

**Subject: Bone Growth Stimulators:  
Electrical (Invasive, Noninvasive),  
Ultrasound**

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## **INSTRUCTIONS FOR USE**

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## **An ultrasound bone growth stimulator is considered medically necessary in skeletally mature individuals for EITHER of the following conditions:**

- When used as an adjunct to closed reduction and immobilization for ANY of the following acute fracture indications:
  - fresh (i.e., < 7 days), closed or grade I open, tibial diaphyseal fractures
  - fresh (i.e., < 7 days), closed fractures of the distal radius (Colles' fracture)
  - fresh, closed fractures when there is suspected high risk for delayed fracture healing or nonunion (i.e., due to location and poor blood supply [e.g., scaphoid, 5<sup>th</sup> metatarsal] or comorbidities [e.g., smoking, obesity, diabetes, renal disease, or other metabolic disease where bone healing is likely to be compromised])
  
- For nonunion of fractures when ALL of the following criteria are met:
  - The treatment is for nonunion of bones other than the skull or vertebrae (e.g., radius, ulna, humerus, clavicle, tibia, femur, fibula, carpal, metacarpal, tarsal, or metatarsal).
  - The nonunion is not related/due to malignancy.
  - It is ≥ three months from the date of injury or initial treatment.
  - The fracture nonunion is documented by at least two sets of appropriate imaging studies separated by a minimum of 90 days confirming that clinically significant fracture healing has not occurred.
  
- For treatment of a stress fracture that has failed a minimum of 90 days of conventional, nonsurgical management and demonstrates a fracture line that has not healed on imaging studies.

## **An electrical bone growth stimulator (i.e., noninvasive or invasive) is considered medically necessary in skeletally mature individuals for ANY of the following conditions:**

- The treatment is for a fracture nonunion, and ALL of the following criteria are met:
  - The nonunion is located in a long bone (i.e., clavicle, humerus, radius, ulna, femur, tibia, fibula, metacarpal or metatarsal bone) or the carpal and tarsal bones.
  - The fracture gap is ≤ 1 cm.

- The fracture nonunion is documented by at least two sets of appropriate imaging studies. separated by a minimum of 90 days confirming that clinically significant fracture healing has not occurred.
- When used in conjunction with surgical intervention for the treatment of an established fracture nonunion.
- For failed fusion of a joint other than the spine when a minimum of three months has elapsed since the time of initial surgery.
- For treatment of a stress fracture that has failed a minimum of 90 days of conventional, non-surgical management and demonstrates a fracture line that has not healed on imaging studies.
- As an adjunct to spinal fusion surgery when ANY of the following criteria are met:
  - History of prior spinal fusion failure
  - Multi-level fusion to be performed
  - Presence of any risk factor for nonhealing such as: smoking, obesity, diabetes, renal disease, or other metabolic disease where bone healing is likely to be compromised

**The use of a bone growth stimulator for ANY of the following indications is considered experimental, investigational or unproven and thus not medically necessary (this list may not be all-inclusive):**

- fresh fractures (other than for the above listed indications)
- toe fractures
- sesamoid fractures
- avulsion fractures
- osteochondral lesions
- displaced fractures with malalignment
- synovial pseudoarthrosis
- the bone gap is either > 1cm or > one-half the diameter of the bone

## General Background

Bones are divided into four major categories. Long bones are found in the extremities and are comprised of a shaft (i.e., diaphysis) and two ends (i.e., epiphyses). Long bones, which form levers, support weight and provide for motion, and include the clavicle, humerus, radius, ulna, femur, tibia, fibula, metatarsals and metacarpals. Short bones, which include the tarsal bones in the foot and carpal bones in the hand, are cube-shaped and are designed for strength. Flat bones provide protection and areas for muscle attachment and include the cranial bones, sternum, ribs, and the scapulae. Irregular bones include the vertebrae, sacrum, coccyx and some facial bones. Sesamoid bones are a type of short bone embedded within a joint capsule or tendon.

