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SPECIAL SECTION

Reporting on Dynamic SEMG Evaluation of the Cervical Musculature

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It is regular practice for a clinical investigator to report the findings of any pertinent test. SEMG endeavors to investigate several aspects of skeletal muscular dysfunction. Dynamic SEMG evaluation reporting of the cervical musculature range of motion is the subject of this report. The report content and format is in line with the Daubert Rule of Evidence (Federal Rule 702). The format of the report allows the clinician to present the data in a manner that allows readily for court testimony or other presentation of objective evidence.

Introduction

Reporting of diagnostic testing to the patient, the insurance industry, or to any other requesting authority, under the premises of HIPAA, is a common procedure. Not too long ago, the clinician was rarely expected to follow any standard reporting format. This is no longer the case. If a clinician wants to have the procedure reimbursed or recognized, one has to follow diagnostic testing with a comprehensive report.

Reporting an SEMG diagnostic test has to follow the same parameters that are expected under the Daubert Rule of Evidence (Rule 702 of the Federal Rules of Evidence) and that are applicable to the procedure (Sella, 1997a). The three tenets of the Rule are as follows: "(1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case" (Rule 702 of the Federal Rules of Evidence, Daubert/Kumho/Joiner requirements, 2007).

The present paper deals exclusively with the reporting of the dynamic SEMG procedure. It does not include reporting on the static SEMG procedure or on SEMG neuromotor reeducation/biofeedback training sessions.

Furthermore, it deals only with the dynamic SEMG testing of the cervical range of motion, to be described below. Some reporting parameters are common to most diagnostic techniques in the medical, physical, and occupational therapy or psychological office setting. Some parameters are pertinent only to this SEMG dynamic testing procedure.

The Cervical SEMG Dynamic Testing Protocol

The cervical range of motion (ROM) includes the segments of flexion, extension, lateral rotation (right and left), and bending (right and left). The motion of cervical translation is not discussed because it has not been standardized to date. Cervical translation is a multimodal motion along the axis of the first two vertebrae. It can be visualized easily as the type of cervical motion seen in Indian and Thai dancing. It is expected that the patient or subject of the test may be able to perform the full degrees of motion (see Table 1 for expected values). Goniometry or inclinometry testing needs to be performed before the SEMG dynamic testing (AMA, 1993; Gerhardt & Sella, 2002). If there are restrictions of motion in any particular dimension, this may affect the results of the SEMG testing, and that needs to be part of the report.

The SEMG testing protocol is standardized for all joint and muscle groups. The testing for the appendicular skeleton may be performed with concomitant or sequential motion of contralateral muscles. A movement of the two sides of the body performed at the same time is a concomitant movement. A movement of one side while the other is at rest followed by the opposite is a sequential movement. Contralateral muscles are the muscles on the two sides of the neck or other parts of the body. The testing for the axial skeleton may be performed only with concomitant motion of the contralateral muscles.

The test starts with the joint (or region) in neutral position and the subject at rest—"initial rest"—for 30 seconds. The test ends in a similar way with a "final rest." Each segment of motion is repeated five times for a period of 9 seconds, interspersed with an intramotion resting periods of five times, 9 seconds each. Minimal effort is

Table 1. Expected Angular (Degree) Values of Cervical ROM	
Segment of motion	Degrees of cervical ROM (°)
Flexion	50
Extension	60
Rotation (right and left)	80
Lateral bending (right and left)	45

Note. AMA, 1993; Gerhardt and Sella, 2002.

encouraged during the test. The rationale for this protocol is described in different texts (Sella, 2000a, 2002a).

A number of muscles surround the cervical region and are amenable to SEMG testing. Commonly assessed muscles are the sterno-cleido-mastoid, the upper trapezius, the scaleni group, and the cervical paraspinals (C1 through C7). Less commonly assessed muscles are the anterior digastric, the suprahyoid and infrahyoid groups, and the splenius capitis and splenius cervicis. The clinician also has the option to test muscles of the head, shoulder, or upper back when clinically pertinent.

