COMMENTARY

# Applications of Transcutaneous Electrical Nerve Stimulation in Dentistry

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## Summary

TENS is extremely useful in some dental procedures, such as TMJ syndrome and tooth extraction; however, its use is not practical in all situations. The dentist must remember that TENS is an adjunctive form of treatment. It is not a panacea for all types of pain, nor should it be used as a last resort. When applied correctly and with care, TENS is useful in the management of pain in the head and face.

Pain in the United States supports an industry worth several billion dollars in sales each year. More than 200 varieties of biofeedback devices and dozens of pain-relieving techniques have been developed to aid in solving the problems of pain. In 1982, over 20 million Americans sought help for some form of pain. Of this number, 250,000 used transcutaneous electrical nerve stimulation (TENS). On the average, more than $200 was spent each month by or for pain patients.

TENS is the method by which controlled, low-voltage electrical pulses are applied to the nervous system. TENS is used to reduce the symptoms of pain. Secondary benefits, such as sedation and increased tissue temperature, are noted; however, the primary effect of TENS is to produce analgesia.

The idea of using electricity to reduce pain is not a new concept. Scribonius Largus recorded the use of an electric eel for treatment of headache and gout in 46 A.D.[1] More recent research into pain and electricity led to the proposal of the Gate Control Theory of pain by Melzack and Wall in 1965.[2]

The authors of the Gate Control Theory proposed that a constant and dynamic interaction occurs between the large diameter afferent cutaneous fiber (A fibers) inputs and the smaller diameter (A-delta and C fiber) fiber inputs at the segmental level of the spinal cord. The A fibers convey input responding to pressure, thereby activating the cells of the substantia gelatinosa (SG). The A-delta and C fibers are associated with pain conduction and attenuate SG cell presynaptic inhibition and, in effect, close the gate. Collaterals from the A-delta and C afferents inhibit SG interneurons to reduce presynaptic inhibition and open the gate. Functional results of this theory are well supported.

Wall and Street demonstrated successful alleviation of severe and chronic pain of cutaneous origin in eight patients by stimulating sensory nerves or roots in the painful area. Relief persisted as long as 30 minutes after a 2-minute administration of stimulation. Related clinical trials have continued with good results.

TENS has found broad applications in medicine. Physicians and physical therapists have accepted the ease, efficacy, and lack of undesirable side effects of the therapy. The indications for TENS are believed, by some, to be limitless. Shealy believes that "TENS is completely safe and can be used universally, subject to instruction and caution that it should not be used in cases of persistent pain without medical advice."

The practitioner is asked to initiate TENS therapy early and aggressively to improve the early management of the pain cycle, thereby to reduce or prevent development of problems that are part of progressive pain. Even in worst patient circumstances, 20 to 40% of patients obtain significant pain relief with TENS. Although 20-40% positive results may not appear to be significant, this percentage of favorable responses makes a strong statement regarding TENS therapy.

Of course, some skepticism about the use, safety, and effectiveness of TENS remains. The currents generated are safe, reliable, and controlled. TENS has passed the scrutiny of the Food and Drug Administration successfully to become a Class II device restricted to use on the prescription of a licensed physician.

The single indication for the use of TENS is in symptomatic relief of pain. Guidelines suggest that relief of pain should not be attempted until appropriate diagnostic and evaluation procedures are complete. Acute pain can act as a warning system to alert the patient to seek proper medical attention.

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## TENS and Analgesia

Any assessment of TENS must make some comment on its relationship to medication. The combined effects of TENS and drug therapy may provide the optimal clinical result. Some medications seem to reduce the effectiveness of TENS. Diazepam, codeine, and narcotics seem to diminish the patient's response to TENS.[4] However, TENS is effective in withdrawal therapy from these drugs.

Some medications reduce the effectiveness of TENS by antagonistic function; others act synergistically to enhance therapy. Use of TENS in conjunction with certain medications may reduce the drug dosage needed for effective analgesia and reduce or abate the associated adverse side effects of oral therapy. This is one more advantage of TENS—no such side effects are associated with TENS.

While recognizing these advantages, the practitioner must remember that TENS should not be used as a last resort. TENS also is not a panacea. No single therapy can manage and resolve all pain effectively. Although TENS may provide adequate symptomatic relief of pain, it is not usually used as an independent alternative to drug or other pain therapy. TENS is an adjunct to the total rehabilitation program of evaluation, treatment of cause, modulation of pain, and prevention of recurrence.

