Clinical Practice Guideline: **Surface Electromyography (SEMG)**

Date of Implementation: **February 9, 2006**

Product: **Specialty**

GUIDELINE

Surface Electromyography (SEMG) is considered experimental and investigational for diagnostic purposes of any condition. There is insufficient evidence in the peer-reviewed literature to establish its clinical utility and effectiveness.

HCPCS Code

HCPCS Code	Description
S3900	Surface electromyography (EMG)

DESCRIPTION/BACKGROUND

Surface Electromyography (SEMG) is a technique in which electrodes are placed on (not into) the skin overlying a muscle to detect the electrical activity of the muscle.

EVIDENCE AND RESEARCH

There is a wide variety of Surface Electromyography (SEMG) hardware and software that is used depending upon the specific clinical purpose intended. However, all SEMG hardware and software have in common the following:

- Electrical signals are measured from skeletal muscles.
- Sensing electrodes are placed on the skin overlying the muscle of interest.
- The electrical activity is measured when the muscle is active.
- SEMG records a narrow frequency of electrical activity (20-500 Hz).
- SEMG findings are based on computer analysis of either the frequency spectrum (spectral analysis), amplitude of signal, or root mean square of electrical action potentials.

There are four different clinical circumstances identified in the literature in which SEMG might be used. A discussion of each is presented below.

The Evaluation of Specific Neuromuscular Pathologies

The literature on the subject of SEMG use for neuromuscular disorders indicates that it is inferior in all parameters (sensitivity, specificity, spatial resolution, signal to noise ratio) to the invasive procedures such as needle electromyography (NEMG) or fine-wire electromyography (FWEMG) and thus cannot be used as a substitute for those procedures.

To CQT for review 10/09/17
CQT reviewed 10/09/17
To QIC for review and approval 11/07/17
QIC reviewed and approved 11/07/17
To QOC for review and approval 11/16/17
QOC reviewed and approved 11/16/17

Both systematic reviews of this subject explicitly reject SEMG for the diagnosis of neuromuscular disease.

The gold standard for this type of evaluation is either NEMG or FWEMG. Because these procedures are both invasive and painful, there is an obvious desire to find equally useful, but less onerous diagnostic tests. There are, however, several inherent limitations to the use of SEMG for the analysis of neuromuscular pathology. SEMG records input from a much wider spatial field than do either of the invasive procedures. Muscles adjacent to those of interest can produce signals that appear to originate from the target muscles (which are located immediately beneath the sensing electrodes). Thus, the specificity of SEMG findings is always in doubt. SEMG is also very susceptible to movement artifact. Even with the most careful procedural safeguards, small (and even imperceptible) body movements may produce spurious signals. There is a much poorer signal to noise ratio with SEMG. This is particularly a problem when target muscles are located more than 10 mm below the skin surface. Finally, the electrical activity that is recorded by SEMG is only of skeletal muscle origins. It is not possible to capture any electrical activity along motor neuron axons, as it is with NEMG or FWEMG.

The Evaluation of Movement and Gait Disturbances

There are a variety of experimental applications such as studies of human movement, the study of nerve conduction velocities after electrical stimulation of peripheral nerves, etc., in which SEMG is considered standard. Because of its relative ease of use and non-invasive nature, SEMG is considered superior to NEMG and FWEMG for many of these applications. There are also thought to be advantages in using SEMG to evaluate/study movement disorders of CNS origins such as tremor, dystonia, dyskinesia, and myoclonus. While it is thought that SEMG can accurately measure these disorders, it is less clear what the clinical utility of these measurements might be. This is the only application for which the American Medical Association (AMA) Current Procedural Terminology (CPT) coding committee has developed a procedure code.

The Evaluation of Functional Back Pain

There are a number of studies that have investigated the possibility that SEMG may differentiate between those with and those without back pain by evaluating muscle fatigue through "spectral shift". However, the findings are inconsistent and contradictory, the relationship between muscle fatigue and back pain is not established, and there may be unrelated factors affecting spectral shift.

The clinical context in which chiropractors are most likely to use SEMG is for the evaluation of functional low back pain and neck pain. There are two proposed mechanisms by which SEMG is thought to relate to back pain. First is the presumed relationship between muscle fatigue and back pain. The theory posits that excessive muscle fatigue, due to deconditioning, may result in back pain. Further, it has been shown that when muscles fatigue they produce a different set of electrical frequencies as measured by SEMG. This phenomenon has been dubbed the “spectral shift.” Thus, it has been hypothesized that by using dynamic SEMG (recording muscle activity while exercising) it should be possible to differentiate those with back pain from those without back pain. There are a number of studies that have investigated this possibility and some have had success in doing so. However, this success is tempered by several caveats. First, these findings are inconsistent and somewhat contradictory. Second, the exact nature of the relationship between muscle fatigue and back pain is uncertain. In fact, the direction of the relationship is uncertain—does muscle fatigue cause back pain or does back pain cause muscle fatigue? Third, it is unclear what other factors might cause a spectral shift making the specificity of such findings doubtful.