A fracture is a break in the bone and results from a strong force applied to the bone. Classifications of the extent and type of fracture may vary. Fractures of bone that frequently occur as a result of acute trauma may include simple or compound fractures, open or closed fractures, or complete or incomplete fractures, to name a few. In some cases where there is less intense but repetitive trauma, stress fractures may occur. This type of fracture can occur in any bone; however, most frequently they occur in the tibia, fibula, metatarsals, navicular, and less often in the sesamoid and hindfoot, and are often the result of sport participation. In some cases, stress fractures can result from conditions such as metabolic abnormalities or calcium deficiency. In order to promote bone healing, treatment for fractures generally involves immobilization and occasionally surgery. Additionally, treatment of stress fractures involves elimination of the cause, dietary modification and metabolic treatment, if necessary.

Fractured bones heal in several distinct stages. Initially, bleeding and swelling at the fracture site causes a hematoma to form. As the hematoma necroses, macrophages and osteoclasts arrive at the site to remove the debris, and osteoblasts (bone builders) and endothelial cells (blood vessel builders) are stimulated and begin rebuilding the bone and vasculature. Within two weeks, fibroblasts, osteoblasts and chondroblasts combine to form a soft callus that becomes a hard callus of woven, immature bone that bridges the gap in the bone (approximately four weeks post-injury). Two to three months post-fracture, a hard callus develops into a revascularized bony union that will be modified to lamellar bone that may be thicker and stronger than the original bone (U.S. National Cancer Institute's Surveillance, Epidemiology and End Results [SEER]).

Bone union is evident when sufficient strength and stiffness has been regained, allowing the bone to function as a weight-bearing structure without external support (Hayes, 2003). Delayed union occurs when the healing process is impaired and has not progressed at an average rate for the site and the type of fracture. Delayed union may be evidenced by slow radiographic progress and continued pain and mobility at the fracture site. A nonunion occurs when bone healing has stopped prematurely and will not likely continue without medical intervention. Several methods are available to evaluate healing and nonunion of a fracture and include radiographs, fluoroscopy, bone scintigraphy and bone scanning. Occasionally, computed tomography (CT) scans, x-ray tomograms and magnetic resonance imaging (MRI) may be used to establish nonunion. Nonunion of long bone fractures is considered to exist only when a minimum of two sets of radiographs, obtained prior to starting treatment, are separated by a minimum of 90 days, showing no evidence of fracture healing between the two sets of radiographs (Centers for Medicare and Medicaid Services [CMS], 2000). Fracture nonunion of bones such as the carpal and tarsal bones (e.g., talus, scaphoid, and calcaneus) should be clearly evident through the entire body of the bone.

Authors have reported that approximately 5–10% of fractures will result in delayed union or nonunions (Ryaby, 1998; Rubin, et al., 2001). Several factors play a role in bone healing. At the fracture site, the extent of the bone and soft tissue damage, adequacy of the blood supply, the gap between bone ends and infection may all have an impact on healing. The individual's general health and nutritional status play a significant role in bone healing. Authors generally agree that factors associated with diminished blood flow to the fracture site will suppress the healing response. Factors such as heavy smoking, obesity, diabetes, alcoholism, peripheral vascular disease, increasing age, and use of some medications such as steroids can impact the rate and quality of bone healing. Other characteristics such as high grade trauma, high grade and open fractures, comminution of the fracture, vertical or oblique fracture pattern, and fracture displacement may also contribute to poor healing of bone (Agency for Healthcare Research and Quality [AHRQ], 2005).

Nonunion is likely to occur when there is limited blood supply to the specific bone or if there is severe trauma, difficulty in controlling mechanical strain, and a propensity for more severe fractures. According to the American Academy of Orthopedic Surgeons (AAOS), toe bones have inherent stability and blood supply. They typically heal with little or no intervention. Bones such as the upper thigh (i.e., femur head and neck); and small wrist bones such as the scaphoid, have a limited blood supply, which can be destroyed if the bones are broken. Bones such as the tibia have a moderate blood supply; however, severe trauma and injury can destroy the internal blood supply or the external supply from overlying skin and muscle (AAOS, 2005). Fracture of the fifth metatarsal (i.e., Jones fracture) frequently results in delayed healing and nonunion despite surgical treatment, generally due to poor blood supply of the proximal metaphyseal diaphyseal region (Nunley, 2001).

