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Review Article

CRITICAL REVIEW OF TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TENS)

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ABSTRACT
Between the different Modalities for pain management Transcutaneous Electrical Nerve Stimulation (TENS) is one of them, which is safe, very effective, painless, transcutaneous and cost-effective modality. It is mostly used in Arthritis and different type of other pains such as joint pain, neck, lower and upper back pain, Fibromyalgia, Muscle pain and also in Neuropathic pain etc. In this paper description of TENS and its mode of action is elaborated.

KEY WORDS: Transcutaneous electrical nerve stimulation, Arthritis, Fibromyalgia, Muscle pain and Neuropathic pain.

INTRODUCTION

Pain effects economy of the country by increased morbidity which leads to loss of work hours, leading to financial losses to the person, his/her family and indirectly to the country. So it is expensive in terms of personal, social sufferings and also leads to impaired quality of productive life.[1,2] Use of TENS as an supplementary to core treatment is also the recommendation of National Institute of Health and Care Excellence[3] Transcutaneous electrical nerve stimulation (TENS), uses the electric current to activate nerves, which leads to decrease pain by blockage of pain sensation. TENS is noninvasive, transcutaneous technique[4] used for pain management, which is a simple, economic and safe approach used as an adjunct treatment for the treatment of painful musculoskeletal conditions having a considerable impact on basic and common daily activities of patients. The frequency (pulses per second), intensity (pulse amplitude) and pulse duration (periods when the electrical current is deliver) settings can be adjusted, leading to different types of TENS being used in clinical practice[5]TENS stimulates peripheral nerves by applying electric current in the form of pulses over the intact skin surface, primarily to relieve pain[6,]This electrical pulse may interrupt the pain signals in our body and help us feel less pain.

Historical Reviews

- **2,500 BC**: Ancient Egyptians- applied electrogenic fish to painful body parts to get relief in pain.

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- **60AD**: The Roman physician Scribonius Largus used contact with "electric fish" from the ocean for symptomatic relief in pain.
- **Early 18th century**: Electrotherapy gained popularity with the aid of electrostatic generators. Benjamin Franklin eventually became an advocate of the various devices designed to administer electrostatic exposures in the hopes of curing anything from cancer to headaches. (Johnson, M. I. (2007).
- **Late 19th century**: Increasing use of pharmacological treatments meant the decline in use of electrotherapy for pain.
- **The 20th and 21st century**: New small and compact machines, lead the way in clinical therapeutic usage of electricity in managing acute and chronic painful conditions. Now it is also used in combination with analgesics.
- **In 1965** : There was renewed interest in the application of electricity to treat pain following the publication of Melzack and Wall's "Pain Mechanisms: A New Theory". They proposed that the central transmission of harmful information such as pain could be inhibited by electrical stimulation of large diameter peripheral afferents (Aδ and C-nerve fibers). Clinical observations verified that patients' pain could be reduced by electrical stimulation of dorsal columns, descending pain inhibitory pathways, and peripheral afferents.
- Initially TENS was used to predict the success of dorsal column stimulation implants until it was realized that TENS could be used as a successful modality on its own.
- As the study of transcutaneous electrical nerve stimulation advanced, there came new techniques inherent to the modality, such as intense TENS, acupuncture TENS, and conventional TENS.

Definition

TENS is any technique that passes electrical currents across the intact surface of the skin to activate underlying nerves. This consists of a battery-powered hand-held stimulating device which generates very low-level pulsed electrical currents which are delivered through the skin using electrode pads (electrodes) attached to the skin surface near the site of pain.

The TENS unit: A devise, preferably small in size, portable and pocket friendly which produces gentle, pulsed electrical currents that are applied to the skin's surface through electrode pads to activate peripheral nerves. (Johnson 2015).

The TENS system has 2 parts:

- A control unit, kept next to your bed or on your intravenous (IV) pole
- A cable that connects to the electrodes on your body

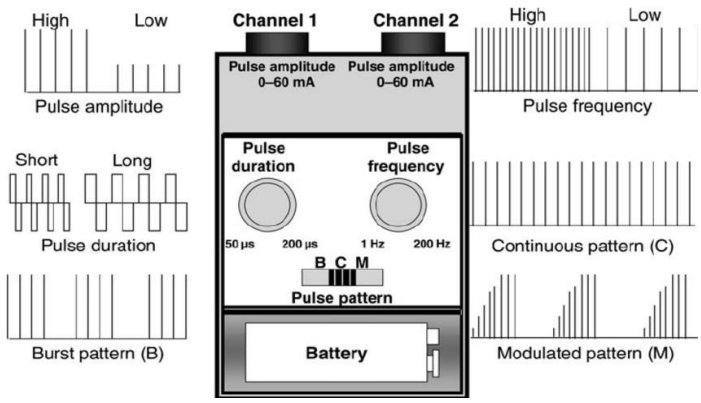

Figure.1 TENS system

Figure 2: TENS System

Use the TENS system:

The Control Unit

• The control unit has different settings called modes.

