps on average. N2-P2 slope amplitudes increased 34.79 milliamps. ***EMG:*** Mechanical elicitation of evoked discharges occurred in 6 cases, (33%). Discharges correlated with the action of tapping past the nerve into the disc space with a cannula. EMG neurotonic irritation response patterns were exhibited by 2 patients (11%). In both cases, the EMG returned to baseline after disc material was removed from the nerve area.

Discussion and Conclusion: SEP monitoring documented the decrease in latency of the initial cervical and cortical responses post operatively. Marginal amplitude decrease of the initial slope of the cortical waveform was noted, but significant increase in 2nd slope amplitude was seen on average. Overall, these latency and amplitude changes reflect measurable recordable improvement of the central and peripheral nervous system pathways when comparing pre-op and post-op values. EMG monitoring provided additional information to the surgeon regarding the position and irritability of the nerves in the operative area. EMG muscles could be correlated to the level of lumbar spine on X-ray imaging and physician visualization of the nerve in the operative field. No adverse events were reported. The method for SEP collection is presented, results are discussed, and clinical correlation is provided in 100 patients.

Keywords: Dysesthesia; Nervous system; Somatosensory; Physiology

Introduction

Hundred (100) patients undergoing Selective Endoscopic Discectomy (SED) with the Yeung Endoscopic Spine System (Y.E.S.S.) was 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 Visor-TM hardware and HanDBase-TM software were used to acquire data and produce statistics [1,2]. 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 2-16 cc Versed, and 2-16 cc IV Fentanyl. Study demographics include 38 females, 62 males with an average age of 42 years (Figures 1 and 2) [3,4].

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 [5-8].

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 (Table 1).

SEP generators and waveform legend

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 [9]. Peaks are chosen and based on waveform quality and reproducibility. Possible waveform complications include: technical 60 Hz noise, twighlight anesthetic effects, local anesthetic effects, and sympathetic skin response (diaphoresis) (Figure 3).

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.

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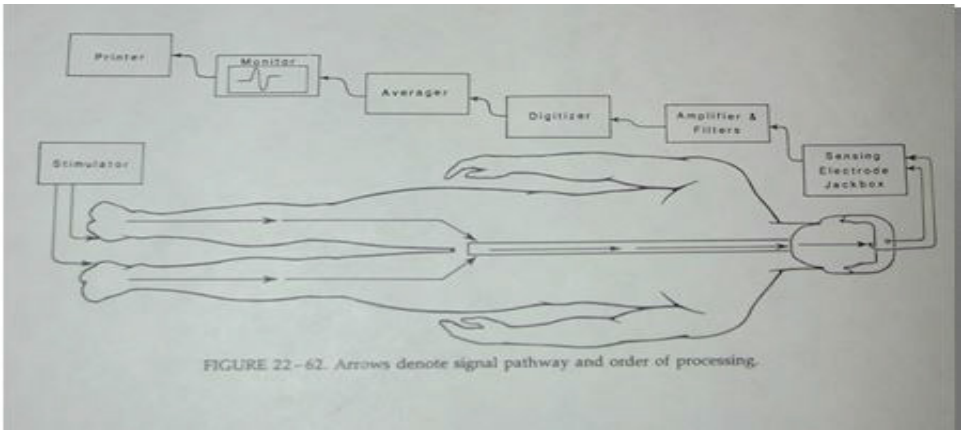
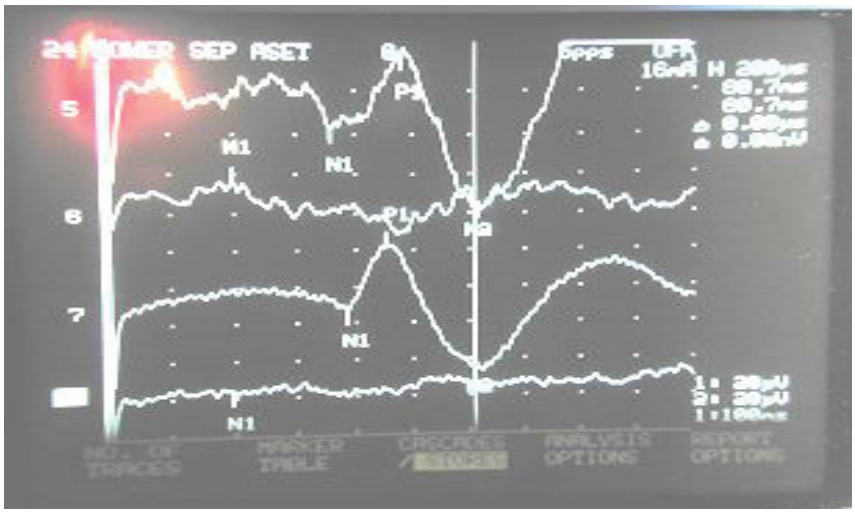