There is another mechanism by which it is proposed that SEMG can assist in the evaluation of back pain: the identification of hypertonic muscles. It is this mechanism that the leading chiropractic proponents of SEMG suggest is the most relevant to patient management. In effect, it is proposed that SEMG is a more objective and accurate tool than palpation in locating hypertonic muscles and thereby the identification of vertebral subluxations. The literature relative to this mechanism is even more limited and of much poorer quality than is the literature on muscle fatigue and SEMG. It is also speculated that the finding of SEMG asymmetry is an indication of spinal dysfunction. There is no literature that finds a relationship between back pain and such asymmetry and at least one study that casts doubt on this hypothesis. SEMG is not reliable for assessing spinal dysfunction or subluxation.

A recent analysis by Triano, et al. (2013) examined the techniques and procedures used by chiropractors to identify the appropriate site for the application of spinal manipulation. Consistent with previous reviews they found limited support for reliability of SEMG to identify cohorts of patients with abnormal neuromuscular control. However the review concluded that there was no support for the use of SEMG to localize treatment to a specific site. Another area of research for SEMG is its use as a prognostic tool. Studies have looked at flexion and extension movements to determine the prognosis of the patient relative to their low back pain recovery. Hu et al. (2014) evaluated the prognostic value of quantitative SEMG topographic analysis and attempted to verify the accuracy of the performance of proposed time-varying topographic parameters for identifying the patients who have better response toward the rehabilitation program. Thirty-eight patients with chronic nonspecific LBP and 43 healthy subjects were included in the study. These patients suffered from chronic nonspecific LBP without the history of back surgery and any medical conditions causing acute exacerbation of LBP during the clinical test were enlisted to perform the clinical test during the 12-week physiotherapy (PT) treatment. Low back pain patients were classified into two groups: "responding" and "nonresponding" based on the clinical assessment. The responding group referred to the LBP patients who began to recover after the PT treatment, whereas the nonresponding group referred to some LBP patients who did not recover or got worse after the treatment. The quantitative time-varying analysis of

SEMG topography showed significant difference between the healthy and LBP groups. The discrepancies in quantitative dynamic SEMG topography of LBP group from normal group, were able to identify those LBP subjects who would respond to a conservative rehabilitation program focused on functional restoration of lumbar muscle. More research is needed to confirm results and evaluate its utility clinically.

In assessing the appropriateness of SEMG for functional back pain, there are three levels of analysis to consider that remain pertinent:

1. **Technical performance of the instrument.** To what extent does the instrument accurately measure what it purports to measure (e.g., muscle fatigue, muscle spasm)? The above discussion regarding neuromuscular disorders identifies several inherent limitations in the technical performance of SEMG. All of those limitations (with the exception of the inability to measure axonal signals) are relevant to this issue as well. The lack of specificity, poor signal to noise ratio, and the problem of movement artifacts will all limit the accuracy and validity of SEMG for the evaluation of functional back pain.

2. **Whether and how the instrument findings can be used in patient management.** The use of SEMG as a "subluxation detector" that can help identify specific levels of spinal dysfunction has not been substantiated and is entirely speculative.

   If it has been determined that it is possible to identify hypo- or hypertonic muscles through the use of SEMG (keeping in mind the inherent technical limitations affecting specificity, accuracy, and validity), the question becomes how this information will be used in the management of the patient. To date, the only clinical correlation that has been established is that there *may* be differences between subjects with back pain and control subjects in their muscle fatigability as measured by SEMG. In other words, it may be possible to differentiate those with and without back pain using SEMG. But as one of the systematic reviews points out, the gold standard for the presence or absence of back pain is the clinical history, and it is far easier and more reliable to simply ask the person whether he or she has back pain. While potentially, it might be possible to use SEMG to identify malingerers, the procedure is currently far too unreliable to permit any such determination to be predicated on SEMG findings. In addition, several established malingering tests are available as taught within standard orthopedic examination courses in chiropractic, osteopathic, and medical schools.

3. **Whether the use of an instrument results in better clinical outcomes.** There is no evidence (and very little theory) to indicate how specific SEMG findings should be used to manage individuals with back pain in order to produce better clinical outcomes.