• After choosing the best mode it will slowly turn up Channel.

The Electrodes

•Electrodes are placed on clean intact skin on either side of the painful area.

• Make sure the electrodes at least 2 inches apart, but less than 8 inches apart. (2>X >8 inches)

For incisions: Place 1 electrode from each channel at the top and 1 from each channel at the bottom of the incision.

For painful areas: Place 1 electrode from each channel on either side of the painful area.

– You can also place both channels on 1 larger area or treat 2 different areas.

Using the System

Electrodes are placed and channels are set and the system is left on for 30 to 60 minutes. This helps decreasing pain for many hours. The goal is to find the right setting. Setting should be adjusted so that it will ease the pain and can also be tolerated for up to 1 hour. If needed, you can change the channel settings while the system is on. Patients and/or the therapy providers can adjust the TENS unit's controls to provide the most desirable amount of pain relief. This can be accomplished by modifying the electrical current in the following ways:

Intensity: Intensity of the electrical stimulation can adjusted by a dial by the user or therapy provider.

Frequency: The number of electrical pulses per second (frequency) can also be adjusted as required at low or high frequency pulses.

High-frequency (HF) pulses:

Range from 80 to 120 cycles/pulses per second and Best results for management of acute pain.

Low-frequency (LF) pulses:

Range from 1 to 20 cycles per second and suitable for the managing chronic pain.

Duration: Pulses of few microseconds are given for varied length of time as per the type of pain and treatment frequency.