Table 2 shows the expected SEMG amplitude potential values (microvolt RMS) during rest or motion through the cervical ROM of some of these muscles (Sella, 2002b, 2006).

Reporting Parameters

A number of parameters of muscular and subject behavior may be evaluated with the SEMG dynamic testing and may be subject to reporting. They include the parameters discussed below.

Internal consistency. This is defined statistically as a coefficient of variation (C.V.) of $<10\%$ or <0.10. This is applicable to the SEMG dynamic testing of any segment of motion of any joint or region, e.g., the cervical ROM. In concrete terms, if the amplitude potentials measured at rest or during the five repetitions of a segmental motion vary within 10%, then the clinical and statistical interpretation is that of *good internal consistency*. If the value is $>10\%$ or >0.10, then the interpretation is either (a) *poor internal consistency on clinical grounds,* and the clinician needs to report the finding and the explanation, or (b) the interpretation may be that of compatibility with *symptom magnification or malingering,* and the clinician may have to report these findings as well (Sella, 1998, 2000a). An example of the former may be poor internal consistency in only one muscle, and the clinical explanation may be that the target muscle is the injured one, whereas the other muscles tested show good internal consistency through the testing protocol. An example of the latter may be the finding that there is poor internal consistency through the whole ROM for the eight muscles tested. It would be very difficult to find a pertinent clinical explanation for such "muscle" behavior. Explanations may reside in the somatoform condition realm or in the forensic field such as with symptom magnification or malingering.

Internal consistency cannot be computed in the presence of muscular tremor, fasciculations, or myokimia (Sella, 2000, 2002b, 2002c).

Contralateral balance. This is defined as a difference in potential amplitudes of less than 25% (Sella, 1997b, 2000a; Sella & Donaldson, 1996). The difference does not have to be the same for all the segments of motion tested. A difference of greater than 25% in favor of a particular side, whether for one or all the muscles tested, must be evaluated further, such as with dynamometry, nerve conduction study/needle EMG, etc. A common reason for a muscle to show increased (consistent) activity is loss of strength, such as in deconditioning or injury. Contralateral balance is of particular interest in the testing of the cervical or trunk muscles in contralateral motions such as rotation and bending. The expectation is that of "mirror image"

Table 2. Expected Activity and Resting Amplitude Potentials (μV RMS) of Four Paracervical Muscles Through the Cervical ROM						
Muscle	Initial Rest	Flexion	Extension	Rotation	Bending	Final Rest
SCM	5.7	14.2	11.8	16.1	13.5	5.7
Upper trapezius	6	12.1	11.5	11.3	12.4	6
Scaleni	2	21.7	17.2	21	18.5	2
Anterior Digastric	6.1	21.1	9.6	10.8	10.4	6.1

Note. Sella, 2002b. (1) Sensor size was 2 cm square, (2) interelectrode spacing was 2 cm, and (3) SEMG bandpass was 15–500 Hz.

amplitude potential values. Contralateral balance cannot be computed in the presence of tremor, fasciculations, or myokimia. (Sella, 2002b, 2002c).

Hyperactivity. This is defined as a muscular potential activity tonus consistently in excess of 20% above the expected reference values for that muscle (Sella, 2000a, 2002b). The increased amplitude potential during activity is not paralleled by that of the resting tonus, which remains within the expected range. Hyperactivity is expected to be found in a dysfunctional muscle, e.g., in deconditioning. If the subject exerts conscious or unconscious effort during the testing, hyperactivity may be found in all the muscles tested.

Hypoactivity. This is defined as an activity amplitude potential that falls consistently >20% below the expected reference value for a muscle during any motion (Sella, 2000a, 2002b). The resting potential stays within the expected reference values. Hypoactivity is found less frequently than hyperactivity. Clinical experience shows that it is found in very athletic individuals with a large muscle mass. Since SEMG testing cannot be conducted validly in the presence of subcutaneous adipose tissue in excess of 1.5 cm, findings of "hypoactivity" in very obese individuals may be a sign of technical limitation rather than clinical abnormalities (Sella, 2000b).