Ultimately what matters is whether or not the use of SEMG results in better clinical outcomes than does the management of back pain without the use of SEMG information. There have been no clinical trials that have addressed this question. In fact, there are no clinical trials of back pain that have used SEMG in any aspect of the diagnosis of subjects, in measuring outcomes of treatment, or otherwise evaluating the effectiveness of the therapeutic intervention (e.g., chiropractic treatment).

Use in Biofeedback

There is a fairly well established basis for the use of SEMG as a form of biofeedback.

References

Ahern, D. K., Follick, M. J., Council, J. R., & Laser-Wolston, N. (1986). Reliability of lumbar paravertebral EMG assessment in chronic low back pain. *Archives of Physical Medicine and Rehabilitation, 67(10),* 762-765.

Ahern, D. K., Follick, M. J., Council, J. R., Laser-Wolston, N., & Litchman, H. (1988). Comparison of lumbar paravertebral EMG patterns in chronic low back pain patients and non-patient controls. *Pain, 34(2),* 153-160.

Alexiev, A. R. (1994). Some differences of the electromyographic erector spinae activity between normal subjects and low back pain patients during the generation of isometric trunk torque. *Electromyography and Clinical Neurophysiology, 34(8),* 495-499.

Ambroz, C., Scott, A., Ambroz, A., & Talbott, E. O. (2000). Chronic low back pain assessment using surface electromyography. *Journal of Occupational and Environmental Medicine, 42(6),* 660-669.

Biedermann, H. J., Shanks, G. L., Forrest, W. J., & Inglis, J. (1991). Power spectrum analyses of electromyographic activity. Discriminators in the differential assessment of patients with chronic low-back pain. *Spine, 16(10),* 1179-1184.

Collins, G. A., Cohen, M. J., Naliboff, B. D., & Schandler, S. L. (1982). Comparative analysis of paraspinal and frontalis EMG, heart rate and skin conductance in chronic low back pain patients and normals to various postures and stress. *Scandinavian Journal of Rehabilitative Medicine, 14(1),* 39-46.

Current Procedural Terminology (CPT®) ©2016 American Medical Association: Chicago, IL.

Danneels, L. A., Cagnie, B. J., Cools, A. M., Vanderstraeten, G. G., Cambier, D. C., Witvrouw, E. E., et al. (2001). Intra-operator and inter-operator reliability of surface electromyography in the clinical evaluation of back muscles. *Manual Therapy, 6(3),* 145-153.

DeGood, D. E., Stewart, W. R., Adams, L. E., & Dale, J. A. (1994). Paraspinal EMG and autonomic reactivity of patients with back pain and controls to personally relevant stress. *Perceptual and Motor Skills, 79(3 Pt 1),* 1399-1409.

Ferdjallah, M., & Wertsch, J. J. (1998). Anatomical and technical considerations in surface electromyography. *Physical Medicine and Rehabilitation Clinics of North America, 9(4),* 925-931.

Geisser, M. E., Ranavaya, M., Haig, A. J., Roth, R. S., Zucker, R., Ambroz, C., et al. (2005). A meta-analytic review of surface electromyography among persons with low back pain and normal, healthy controls. *Journal of Pain, 6(11),* 711-726.

Grassme, R., Arnold, D., Anders, C., van Dijk, J. P., Stegeman, D. F., Linss, W., et al. (2005). Improved evaluation of back muscle SEMG characteristics by modelling. *Pathophysiology, 12(4),* 307-312.

Haig, A. J., Gelblum, J. B., Rechtien, J. J., & Gitter, A. J. (1996). Technology assessment: The use of surface EMG in the diagnosis and treatment of nerve and muscle disorders. *Muscle & Nerve, 19(3),* 392-395.

Heinonen, P., Kautiainen, H., & Mikkelsson, M. (2005). Erector spinae SEMG activity during forward flexion and re-extension in ankylosing spondylitis patients. *Pathophysiology, 12(4),* 289-293.

Hogrel, J. Y. (2005). Clinical applications of surface electromyography in neuromuscular disorders. *Neurophysiologie Clinique, 35(2-3),* 59-71.

Hu Y, Kwok JW, Tse JY, Luk KD. Time-varying surface electromyography topography as a prognostic tool for chronic low back pain rehabilitation. Spine J. 2014 Jun 1;14(6):1049-56.

Jalovaara, P., Niinimaki, T., & Vanharanta, H. (1995). Pocket-size, portable surface EMG device in the differentiation of low back pain patients. *European Spine Journal, 4(4),* 210-212.

Jurell, K. C. (1998). Surface EMG and fatigue. *Physical Medicine and Rehabilitation Clinics of North America, 9(4),* 933-47, viii-ix.