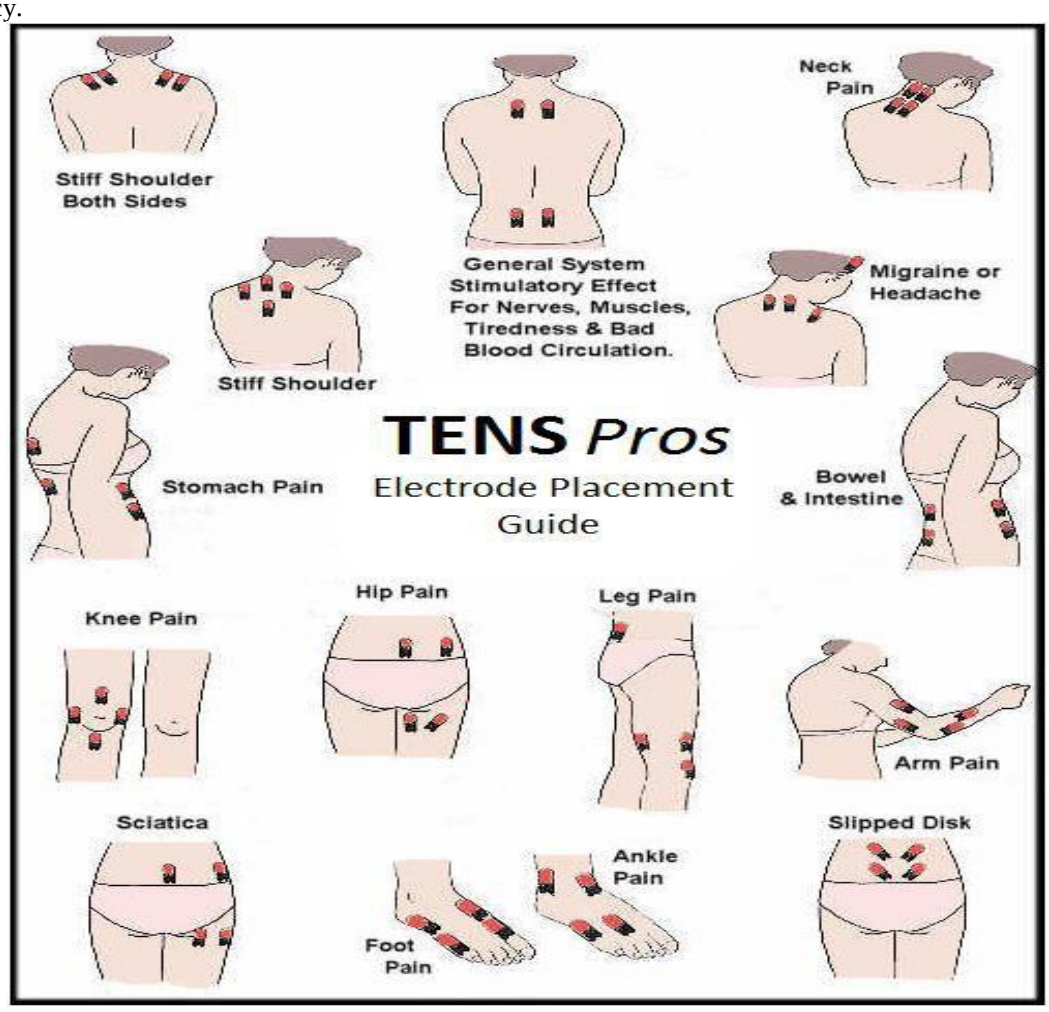

Figure .3 types of tens

TYPES OF TENS

Different TENS techniques are applied to selectively activate groups of nerve fibers to elicit mechanisms to attain relief in pain(Table 1). The main techniques are:

Sensory level (low intensity) TENSor Conventional TENS (low-intensity, high-frequency)

Motor-level TENS or Acupuncture-like TENS (high-intensity, low-frequency)

Noxious level or Intense TENS (high-intensity, high-frequency)

Conventional TENS is most the commonly used technique and for most patients is selected in the first instance.

Conventional TENS

The International Association for the Study of Pain (IASP) describes conventional TENS as *"High-frequency (50–100 Hz), low-intensity (paraesthesia, not painful), small pulse width (50–200μs)"* .

The intention of conventional TENS is to stimulate selectively large diameter, low threshold non-noxious afferents (A-beta) in dermatomes related to the pain (Fig 2a).

To achieve a strong, comfortable, and painless paraesthesia between the electrodes, TENS pulse amplitude is increased or adjusted accordingly. This suppresses activity in second order nociceptive transmission neurones in the central nervous system.

Further increases in pulse amplitude leads to high threshold A-delta/ A-***δ*** afferent activity and a painful paraesthesia beneath the electrodes. This is not the intended result of conventional TENS.

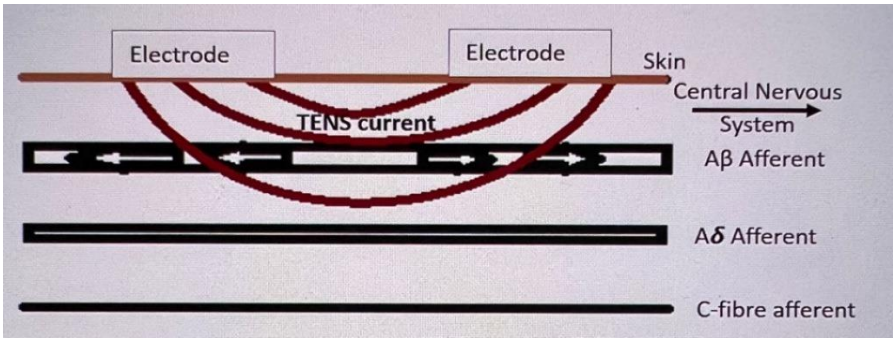

Figure 4: Conventional TENS.(TENS induced impulses (arrows) travel towards central and peripheral structures).

Acupuncture-like TENS (AL-TENS)

- AL-TENS is a form of hyperstimulation described by Sjölund and colleagues in the 1970s. It can be used if patients do not respond to conventional TENS .
- IASP defines the characteristics of AL-TENS as *"Low-frequency (2–4Hz), higher intensity (to tolerance threshold), longer pulse width (100–400μs)"*. Low-frequency trains or bursts (2–4Hz) of high-frequency pulses (100–200pps) are often used in clinical practice.
- The intention of AL-TENS is to stimulate small diameter, high threshold peripheral afferents (A-delta/ A-***δ***) in order to activate extra-segmental descending pain inhibitory pathways. Non-painful muscle twitches occur during stimulation causing activity in small diameter muscle afferents (Fig 2b).
- Electrodes are positioned over myotomes, trigger points and acupuncture points. It is advised to administer AL-TENS less frequently than conventional TENS e.g. 20 minutes, 3 times a day .