## Contraindications to TENS Use

There are no reports of adverse effects with TENS, but its use is contraindicated in patients with cardiac pacemakers.[5] TENS stimulation should not be applied over the cardiac sinuses, as a hypotensive response might produce cardiac arrest.

Care should be taken in applying TENS in other conditions. Effects on pregnancy are unknown, although several reports describe the successful use of TENS in labor and delivery. Electrodes should not be placed over the eyes, but there are no damaging effects when cutaneous areas surrounding the bony orbit are stimulated. TENS electrodes should not be placed internally. Electrodes should not be placed on the anterior chest wall of patients with a history of cardiac problems. TENS should not be used in cases of cerebrovascular accident, transient ischemia, or epilepsy. TENS should not be used in the incompetent patient.

No deaths or complications of existing disease have been reported with the use of TENS; however, slight skin reactions have been reported at electrode sites. The incidence of such reactions is quite low. Skin reactions may be caused by the electrical current, composition of the electrodes, composition of the coupling gel, the adhesive used to secure the electrodes, or, more often, the techniques used to fasten the electrodes to the skin.

Electric burns occur from excessive stimulation by small surface area electrodes. To ensure safety, electrode surface area must be equal to or greater than 4 cm.[2] Electric burns also occur if electrodes are placed too close together. The distance between electrodes must be greater than the cross-sectional diameter of the electrodes.[4]

Micropunctate burns may occur secondary to poor electrical contact at the skin-electrode interface. Thermal damage is not an inherent complication of TENS therapy.

Chemical reactions within the skin are unlikely contributors to skin irritation. Patients may experience skin irritation owing to an allergic reaction to the adhesive tape used to fasten the electrodes to the skin, or to the electrode gel itself.

The most common skin reactions result from shearing forces created between the tape and skin. Incidence of skin reactions is low; such reactions are usually unrelated to allergic reaction.

## Patient Evaluation

At the start of any evaluation, the practitioner must learn the etiology of pain and the specific time of onset. In recent onset pain, questions related to treatment and change in symptoms are of minor concern. Long-standing pain requires a more extensive history and consideration of the possibility of a chronic pain cycle.

If the patient complains of chronic pain, it is necessary to determine whether the pain is altered by movement. Does the pain follow a specific pattern? Changes in pain may be related to humidity, temperature, menstrual cycle, or consumption of certain foods. Pain of arthritis and migraine headache may fall into this category.

Intense pain is difficult for the patient to localize. As severity increases, so does pain distribution. Patients sometimes cannot differentiate paresthesia from anesthesia. Most use the term "numb" to describe paresthesia, an indication of nerve irritation. Anesthesia is indicative of nerve compression.

Pain thresholds vary considerably. The face and neck are significantly more sensitive than the feet and hands and the latter are more sensitive than the feet. Most patients have a greater sensitivity on the left side than on the right. Pain thresholds also have been found to vary throughout the day and evening.

## Location

The successful application of TENS depends on the definitive location of pain. It is useful to have the patient outline the exact areas of pain on anterior, posterior, and lateral views of the body. Marking X's on the *most* sensitive areas may indicate areas such as trigger points that can be used for therapy. Studies of lateralization of pain found that trigeminal neuralgia patients experience pain mostly on the right side.[7]

Pain is a multi-dimensional experience and often presents a confusing picture for both the patient and the clinician. The scope of this article permits description only of the application of TENS in several dental pathological conditions.

## Trigger Points

A trigger point is a small, hypersensitive region in muscle, ligament, fascia, or joint capsule from which impulses bombard the central nervous system and cause referred pain. It is agreed that excitation of an active trigger point produces the "jump sign," a flinch by the patient in which shortening of the muscle or fasciculation (or both) is evident.[8]

A few trigger points deserve special mention because of the symptoms they cause in the head and neck. A sternocleidomastoid muscle (SCM) trigger point gives rise to vertigo, lacrimation, ptosis or reddening of the eye, headache, tinnitus, and blurring of the hearing or vision.

The SCM has dual innervation; the cranial (accessory) branch innervates the upper trapezius muscle. Anastomoses between the accessory nerves and the hypoglossal nerve join the sensory nucleus of the trigeminal nerve. A large percentage of fibers of the sensory nucleus of this nerve crosses the midline; a smaller number remain ipsilateral. The resulting anatomic relationship and nerve paths account for much of the pathology of the SCM.