Currently, a variety of invasive and noninvasive interventions are used to treat nonunions, including immobilization/casting, open or closed reduction, pins, screw fixation, intramedullary rods and bone grafting. Immobilization is considered the primary treatment for any nonunion. Bone growth stimulators, which may be noninvasive or invasive, may be used instead of, or in addition to, other interventions to promote bone healing. Implantable devices may be used as an adjunct to planned surgical treatment (e.g., bone grafts, internal/external fixation) of an established nonunion.

Bone growth stimulators are indicated for use only in individuals who are skeletally mature. A person is said to be skeletally mature when all bone growth is complete; the cartilage cells of the growth plate

cease to proliferate, the growth plate becomes thinner, is replaced by bone and disappears, and the epiphysis is "closed" or fused with the shaft.

Evidence in the peer-reviewed scientific literature and textbook sources does not allow strong conclusions regarding the efficacy for the use of bone growth stimulators as a treatment of stress fractures. Nonetheless, although evidence is limited, some authors have reported encouraging results and support the use of bone stimulation devices for treatment of stress fracture nonunion (DiGiovanni, et al., 2003).

### **Ultrasound Bone Growth Stimulators**

Ultrasound bone growth stimulation is a noninvasive intervention, designed to transmit low-density, pulsed, high-frequency acoustic pressure waves to accelerate healing of fresh fractures and to promote healing of delayed unions and nonunions that are refractory to standard treatment. Ultrasound devices have been proven to stimulate fresh fracture healing and healing of nonunions in humans. Low-intensity ultrasound also has been suggested to enhance healing of fractures that occur in patients with diseases such as diabetes, vascular insufficiency, and osteoporosis, and those taking medications such as steroids, NSAIDs, or calcium channel blockers (Wood, 2003). The exact mechanism for fracture healing is unclear; however, it is thought that ultrasound causes biochemical changes at the cellular level to accelerate bone formation. Some authors hypothesize that ultrasound increases blood flow to the capillaries, enhancing cellular interaction (Rubin, et al., 2001). The device is intended to be used by the patient at home. It is applied 20–30 minutes daily until healing occurs.

**U.S. Food and Drug Administration (FDA):** Ultrasound bone growth stimulators are premarket approved (PMA), U.S. Food and Drug Administration (FDA)-approved as class III devices. Class III devices are the most regulated devices by the FDA and require data from clinical studies to ensure safety and effectiveness. Several devices have received approval from the FDA. The Sonic Accelerated Fracture Healing System (SAFHS<sup>®</sup>) Model 2A was granted approval by the FDA on October 5, 1994, for accelerating the time to a healed fracture for fresh, closed Colles' fractures and fresh, closed or open tibial diaphysis fractures in skeletally mature individuals. On July 7, 1995, the FDA granted approval for the SAFHS Model 2A to be used by patients at home. The SAFHS Model 2000, also known as Exogen 2000<sup>®</sup> (Smith & Nephew, Inc., Memphis, TN) received FDA premarket approval (PMA) in 2000 for treatment of fractures through bone growth stimulation. On February 22, 2000, the FDA granted approval for the SAFHS 2000 and the Exogen 2000 for the noninvasive treatment of established nonunions. Device labeling excludes nonunions of the skull or vertebrae (FDA, 2000).

The manufacturer of the Exogen device maintained a patient registry with physician input regarding information pertaining to the initial fracture, patient characteristics, and final outcomes from use of the device. According to Rubin et al. (2001), the device was prescribed for more than 22,300 patients, of which 10,050 had a 91% rate of healing, an average healing time of 144 days, and an average fracture age of 168 days from the date of initial injury. At the time of the author's publication, a total of 1470 patients were lost to follow-up, 1640 patients withdrew from the program or were noncompliant, and 9100 were still receiving treatment. Moreover, fractures other than the radius or tibia were also treated with ultrasound in the registry and demonstrated improved healing times.

The 2000 FDA approval for the noninvasive treatment of nonunion was based on data from the registry and unpublished retrospective case series. The decision from CMS to cover ultrasound bone stimulators was based on similar data (Hayes, 2001).