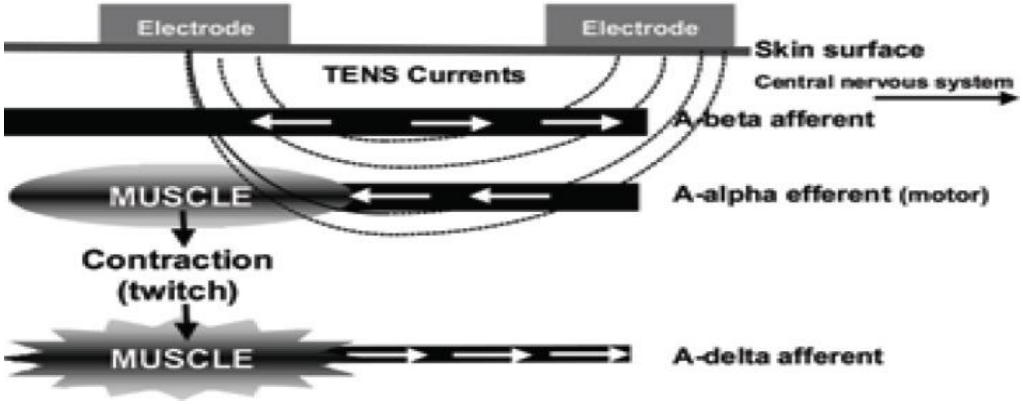

Figure 5: Acupuncture-like TENS.(Arrows indicate direction of impulses).

Intense TENS

The intention of intense TENS is to stimulate small diameter, high threshold cutaneous afferents (A-delta/ A-***δ***) to block transmission of nociceptive information in peripheral nerves and to activate extra-segmental analgesic mechanisms. High frequencies (up to 200 pps) and high intensities that are just tolerable to the patient are used but only delivered for short periods of time (Fig 2c). If motor level intensity is increased to the maximal level, it becomes noxious level (high intensity) TENS[7] Intense TENS acts as a counter irritant and is useful for minor procedures such as wound dressing and suture removal.

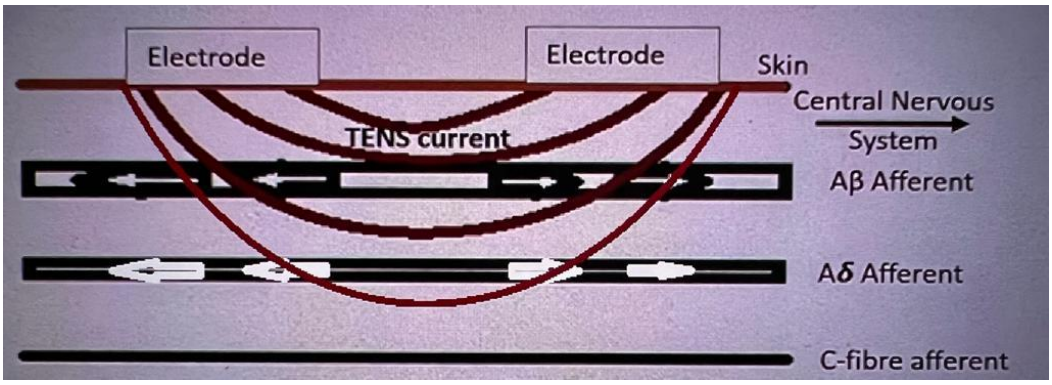

Figure 6: **Intense TENS.(TENS-induced impulses (arrows) travel towards central and peripheral structures).**

Table 1. Types intensity and frequency of TENS

Type of TENS	Intensity	Frequency	Afferent Nerve Fibres stimulated	Clinical Technique
Conventional TENS	Low	High	A-β	Applied at site of pain to produce "strong but comfortable TENS paraesthesia". Administer whenever in pain
Acupuncture-like TENS	High	Low	A-***δ***	Applied over muscles, acupuncture points or trigger points to produce "strong but comfortable muscle contractions". Administer for 15-30 minutes at a time
Intense TENS	High	High	A-***δ***	Applied over nerves arising from painful site to produce "maximum tolerable (painful) TENS paraesthesia". Administer for a few minutes at a time

Mechanism of action of TENS:

A TENS unit sends electrical pulses through the skin to start your body's own pain killers. The electrical pulses can release endorphins and other substances to stop pain signals in the brain. TENS can help with short term pain relief.

Postulated Mechanisms

Low-intensity, non-noxious TENS paraesthesia (conventional TENS) relieves pain by a segmental mechanism. Higher intensity TENS increases the likelihood of activating extra- segmental descending pain inhibitory pathways and diffuse noxious inhibitory controls via counter-irritant effects.