Hypertonus. This is defined as activity or resting amplitude potentials that are >20% in excess of the expected reference values (Sella, 2000a, 2002). A muscle in the phase of hypertonus is tense and unable to rest, though not necessarily hypertrophic on palpation. If the finding of hypertonus is generalized over the eight (or other total number) muscles tested, the finding may be attributed to emotional tension and probable sympathetic overload. If hypertonus is found on only one muscle, clinical reasons for "irritation" must be sought and reported. Hypertonus is a variable reportable finding. It may be found in all the segments of motion or only in a particular segment. It may show a rather consistent amplitude through the five repetitions of motion or a "crescendo" or "descrescendo" pattern. Internal consistency and muscular balance cannot be validly computed in the presence of hypertonus (Sella, 2000b).

Hypotonus. This is defined as activity or resting amplitude potentials that are >20% below those of the expected reference values (Sella, 2000a, 2002b). A muscle in the phase of hypotonus is rather flaccid, for a variety of clinical or pathologic reasons, though not necessarily hypotrophic on palpation. If the finding of hypotonus is generalized over the eight (or other total number) muscles tested, the finding may be attributed to pathological reasons. If hypotonus is found on only one muscle, clinical reasons for "flaccidity" must be sought and reported. Hypotonus is not a variable finding. Internal consistency and muscular balance cannot be validly computed in the presence of hypotonus (Sella, 2000b).

Spasm. This is a variable of hypertonus or hypotonus. (The values of the amplitude potentials during the resting or motion phase cannot be distinguished from one another). Technical artifact must be ruled out if the finding is generalized over one or more muscles, such as poorly attached electrodes. A muscle in spasm generally shows potential amplitude values in excess of the expected reference values. However, those values may also be within the expected range or below the expected range. Spasm may be found variably for a particular muscle during any or all segments of motion tested, or it may be found in several muscles. Spasm may show a crescendo or decrescendo pattern through the five repetitions of any segment of motion. Clinically one may see spasm become hypertonus or vice versa during any segment of motion. The author has not observed the same for spasm and hypotonus. Internal consistency and muscular balance cannot be validly computed in the presence of spasm (Sella, 2000b).

Tremor. There are several types of tremor. The most common is normal physiologic response to cold, and in that case it is called *shivering*. If it occurs over the pectoralis muscle, it needs to be ruled out via EKG from atrial fibrillation. Muscular tremor may be the result of sympathetic "overcharge," such as in conditions of fear. It may be of neuro-pathology etiology, ranging from "familial tremor" to intentional and nonintentional tremor, such as in Parkinson's or other conditions.

Fasciculations. Fasciculations are repeated muscle jerking motions of a variety of amplitudes. They are by definition involuntary and may last from a couple of seconds to several minutes. This is a neurologic finding compatible with various etiologies of neuro-muscular irritation. Fasciculations may be observed during SEMG dynamic testing. They may occur on one or more muscles, in a constant or inconstant pattern over a period of time. Fasciculations observed with SEMG are reportable as true fasciculations. They may be provoked by the insertion of a needle-EMG. The same cannot be imputed to the SEMG technique. The presence of fasciculations precludes any statistical treatment of the data, and the clinician needs to report this finding (Sella, 2000b).

Myokimia. Myokimia is a variant of fasciculations. It is the result of muscle irritation and appears mainly in the facial muscles. Statistical treatment of the data is precluded in the presence of myokimia (Sella, 2000b).

Contracture. Contracture refers to a complete lack of muscular amplitude potentials during activity or rest. Technical artifact needs to be ruled out at all times, i.e., lack of electrode connectivity. Contracture may be seen in denervated muscles in neurological conditions such as poliomyelitis (Sella, 2000b).