Trigger points of the masseter, temporalis, and external and internal pterygoids are all involved in temporomandibular joint (TMJ) syndrome and result in referral of pain to the cheeks, jaws, ears, TMJ, teeth, eyes, head, and neck. Associated symptoms include vertigo, tinnitus, joint crepitation, paresthesia of one side of the tongue and roof of the mouth, sore throat, swallowing problems, decreased hearing, and decreased oral aperture.[9] Long-standing TMJ syndrome can result in total body muscular tension.

## Selecting a TENS Unit

### Cost-quality review

The dentist must evaluate carefully the various types of equipment used in TENS therapy for safety and quality. Materials, engineering, and assembly should be assessed. Service contracts also are an integral part of the cost-quality review.

### Energy source

Most TENS units use batteries as their energy sources. AC 60-cycle current sources are called "clinical" models; most "patient" models use an alkaline or nickel-cadmium energy source. The per-use cost of the nickel-cadmium system is slightly higher, but there are advantages, such as when the system is used in constant 24-hour stimulation and when recharging of the nickel-cadmium system is impractical.

Energy sources may provide stimulation through one channel in a single-channel unit or through one or both channels in a dual-channel system. If pain relief is adequate with two electrodes (one channel), a dual-channel unit is unnecessary. If pain exists at several locations on the same patient, the dual channel is better; such units provide greater versatility in meeting the multiple needs of the patient.

### Lead wires

Many different wire systems are available. These vary in thickness, tensile strength, degree of flexibility, and length. Various systems should be evaluated to determine which lead wire system meets the needs of the practitioner.

### Electrodes

Electrode systems are perhaps the most difficult items to specify in a TENS system. Sponge electrodes do not conform to the body as well and the electrode-skin conducting fluids evaporate quickly. Carbon-silicone systems with a gel medium provide the best electrode-skin interface. Recently developed systems provide self-conductive tape strips, karaya gum electrodes, and synthetic polymer electrodes. These conform well and adhere to the skin without extensive taping; conductive substances evaporate less quickly and some electrodes can be worn over long periods.[4] These systems must be evaluated by the practitioner to assess their actual performance.

### Stimulation

A stimulus is any charge in the environment of excitable tissue that causes a reaction. To be effective, a stimulus must (1) be of a certain intensity; (2) have a certain duration; and (3) rise to a final intensity with a minimum certain speed.[4] These guidelines can be used in the adjustment of amplitude and pulse in TENS.

High wave, conventional TENS; low-rate, acupuncture-like TENS; single pulse TENS; burst/chain TENS; and brief, intense TENS all have advocates. However, no definitive study has been able to pinpoint one "best" method of TENS application. Mannheimer and Lampe recommend that the clinician have access to more than one wave form.[4] Occasionally, a patient who receives limited benefit from one wave form may receive additional relief from another.

### Electrode placement

One of the largest factors in the successful use of TENS is electrode placement. Placement must be adapted to pain referral and is based on anatomic and physiologic factors. Identical placement patterns for different patients with similar pain syndromes are not always effective. Several patterns should be tested in the average patient. There is no "cookbook" approach to electrode placement.

The effectiveness of TENS must be evaluated when the patient is in pain. Therefore, patients are requested to halt pain medication 4-6 hours before a clinic visit. In an inpatient setting, the physician should write a hold order for pain medication. Specific electrode arrangements should be evaluated during an activity which results in pain.

## Mode of TENS

The most common TENS mode is high rate, narrow pulse, and moderate intensity. This mode is best suited to the large afferent fibers. Muscle contraction should not be evident. If effective, this mode produces fast relief; however, its after-effect is short, generally not longer than the length of stimulation. Mannheimer and Lampe are able to obtain 1 to 3 hours of relief.[4] Conventional TENS produces a sensation of mild to moderate paresthesia.

Parameter adjustment begins with a high rate (50 to 100 Hz) and low pulse (40-75 $\mu$sec). Intensity is raised until a deep sensation of paresthesia is perceived. Small increases in pulse may help if current is not felt throughout the area of pain.

Others have used higher rate, shorter pulse TENS with poor results.[10] Lower rate TENS (10-25 Hz) also was less effective.