Additionally, TENS will result in peripheral blockade of afferent impulses originating from peripheral structures. (i.e. 'busy line-effect').[8]

Segmental mechanisms

TENS, when applied to somatic receptive fields and after spinal cord transection, reduces ongoing nociceptor cell activity and sensitization in the central nervous system, as per the evidence from animal studies. TENS-induced A-***δ*** activity causes long-term depression of central nociceptor cell activity for up to 2 hours. In 1965, Melzack and Wall[9] proposed that TENS could stimulate low-threshold cutaneous afferents to inhibit onward transmission of nociceptive information in the central nervous system and thus, alleviate pain (ie, segmental modulation).[10,11]

Extra- segmental mechanisms

TENS-induced activity in A-delta/***δ***, small diameter afferents activates the rostral ventromedial medulla and midbrain periaqueductal grey (descending pain inhibitory pathways) while inhibiting the descending pain facilitatory pathways. When muscle afferents are stimulated instead of skin afferents, larger effects have been seen. TENS may cause descending pain inhibitory pathways to become active by stimulating small-diameter afferents.[12-14]

Peripheral mechanisms

Antidromic activation of peripheral nerves by TENS generates nerve impulses that have been shown to collide and extinguish afferent impulses arising from peripheral structures. Peripheral blockade of nociceptive impulses is more likely when TENS activates A-delta/***δ*** fibres (i.e. intense TENS). TENS-induced activity in large diameter afferents (i.e. conventional TENS) will block afferent activity in large diameter fibres that may be contributing to pain.

Neurochemicals

TENS effects are mediated by many neurochemicals including opioids, serotonin, acetylcholine, noradrenaline and gamma-aminobutyric acid (GABA) .

Low but not high-frequency TENS has been shown to involve mu(μ) opioid and 5-HT2 and 5-HT3 receptors. High but not low-frequency TENS has been shown to involve delta(***δ***) opioid receptors and reduce aspartate and glutamate levels in the spinal cord .

Evidence from experimental pain studies using pain-free volunteers suggests that TENS hypoalgesia is greater than sham TENS but the relationship between pulse frequency and outcome is equivocal (Fig 3).

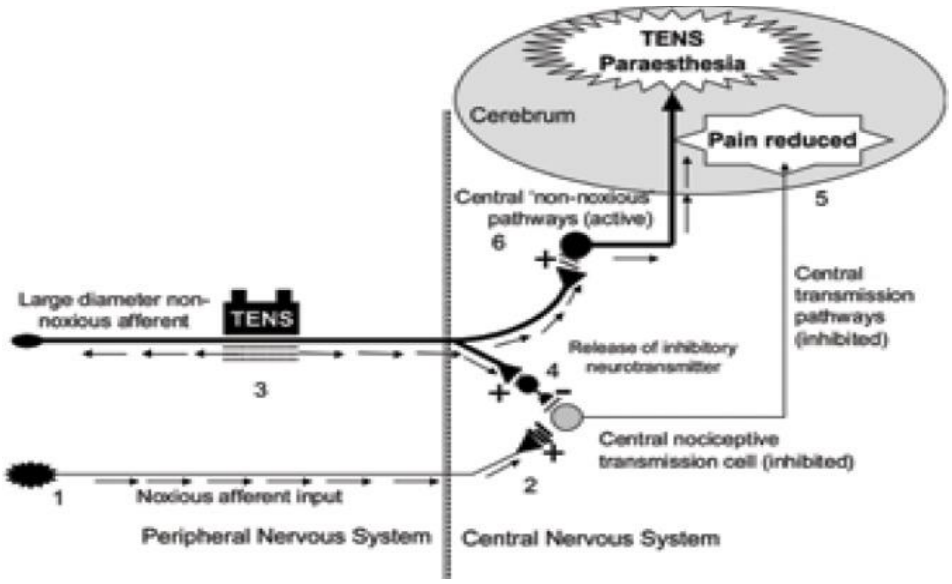

Figure 7: Activity in peripheral nociceptive afferents [1] releases excitatory neurotransmitters causing activity in second order nociceptive transmission cells in the central nervous system [2] which leads to pain.Activation of large diameter non-noxious afferents by TENS [3] causes the release of inhibitory neurotransmitters which reduce activity in second order nociceptive transmission cells [4]. The reduction in nociceptive input to the brain results in pain relief [5]. TENS induced activity in non-noxious transmitting pathways in the central nervous system results in a sensation of electrical paraesthesiae [6].