Co-contractions and co-activation. Co-contractions and co-activation could not be observed during the testing of the axial muscles, as they are observed only during activation of the homologous contralateral muscles in sequential activity. The axial muscles can be tested only through concomitant motions (Sella & Donaldson, 1996).

Loss of strength (LOS). This parameter of muscle function needs to be assessed with dynamometry when possible and clinical assessment such as observable loss of trophy and tonus. Trophy refers to the fullness of a muscle body. A normal muscle is called "normotrophic." A poorly defined muscle is "hypotrophic." Muscular "atrophy" refers to muscle wasting and very poor strength. SEMG is a useful tool for investigation of muscular strength, since muscles that have LOS need to perform at a higher level of electrical potential activation to achieve a given task (Sella, 2000a). The presence of hyperactivity or hypoactivity allows the clinician to rule out potential abnormal muscular activity related to the strength factor. The presence of muscular contralateral imbalance as well as of hyperactivity or hypoactivity may show further light on this subject. LOS is a reportable observation or finding.

Pain. SEMG is a confirmatory test for the presence of pain. The clinician needs to assess or rule out the presence of pain with multiple relevant modalities, and SEMG is one of them. An axial muscle in pain may exhibit variably hypertonus, spasm, or hypotonus. An appendicular muscle may also exhibit co-contraction or co-activation. Any muscle affected by a neurologic condition may exhibit fasciculations. The presence of pain is usually reportable on a semiquantitative visual analog scale. This self-reporting is subjective and has only partial value, mainly within a time span scale. SEMG is a singular test can be used to rule out the presence of somatoform disorders, symptom magnification, and/or malingering, thus helping to rule out the simulation of pain or loss of strength.

The Report Components

The administrative or legal authorities expect a useful and comprehensive report. The clinician may format and send a report that includes the following:

1. Name and address of the clinician and/or clinic
2. Date of test
3. Title of report, i.e. "SEMG dynamic investigation of the cervical muscles ROM"
4. Clinical and SEMG diagnostic findings. The diagnoses are in the ICD-9 format (soon to be changed to the ICD-10 format). Examples of 10 common cervical-associated diagnoses are as follows: 723.1 Neck pain NEC, 959.09 Injury face, neck, sprain/strain neck, 781.92 Abnormal posture, 728.85 Muscle spasm, 728.9 Disorders of muscles, ligaments and fascia, 781.0 Abnormal involuntary movements, spasm, spasticity, 306.0 Torticollis, psychogenic spasm, 300.89 Occupational spasm, 307.80 Psychogenic pain, 308.2 Stress psychomotor.
5. Name of body region or joint tested
6. Names of the muscles tested bilaterally through the SEMG dynamic protocol. If the clinician uses muscles that are not primarily of the myotatic unit tested, one needs to add a clinical explanation for the procedure. A myotatic unit refers to the anatomic group of muscles that surround and activate one or more joints, functioning simultaneously as a unit. For instance, the myotatic unit of the elbow joint consists of the following muscles: biceps, triceps, brachialis, brachioradialis, and anconeus.
7. Tabular formats (i.e., tables containing the names of the muscles tested through the cervical ROM and the segments of motion tested through activity and rest) for the following testing parameters: internal consistency and contralateral balance. The reporting needs to include statistical conclusions and clinical inferences.
8. Individual tabular formats (same format as above) for any finding such as hyperactivity, hypoactivity, hypertonus, hypotonus, spasm, tremor, fasciculations, myokimia, or contracture. The reporting needs to include statistical conclusions and clinical inferences.
9. Individual tabular formats for the issues of LOS and presence of pain. The reporting may need to include conclusions based on the clinical observations and other objective or subjective findings as well as inferences based on the statistics of internal consistency and contralateral balance.
10. Overall conclusions, recommendations for further testing, and recommendations for treatment, which may include SEMG neuromuscular rehabilitation, other biofeedback modalities, or active or passive physical therapy modalities.
11. Clinician signature, titles (including BCIA certification and credentials), and date of report.
12. Reference list. The clinician may add any further relevant references to the list below.

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