Figure 1: Stimulator to output.



Ch 1: Cortical response: Affected Leg

Ch 2: Spinal response: Affected Leg

Ch 3: Cortical response: Control Leg

Ch 4: Spinal response: Control Leg

Figure 2: Normal bilateral SEP.

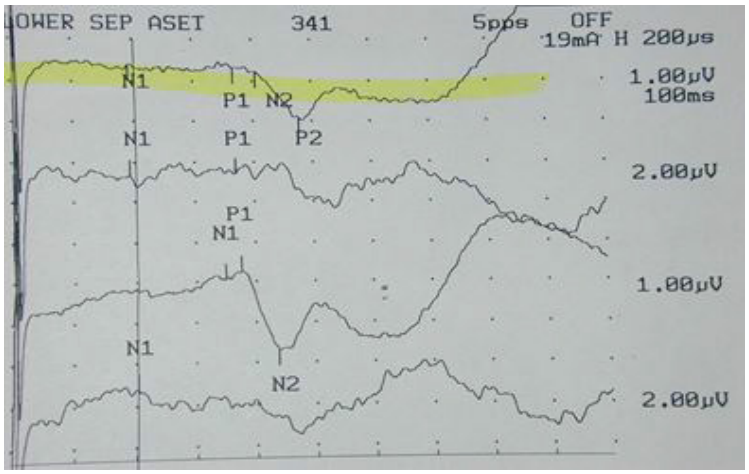


Figure 3: SEP latency data normalizes post-operatively (Equally and bilaterally).

Why monitor SEP's before and after surgery?

SEP testing measures the gross somatosensory pathway signal from peripheral nerve to central nervous system. When stimulated at the posterior tibial nerves at the ankle, the electrical signal transmits from the Peripheral to the Central nervous system (Figure 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 as in our study.

Pathology affecting structures along this pathway may manifest themselves as latency delays or depressed amplitudes in the SEP waveform [10-12]. Radiculopathy, neuropathy, peripheral nerve or spinal cord impingements along the recorded pathway may show asymmetries between limbs (Figure 5). Note the cortical waveform in the top channel occurs approximately 10 milliseconds after the control leg waveform in channel.

When SEP's improve

Figure 6 is an example of an abnormal SEP. Affected leg baseline shows initial waveform components are depressed but return once surgery is over. 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. This cortical SEP changed with initial components decreasing from 52.3 msec to 36.6 msec [13-16]. The control leg was 33.2 pre-op and 34.7 post-op. Although baseline SEP's are not a valid indicator of outcome, 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 (Figure 6 and 7).

Results

In 100 patients studied at our facility, there was no relationship between SEP's performed before surgery and surgical outcome. Similar results were seen in 120 patients at another facility using the open-spine method. [17-20] (Table 2).

SEP and outcomes

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

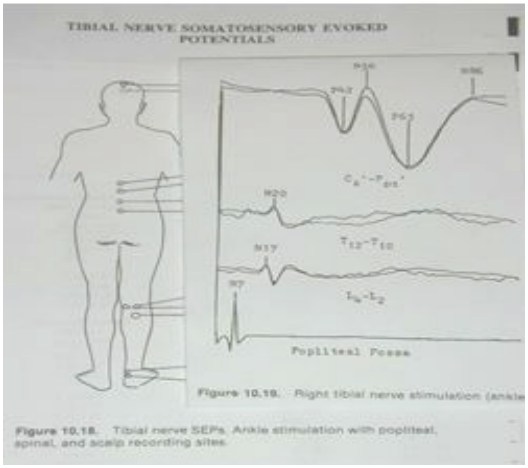


Figure 4: Origins of SEP.