Uses of TENS:

A TENS may be used to help with many types of chronic (long-term) pain, such as:

→ Arthritis or other joint pain
→ Back and neck pain
→ Fibromyalgia
→ Muscle pain
→ Neuropathic pain

TENS also used in the following conditions:

- period pain
- labor pain
- postoperative pain

EFFICACY

TENS is useful for acute and chronic pain of nociceptive, neuropathic and musculoskeletal origin. Many of the 400 clinical trials cited in PubMed [28 March 2007] have methodological shortcomings.

TENS and acute pain

- TENS works very well for mild to moderate acute pain, but it is not very helpful when used alone for severe to moderate pain. In these cases, TENS may be helpful when used in conjunction with medication.
- Systematic reviews on effects of TENS on postoperative and labour pain have reported negative outcomes [15,16]. A meta-analysis demonstrated that TENS reduced post-operative analgesic consumption and that adequate TENS technique was critical to outcome [17].
- One Cochrane review concluded that high but not low-frequency TENS was superior to sham at reducing pain associated with primary dysmenorrhoea [18].
- RCTs suggest that TENS may be beneficial for acute orofacial pain, painful dental procedures, fractured ribs, acute lower back pain. TENS can be used for angina by placing electrodes over the painful area of the chest.

TENS and chronic pain

- Clinical experience suggests that TENS may be useful for any type of chronic pain. RCTs suggest that TENS is beneficial for localised muscle pain, post-herpetic neuralgia, trigeminal neuralgia, phantom limb and stump pain, diabetic neuropathies and entrapment neuropathies, radiculopathies (cervical, thoracic and lumbar), complex regional pain syndromes type I (reflex sympathetic dystrophy) and type II (causalgia).
- Cochrane reviews on chronic low back pain, rheumatoid arthritis of the hand, whiplash and mechanical neck disorders, post-stroke shoulder pain and chronic recurrent headache are inconclusive. One Cochrane review reported that TENS relieved pain and stiffness associated with knee osteoarthritis (294 patients, [19].
- A recent meta-analysis of transcutaneous and percutaneous electrical nerve stimulation included 38 studies and concluded that electrical nerve stimulation was an effective treatment for chronic musculoskeletal pain [20]

TENS safety [21,22]

Table 2. TENS should not be used

TENS should not be used on:	**TENS should not be used in**:
Open wounds or rashes o Swollen, red, infected, or inflamed skin	Pregnant females in abdominal and pelvic region
Cancerous lesions, or close to them	People with Epilepsy
Skin that does not have normal sensation (feeling)	People with heart problems
Any part of your head, face or throat	People with a pacemaker or another type of electrical or metal implant.
Both sides of the chest or trunk at the same time	People with cognitive disorders
Directly on your backbone	Deep-vein thrombosis

Precautions:

- Turn the TENS unit off before you put on, move, or take off the electrode patches.
- Do not share your patches with other people.
- Only use the TENS unit on yourself as instructed.
- Keep out of the reach of children.
- Electronic equipment, such as EKG monitors and EKG alarms, may not work the right way when TENS is in use.

Stop using TENS and talk with your doctor or health care team if you have:

- Skin irritation (redness, rash, itching) due to allergy to pad adhesive.
- Headache
- Dizziness
- Nausea

Benefits

- TENS is a noninvasive method for relieving pain.
- TENS may be able to reduce their intake of pain medications.
- TENS units are also convenient because they are small, portable, and relatively discrete.
- People can carry a TENS unit in their pocket or clip it onto a belt to ensure that they have immediate access to pain relief throughout the day.

CONCLUSION

TENS units are small, portable, relatively discrete and convenient device for the patient. Pain relief with TENS is rapid in onset and offset, although post-TENS effects vary considerably in reports and may be due to natural fluctuations in symptoms and patient expectation rather than TENS hypoalgesia. TENS effects may decline over time due to habituation to TENS or a worsening pain problem, which can be resolved by experimenting with electrode placements and TENS settings or temporarily withdrawing TENS treatment. The electrical pulses can release endorphins and other substances to stop pain signals in the brain. TENS can help with short term pain relief. Maximal pain relief occurs in the presence of a strong but comfortable electrical paraesthesia so TENS should be delivered as per the needs. TENS unit is safe, nonpharmacological, noninvasive, inexpensive, and easy to use.

The mechanism of action of TENS primarily involves neuromodulation of central nociceptive transmission irrespective of medical diagnosis. Therefore, TENS is used for symptomatic relief of pain rather than cure of pathology.

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