**Literature Review:** Leung et al. (2004) conducted a randomized, prospective intervention trial to evaluate the potential effect of low-intensity pulsed ultrasound on intact bone for prevention of postmenopausal bone loss in the distal radius. Twenty healthy postmenopausal Chinese women between the ages of 51–81 met the inclusion criteria. For each woman, the treatment hand was randomly selected, and the contralateral site served as a control. Integral and trabecular bone mineral density were measured using highly precise multiplayer, peripheral, quantitative computed tomography at the bilateral distal radius at baseline, three months after daily low-intensity pulsed ultrasound treatment, and three months after discontinuing treatment. Results showed that the rate of bone change (trabecular bone mineral density and integral bone mineral density) did not significantly differ between the site treated with low-intensity pulsed ultrasound and the contralateral control at either follow-up. Also, during the follow-up, bone mineral density did not change significantly in the contralateral control site. This was the first prospective

and randomized study to show that low-intensity pulsed ultrasound at the current regimen did not have significant effects on intact bone for prevention of postmenopausal bone loss in the distal radii of older Chinese women.

Nolte et al. (2001) conducted a controlled clinical trial evaluating low-intensity ultrasound for the treatment of fracture nonunion. Twenty-nine cases with fracture nonunion of the tibia, femur, radius/ulna, scaphoid, humerus, metatarsal, and clavicle were included in the study. The initial fracture care consisted of conservative treatment in eight cases and of surgical care in 21 cases. Ultrasound treatment was started an average of 61 weeks post-fracture treatment. The study demonstrated 25 of the 29 cases healed in an average of 22 weeks. The authors concluded noninvasive ultrasound therapy can be useful in the treatment of nonunions.

In a published review, Rubin et al. (2001) reported there is a large body of evidence supporting fracture healing augmented by low-intensity ultrasound. In addition, the authors reviewed several studies evaluating the use of ultrasound for delayed union and nonunion of various sites such as the scaphoid, clavicle, ulna, femur and metatarsals and concluded that the data suggest ultrasound is a reasonable treatment for fractures that have delayed healing, for those not yet on a normal course of healing, and for those patients whose metabolic status may be compromised by disease or medication.

Cook et al. (1997) conducted a randomized, controlled trial of low-intensity ultrasound in the healing of tibia and distal radius fracture in patients who smoke (tibial fracture n=67, radial fracture n=63). The time needed for healing of a tibial fracture in patients who smoked and were treated with the active ultrasound device was reduced 72 days, or more than 43% less than that of patients who smoked and were treated with a placebo-control device.

Kristiansen et al. (1997) conducted a multicenter, randomized, double-blind, placebo-controlled clinical trial to test the efficacy of a low-intensity, non-thermal, pulsed ultrasound device for decreasing the healing time of the radius. Sixty patients (61 fractures) were enrolled in the study within seven days after experiencing a fracture. One group was treated with the active ultrasound device (n=30), and the second group, which had thirty-one fractures, was treated with placebo. Comparison of the two fracture groups demonstrated significant acceleration of the fracture healing in a mean of 61 days for the patients who were treated with ultrasound stimulation and 98 days for those managed with placebo ( $p < 0.0001$ ). Compared to treatment with the placebo, treatment with ultrasound was associated with significantly smaller loss of reduction (20% vs. 43%  $p < 0.01$ ). The authors concluded that the ultrasound signal accelerates the healing of fractures of the distal radial metaphysis and decreases the loss of reduction during fracture healing.

Heckman et al. (1994) reported a multi-institutional, prospective, randomized, double-blind, placebo-controlled study (n=67) involving closed or grade one fractures of the tibial shaft. Thirty-three participants were treated with an ultrasound stimulating device and thirty-four with a placebo control device. A significant decrease in the time to clinical healing (86 days in the active treated group versus 114 days in the control group [ $p = 0.01$ ]) was noted.

Hayes conducted a literature review regarding ultrasound bone growth stimulation technology (2003) and concluded there are no adverse effects of low intensity ultrasound reported in the literature, and there are no significant thermogenic effects with this level of ultrasound.

According to the manufacturer, the safety and effectiveness of ultrasound bone growth stimulation has not been established for the following: Fracture locations other than the distal radius or tibial diaphysis; fractures with post-reduction displacements of more than 50%; fractures that are open Grade II or III; fractures that require surgical intervention or external fixation; or for fractures that are not sufficiently stable for closed reduction and cast immobilization. Individuals who are not skeletally mature or who are pregnant/nursing are not candidates for this therapy. Ultrasound bone growth stimulation is also not indicated in fractures related to bone pathology or malignancy (Exogen, 2000).