## TENS in the Head and Face

Pain of the head and face includes headache, toothache, trigeminal neuralgia, and TMJ syndrome. Electrode placement on the head is hindered by the hair unless sponge electrodes are used with water. Shealey introduced transcranial stimulation, a TENS device known as the Pain Suppressor,* to deliver low amperage current to both sides of the skull.[11] Electrodes are placed in the temporal region, above and slightly anterior to the ear. Stimulation for 12 minutes, five to eight times daily produced mood changes in some patients, indicative of a reduction in psychologic depression.

The Pain Suppressor is different from most TENS units in that its output is low, making its use in the head and face tolerable. Only amplitude and intensity are adjustable parameters.

## TMJ Syndrome

Transcranial stimulation with the Pain Suppressor has been used in patients with headache and TMJ syndrome. Electrodes are placed anterior to and at the level of the ear. Because of the low intensity of this application, it is recommended only as an adjunctive therapy. Definitive treatment includes physical therapy to the cervical spine and TMJ—joint mobilization, manual cervical traction, stretch techniques, postural exercises and relaxation training. Many TMJ patients also require insertion of a mandibular appliance. These patients may need to use TENS until such an appliance can be obtained.

## Case study

A 10-year-old girl was referred for pain control of TMJ syndrome. The patient had a history of chronic ear infections and recent trauma to the left side of the face and mandible. Severe left ear pain was worse at night. When medication did not alleviate the pain, TMJ syndrome was diagnosed.

Mandibular function was painful with deviation to the left. The left masseter, temporalis, digastric, and medial pterygoid were painful on palpation. There was a palpable click at the left TMJ with movement. Bruxism was confirmed by the parents.

Pain relief of 50-75% was reached after 20 minutes of TENS therapy and stretch exercises. Three treatments were given, with pain control maintained at home with TENS and ice massage. Use of a dental appliance has rendered the patient free of pain.

Moriconi, *et al.* advocate the use of TENS in the immediate postoperative period following TMJ reconstruction.[12] Electrodes are placed at each side of the incision, both in the preauricular or submandibular regions. There has been no need for postoperative analgesics if TENS is used.

## TENS and Tooth Pulp

Early reports of the use of TENS in dentistry described a handpiece that delivered small electric impulses to the tooth during cavity preparation. The subliminal current decreased pain effectively. Andersson *et al.* reported that tooth preparation can be performed without pain if strong TENS is applied to the cheek (infraorbital nerve).[13] Pain threshold had to be increased three-or four-fold.

Strassberg *et al.* used TENS to produce electroanalgesia in tooth extractions and minor surgical procedures.[14] Adequate pain control was obtained in 98% of patients with one electrode at the mandible and another at the main trigeminal trunk.

Ihalainen and Perkki used TENS for pain control after extraction of the mandibular third molars.[15] A 100 Hz current was applied for 30 minutes ipsilateral to the side of the extraction in the immediate postoperative period. The best results were obtained with stimulation at the mental foramen and angle of the mandible. Bilateral infraorbital stimulation was less effective.

The use of TENS in dentistry is gaining momentum as its value as a means of control of pain in TMJ syndrome, toothache, and tooth extraction is established. Experiments with the use of TENS in electroanalgesia and tooth preparation are ongoing and still inconclusive.

## Trigeminal Neuralgia

Trigeminal neuralgia, the severe paroxysmal facial pain syndrome, can be controlled by inducing a refractory state in the afferent fibers of the mandibular trigeminal fibers.[2] Sheldon *et al.* induce stimulation with an implanted receiver activated inductively at 14 KHz. This system is successful in extended trials, but the patient numbers are limited and conclusions cannot be drawn.

*Pain Suppression Labs, Elmwood Park, New Jersey

Field *et al.* have advocated the use of TENS in topical fluoride treatments for hypersensitive teeth.[2] Use of currents of 80-100 $\mu$amp and 1% Naf solution has reduced hypersensitivity in more than 99% of teeth treated. No contraindications to treatment were found.

Collins and Jensen used an iontophoretic toothbrush (current of 30-50 $\mu$amp) and 3-minute brushings twice daily with stannous fluoride toothpaste with moderate success.

Although no evidence of tooth pulp damage is evident after administration of current, asymptomatic loss of pulp vitality is possible. Histologic examinations have shown delayed healing, large deposits of secondary dentin, and alterations in pulp tissue. Thus, the encouraging results of this treatment for tooth sensitivity are negated by its side effects.

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