Krivickas, L. S. (1998). Electrodiagnosis in neuromuscular disease. *Physical Medicine and*

Rehabilitation Clinics of North America, 9(1), 83-114, vi.

Lariviere, C., Arsenault, A. B., Gravel, D., Gagnon, D., & Loisel, P. (2002). Evaluation of measurement strategies to increase the reliability of EMG indices to assess back muscle fatigue and recovery. *Journal of Electromyography and Kinesiology, 12(2),* 91-102.

Lariviere, C., Gagnon, D., & Loisel, P. (2000). The comparison of trunk muscles EMG activation between subjects with and without chronic low back pain during flexion-extension and lateral bending tasks. *Journal of Electromyography and Kinesiology, 10(2),* 79-91.

Lehman, G. J., & McGill, S. M. (1999). The importance of normalization in the interpretation of surface electromyography: A proof of principle. *Journal of Manipulative and Physiological Therapeutics*, 22(7), 444-446.

Lofland, K. R., Cassisi, J. E., Levin, J. B., Palumbo, N. L., & Blonsky, E. R. (2000). The incremental validity of lumbar surface EMG, behavioral observation, and a symptom checklist in the assessment of patients with chronic low-back pain. *Applied Psychophysiology and Biofeedback, 25(2),* 67-78.

Mohseni Bandpei MA, Rahmani N, Majdoleslam B, Abdollahi I, Ali SS, Ahmad A.Reliability of surface electromyography in the assessment of paraspinal muscle fatigue: an updated systematic review. J Manipulative Physiol Ther. 2014;37(7):510-21.

Ng, J. K., Kippers, V., Parnianpour, M., & Richardson, C. A. (2002). EMG activity normalization for trunk muscles in subjects with and without back pain. *Medicine and Science in Sports and Exercise, 34(7),* 1082-1086.

Ng, J. K, Richardson, C. A., Parnianpour, M., & Kippers, V. (2002). EMG activity of trunk muscles and torque output during isometric axial rotation exertion: A comparison between back pain patients and matched controls. *Journal of Orthopaedic Research, 20(1),* 112-121.

Ng, J. K., Richardson, C. A., Parnianpour, M., & Kippers, V. (2002). Fatigue-related changes in torque output and electromyographic parameters of trunk muscles during isometric axial rotation exertion: An investigation in patients with back pain and in healthy subjects. *Spine, 27(6),* 637-646.

Oddsson, L. I., Giphart, J. E., Buijs, R. J., Roy, S. H., Taylor, H. P., & De Luca, C. J. (1997). Development of new protocols and analysis procedures for the assessment of LBP by surface EMG techniques. *Journal of Rehabilitation Research and*

Development, 34(4), 415-426.

Peach, J. P., & McGill, S. M. (1998). Classification of low back pain with the use of spectral electromyogram parameters. *Spine, 23(10),* 1117-1123.

Pullman, S. L., Goodin, D. S., Marquinez, A. I., Tabbal, S., & Rubin, M. (2000). Clinical utility of surface EMG: Report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. *Neurology, 55(2),* 171-177.

Triano JJ, Budgell B, Bagnulo A, Roffey B, Bergmann T, Cooperstein R, Gleberzon B, Good C, Perron J, Tepe R. Review of methods used by chiropractors to determine the site for applying manipulation. Chiropr Man Therap. 2013 Oct 21;21(1):36

Rau, G., Disselhorst-Klug, C., & Silny, J. (1997). Noninvasive approach to motor unit characterization: Muscle structure, membrane dynamics and neuronal control. *Journal of Biomechanics, 30(5),* 441-446.

Stalberg, E., & Falck, B. (1997). The role of electromyography in neurology. *Electroencephalography and Clinical Neurophysiology, 103(6),* 579-598.

Stegeman, D. F., Blok, J. H., Hermens, H. J., & Roeleveld, K. (2000). Surface EMG models: Properties and applications. *Journal of Electromyography and Kinesiology, 10(5),* 313-326.

Watson, P. J., Booker, C. K., Main, C. J., & Chen, A. C. (1997). Surface electromyography in the identification of chronic low back pain patients: The development of the flexion relaxation ratio. *Clinical Biomechanics (Bristol, Avon), 12(3),* 165-171.

Zwarts, M. J., & Stegeman, D. F. (2003). Multichannel surface EMG: basic aspects and clinical utility. *Muscle & Nerve, 28(1),* 1-17.

Zwarts, M. J., Drost, G., & Stegeman, D. F. (2000). Recent progress in the diagnostic use of surface EMG for neurological diseases. *Journal of Electromyography and Kinesiology, 10(5),* 287-291.