There is evidence in the published, peer-reviewed scientific literature from randomized controlled clinical trials that ultrasound has been shown to be effective in promoting healing of fresh fractures of the tibial diaphysis and radial fractures. There is also evidence that ultrasound is effective in accelerating healing

for nonunion and delayed union of various other fracture sites (e.g., tibia, femur, scaphoid, humerus, clavicle, and metatarsals and metacarpals).

### **Electrical Bone Growth Stimulators**

Electrical bone growth stimulators fall into one of three categories: noninvasive, invasive or semi-invasive. A noninvasive device utilizes treatment coils situated around the fracture site and an external power supply. Noninvasive devices deliver current by way of capacitive coupling, pulsed electromagnetic field (PEMF) or combined electromagnetic field (CMF) technology. Invasive and semi-invasive devices are also referred to as implantable devices and use a direct current delivered directly to the fracture site by way of implantable electrodes. Electrical fields that are applied to the fracture site aid bone healing by enhancing the normal electrical potentials and upregulating the cellular processes involved in bone formation. Callus vascularization, cell proliferation, matrix protein synthesis, and secretion of growth factors may all be enhanced by electrical stimulation (AHRQ, 2005).

Indications for use are based upon FDA labeling for specific devices and evidence in the peer-reviewed published scientific literature. Most studies on the use of electrical stimulation have focused on nonunion and spinal fusion; the use of these devices in humans for the treatment of fresh fractures has not been clearly demonstrated (Moucha, Einhorn, 2003). Although indications vary among devices, electrical bone growth stimulation is not indicated for nonunion fractures where the bones are not aligned or a synovial pseudarthrosis exists, when the bone gap is more than one centimeter or greater than one-half the diameter of the bone, and for patients who are unable to be compliant with appropriate use of the device or treatment regimens.

The safety and effectiveness of electrical bone growth stimulation has not been established in bone pathology such as osteomyelitis, spondylitis, Paget's disease, metastatic cancer, advanced osteoporosis or arthritis, or for avascular or necrotic bone tissues. Patients lacking skeletal maturity, pregnant women and patients with demand pacemakers or implantable defibrillators are not candidates for electrical bone growth stimulator therapy. Fixation devices made from magnetic materials may compromise the effects of electric bone growth stimulators (Orthofix 2005).

**Noninvasive Bone Growth Stimulators:** Noninvasive bone growth stimulators use inductive and conductive methods to deliver a broad, uniform electric field, pulse electromagnetic field (PEMF), or combined electromagnetic (CMF) field to the fracture site via treatment coils or disks placed on the skin and attached to an external power supply.

Direct electrical current has been shown to have a stimulatory effect on bone formation. The bulk of the scientific evidence demonstrating the efficacy of electrical bone growth stimulation addresses its use for nonunion fractures in long bones or as an adjunct to spinal fusion.

**U.S. Food and Drug Administration (FDA):** Noninvasive electrical bone growth stimulators are also premarket approved (PMA) FDA-approved as class III devices. The devices include: OL 1000<sup>®</sup> and SpinaLogic Bone Growth Stimulator<sup>®</sup> (Regentek, a division of dj Orthopedics, LLC (formerly OrthoLogic, Tempe, AZ); Physio-Stim Lite<sup>®</sup>, Spinal-Stim Lite<sup>®</sup> (Orthofix, Inc., Richardson, TX); EBI Bone Healing System<sup>®</sup>, SpinalPak<sup>®</sup>, and OrthoPak<sup>®</sup> (Bioelectron, a subsidiary of Electro-Biology, Inc., Parsippany, NJ) (FDA, 2001). FDA labeling and indications for specific devices vary. For example, the EBI Bone Healing System is indicated for the treatment of fracture nonunion, failed fusions, and congenital pseudoarthrosis of the appendicular skeletal system; SpinalPak is indicated as an adjunct electrical treatment to primary lumbar spinal fusion surgery for one or two levels.