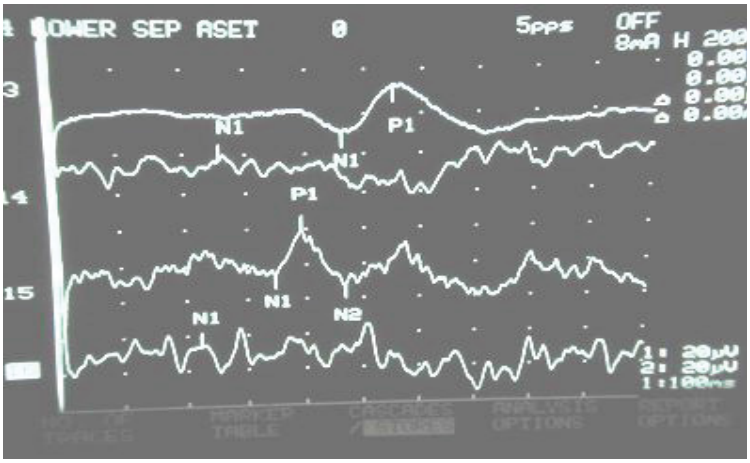


Figure 5: Abnormal SEP: Latency delay pre-operatively.

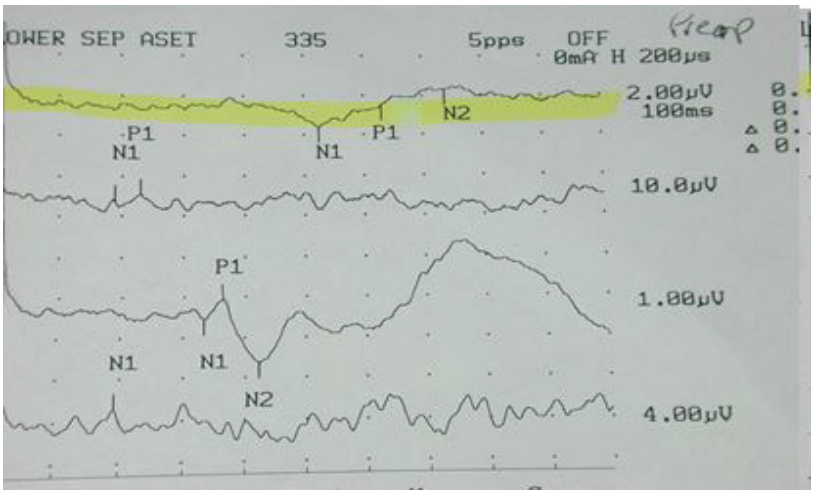


Figure 6: Poor waveform, affected leg.

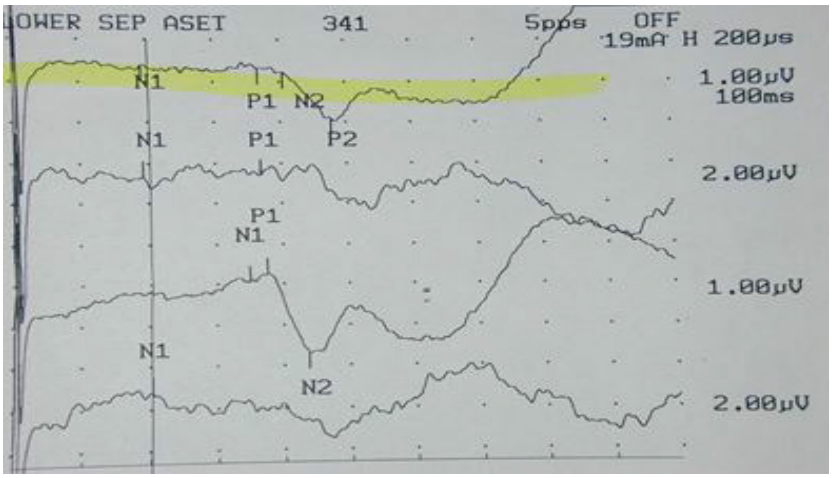


Figure 7: Post-operative restoration of initial waveform.