**Literature review:** In a meta-analysis of available literature, Akai et al. (2002) examined whether electrical stimulation (i.e., direct current, PEMF, capacitive coupling) has a specific effect on spinal fusion. A total of five randomized controlled trials (RCTs) that assessed healing of spinal fusion were identified and scored on methodological quality. All the identified studies reported positive findings, but the quality score of each trial showed wide flaws. The data were able to be pooled because of the relative homogeneity of the subjects who had spine fusion and radiographic assessment from these studies. Excluding one trial with the lowest score, the combined results of four trials, whose major endpoints were the success rate of the fusion, revealed a statistically significant effect of electrical stimulation with various techniques; however, the selected trials still showed wide variation in view of stimulation modalities and

treatment protocol. The pooled result of the studies in this review revealed the efficacy of electrical stimulation based on proven methodological quality. The calculated difference in response rates of treated (i.e., stimulated) or not treated (i.e., placebo) cases in the five trials shows a pooled rate difference of 0.191 (95%), strongly supporting the effectiveness of electrical stimulation with various modalities on the healing times of patients with spinal fusion. As problems on therapeutic modality and protocol remain, there is a further need for improvement in design to constitute acceptable proof and to establish treatment programs that better demonstrate electrical stimulation effects on spinal fusion.

Goodwin et al. (1999) conducted a randomized, double-blind prospective comparison with a placebo control to evaluate the effect of noninvasive capacitively-coupled electrical stimulation (CCEST) on the success rate of lumbar spine fusion surgery, and to compare active with placebo stimulators as adjuncts to contemporary fusion techniques. Previous studies have established the effectiveness of direct current and electromagnetic field stimulation as adjuncts for some forms of spinal fusion. None of the previous placebo-controlled studies on external bone stimulation included posterolateral fusion techniques, and most were conducted with prior generations of internal fixation hardware. The investigation was conducted by 28 U.S. surgeons. Patients with a primary diagnosis of degenerative disc disease with or without other degenerative changes were selected. The study protocol defined success as a clinical outcome rated as excellent or good and a fusion documented as solid by both the investigator and the blinded independent radiologist. Patients were randomized within three weeks of surgery and were instructed to use the stimulator 24 hours a day until healing occurred or for nine months if healing was delayed. Disagreements on radiographic success were resolved by a second blinded, independent reviewer. For the 179 patients who completed treatment and evaluation, the overall protocol success rate (both clinical and radiographic results rated as successes) was 84.7% for the active patients and 64.9% for the placebo patients. This difference is highly significant according to the Yates corrected chi-square test ( $p=0.0043$ ). Best improvements in patient outcomes (20% or greater success rate) occurred when active stimulation was used in conjunction with posterolateral fusion ( $p=0.006$ ) and when internal fixation also was incorporated ( $p=0.013$ ). This study was consistent in that active stimulation improved the results for each stratification; however, some strata had insufficient numbers of patients for the results to have statistical significance. Improved success rates when CCEST is added to internal fixation are hypothesized to result from overcoming the biochemical effects of stress shielding. The authors report that CCEST is an effective adjunct to primary spine fusion, especially for patients with posterolateral fusion and those with internal fixation.

Abeed et al. (1998) conducted an uncontrolled, prospective descriptive study to determine the extent to which CCEST at a long bone fracture site can promote healing of nonunited fractures. Sixteen patients with nonunion of long bone fractures (i.e., radius, tibia, ulnar or femur) of 9–76 months were treated with CCEST. Thirteen patients had previously undergone one or more surgical procedures, and the other three had been given plaster casts. A 63-kilohertz, six-volt peak-to-peak sine wave signal was applied across two 40-millimeter in diameter stainless steel plates placed on the skin at opposite sides of the fracture site. The device was used for up to 30 weeks; if no healing occurred by this time it was removed and considered to have failed. The results indicated that 11 of the nonunions achieved union at an average of 15 weeks of stimulation. The only significant factor determining the success of healing was the distance between the plates; a distance of 80 mm or less resulted in healing in all cases. Healing was not affected significantly by any of the following factors: whether or not the nonunion had been treated surgically prior to stimulation; whether or not it had been infected; whether or not the patient bore weight after treatment; or by the presence or absence of metal from previous surgery at the fracture site. The authors concluded that the findings confirm those of previous studies that CCEST promotes bone healing of fracture nonunions. The dependence of healing on the interplate distance suggests that maintaining sufficient current across the plates is necessary to allow healing, which for larger bones may be achieved by increasing the area of the plates, the applied voltage, or the excitation frequency of the stimulation.

Scott et al. (1994) studied twenty-three patients who had an established nonunion of a long bone (i.e., tibia, ulnar or femur). They were entered into a prospective, randomized, double-blind trial in which electrical capacitive coupling was used for treatment. Twenty-one patients completed the study: ten were actively managed, and eleven were managed with a placebo unit. The duration to healing time was thirty-one months for the actively managed group and twenty-six months for the placebo group. The nonunion healed in six of the ten patients who had been managed actively but in none of the patients who had been

managed with the placebo unit. This difference in the rates of healing between the actively managed and the placebo groups is highly significant ( $p = 0.004$ ).

**Invasive Bone Growth Stimulators:** Invasive bone growth stimulators are implanted devices that deliver electrical energy to a nonhealing fracture or bone fusion site. The goal is to induce osteogenesis, stimulate bone growth and promote fracture healing. Invasive and semi-invasive devices use direct current that is delivered directly to the fracture site by way of an implanted electrode. The advantage of invasive electric bone growth systems over noninvasive systems is that a constant current is delivered to the fracture site without the concerns for patient compliance or cooperation.

Semi-invasive direct current stimulation uses a cathode implanted in the cortex of one end of the nonunion site and attached to an external power supply. An anode attached to the skin completes the electrical circuit. Invasive direct current stimulation involves threading the cathode through or around the bone with the anode and power supply implanted in the surrounding soft tissue.

Implantable stimulators are indicated for nonunion of the tibia, femur and humerus. Invasive electrical bone stimulators have also been shown to be effective in promoting bone healing in high-risk individuals undergoing spinal fusion. A high-risk patient is one with a prior fusion failure, who is undergoing a multi-level fusion, or a patient at risk for poor healing such as one who smokes, is obese or has diabetes.

**U.S. Food and Drug Administration (FDA):** EBI (EBI L.P., Parsippany, NJ) manufactures two FDA-approved implantable bone growth stimulators: the OsteoGen™ and the SpF® Implantable Spine Fusion Stimulator. The OsteoGen™ and OsteoGen™-D are designed for the treatment of fracture nonunion, with the latter model indicated only for use in multiple nonunions or severely comminuted fractures that require more than one electrode to facilitate treatment. Four models of the SpF Implantable Spine Fusion Stimulator are available. The SpF®-2T and SpF®-4T are indicated for fusion of one or two levels, while the SpF®-XL and SpF®-XL IIb are indicated for fusion of three or more levels. In 2003, EBI added the SpF®-PLUS to their product range. The FDA has also approved the Zimmer Direct Current Bone Growth Stimulator (Zimmer, Inc., Warsaw, IN) for the treatment of fracture nonunions (FDA, 2004).

**Literature review:** In June 2005, the American Association of Neurological Surgeons/Congress of Neurological Surgeons Joint Section on Disorders of the Spine and Peripheral Nerves published "Guidelines for the Performance of Fusion Procedures for Degenerative Disease of the Lumbar Spine" (Resnick, et al., 2005). Specific surgical treatments were analyzed and recommendations provided. The authors recommended treatment guideline supports the use of direct current stimulation (DCS) or capacitive coupling stimulation (CCS) as an adjunct to spinal fusion in patients who are at high risk for failure following posterior lumbar fusion, and pulsed electromagnetic field stimulation in similar patients treated with lumbar interbody fusion procedures. The authors reported that much of the published studies have methodological flaws preventing them from being considered Class I evidence regarding the use of bone stimulators for the promotion of bone healing following lumbar fusion. There is Class II and Class III evidence to support the use of DCS or CCS for enhancing fusion rates in high-risk patients undergoing lumbar posterior-lateral fusion. The evidence is not consistent in patients who are not high-risk or in patients treated with interbody fusion. Furthermore, pulsed electromagnetic field stimulation has been shown to promote arthrodesis following interbody fusion, although the evidence is limited to Class II and Class III medical evidence.