Variables	Pre-operative n=100			Post-operative n=100			Normal		Normal		Normal n=24	
	Affected	Control	Diff	Affected	Control	Diff	Normal (+/-)	S2S	Normal (+/-)	S2S	Left	Right
N1	21.65	21.36	-0.29	21.59	21.39	-0.2	-	-	-	-	-	-
P1	43.3	42.12	-1.12	41.8	41.36	-0.44	38.5 (-2.8)	0.45-3.05	39.4 (4.6)	0. .74-6.14	40.4(2.5)	41.0(2.2)
N2	51.37	50.28	-1.09	50.18	49.48	-0.7	48.1 (-4.1)	0..67-5.92	53.7 (5.9)	1.62-12.91	49.3(2.7)	49.5(2.9)
P2	60.35	59.21	-1.14	59.6	58.67	-0.93	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	-1.08	-0.76	-0.32	-0.75	-0.69	-0.06	-1.4 (-0.5)	0.19-1.42	2.1 (.5)	0.27-1.76	-	-
A2	1.06	1.28	-0.22	0.94	1.48	-0.54	1.8 (-0.4)	0.35-1.58	2.8 (.8)0	.47-2.52 -	-	-

Affected: Affected leg, Symptomatic leg, also Ipsilateral site operation (posterior lateral approach); 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.

Table 1: SEP values-What is "normal"?.

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 (Table 3 and Figure 8).

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 (Table 4).

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

Variables	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	-0.2
P1 Cortical	43.24	42.12	-1.12	41.8	41.36	-0.44
N2 Cortical	51.37	50.28	-1.09	50.18	49.48	-0.7
P2 Cortical	60.35	59.21	-1.11	59.6	58.67	-0.93
Amp 1	-1.08	-0.76	-0.32	-0.76	-0.69	-0.07
Amp 2	1.06	1.28	0.22	0.94	1.48	0.54

Table 2: 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.

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%

Table 3: Types of SEP outcomes.

Latency	Patients
3 msec	7
3-5 msec	12
5-10 msec	2
>10 msec	0

Table 4: Breakdown of millisecond drop in cortical latency.

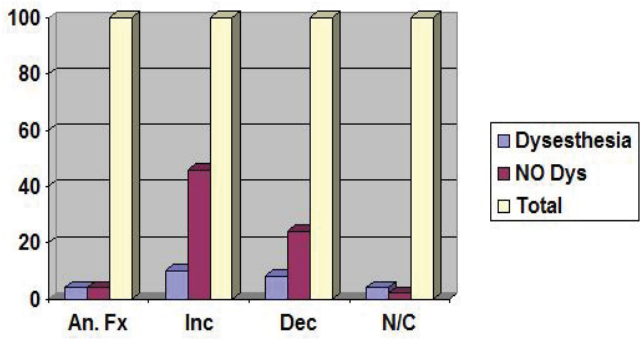
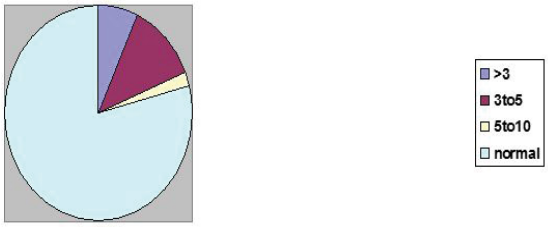


Figure 8: SEP outcome was not a predictor in transient postoperative dysesthesia post operatively; Changes in SEP latency occurred more often in non-symptomatic patients than in the TPD population; Autonomic nerve testing is planned for Phase II of our study.



Graph 1: Pie graph shows all patients, and those with dramatic SEP outcomes (in milliseconds) measured by comparison of pre and post-op values.

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 (Graph 1).

Discussion and 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 preoperatively 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 was reported as transient in nature. Of approximately 70,000 lumbar fusion surgeries in the US, 7-11% regularly produces surgically related dysesthesias [21]. 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 [22,23]. 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, multi-center clinical trials are in development in the US 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.

Principal Investigators

Anthony Yeung, M.D. and John Porter, M.D. Char Merican, Research Associate.

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