Kucharzyk (1999) reported a controlled clinical trial of a series of 65 instrumented patients without stimulation who were compared to a later series of 65 patients with instrumentation and implantable electrical stimulation to test the efficacy of electrical stimulation in instrumented high-risk fusion. The groups were evaluated for risk factors, age, diagnostic groups, levels fused, and radiographic and clinical success to test the efficacy of electrical stimulation in instrumented high-risk lumbar fusions. All patients were instrumented via pedicle screws and autologous bone graft. Diagnostic groups were evaluated, and the risk factors in each group were identified and compared. Postoperation management and follow-up regimen were similar in each group. Radiographs were evaluated and confirmed by an independent radiologist. Clinical success was evaluated and confirmed by a second orthopedic surgeon. Fusion success was 95.6% in the stimulated group compared to 87% in the nonstimulated group ( $p=0.05$ ). Clinical success was 91% in the stimulated group and 79% in the nonstimulated group ( $p=0.02$ ). In a workers' compensation subset, fusion success was 93% in the stimulated group and 81% in the

nonstimulated group. Clinical success was 57% in the stimulated group and 46% in the nonstimulated group. The authors concluded that the results from using both instrumentation and electrical stimulation in a high-risk pool of patients showed a statistically significant difference, with higher rates of fusion and clinical success than in a similar pool that did not receive stimulation.

Rogozinski et al. (1996) reported a randomized controlled trial of 94 patients assigned to groups either with or without implanted bone growth stimulation as an adjunct to instrumented spinal fusion. The trial was conducted between May 1990 and December 1992. Consecutive groups with or without stimulation were compared prospectively; a small group was compared with random assignment of surgery with or without stimulation. The study was designed to test the efficacy of implanted bone growth stimulation in instrumented fusion, especially regarding high-risk patient groups, including smokers, those with previous back surgery, and those with multiple fusion levels. Fusion surgery was performed by the same two surgeons on all patients, using autologous graft and instrumentation (i.e., pedicle screw and rod). Surgical indications and pre- and postoperative regimens were similar for all patients. Average follow-up period was 20.5 months. Ninety-six percent of patients with stimulation had solid fusion versus 85% fusion in patients who did not have stimulation. The authors concluded that implanted bone growth stimulation can improve fusion results in patients with instrumented lumbosacral fusion as has been demonstrated in situ fusions. Patients in high-risk categories (i.e., smokers, those with multiple back surgeries, and multilevel fusions) also are demonstrated to have higher fusion rates with implanted bone growth stimulation than those without benefit of stimulation.

Hotta (1994) completed a health technology review for the Agency for Health Care Policy and Research (AHCPR), currently referred to as the Agency for Healthcare Research and Quality (AHRQ), and determined that direct electrical current stimulates bone formation and that it has been used as a standard of care in the treatment of long bone fractures that have failed to fuse. Direct current stimulation may play a similar role in spinal fusion, especially in patients who have had fusion failures or who are at high risk for fusion failures. The available data appear to suggest that an implantable bone-growth stimulator may be a useful adjunct that could enhance the probability of fusion success in patients who have had previous fusion failure or need extensive bone grafting for multiple level fusion. No quantification of results as to efficacy or duration was possible. The authors conducting the review concluded that there is insufficient data to support use of an implantable bone-growth stimulator in high-risk patients such as those who have spondylolisthesis, who are obese, or are smokers.

There are several clinical studies in the peer-reviewed, published scientific literature evaluating the use of electrical bone stimulators for the treatment of nonunion of long bones. Several of the studies are in the form of case series, comparative trials with historical controls, or uncontrolled trials. Most authors agree that electrical stimulation appears to be as effective as bone grafting and standard fixation methods for nonunion of fractures.

### **Summary**

There is sufficient evidence in the peer-reviewed scientific literature to support the safety and efficacy of ultrasound bone growth therapy in patients with fresh fractures of the distal radius and the tibial diaphysis, when the patients have skeletal maturity, and when the therapy is used as an adjunct to closed reduction and cast immobilization, or for nonunion of bones other than skull or vertebrae in skeletally mature individuals. There is also some evidence to support ultrasound stimulation may enhance healing of fractures that are high risk for delayed union or nonunion, in addition to stress fracture nonunion. .

There is sufficient evidence in the peer-reviewed scientific literature to support the efficacy of electrical bone growth stimulation in the healing of an established nonunion of stress fractures, and for nonunion acquired secondary to trauma, excluding all vertebrae and flat bones, where the width of the nonunion defect is less than one-half the width of the bone to be treated. Literature supports the safety and efficacy of invasive or noninvasive bone growth stimulation devices in the adjunctive treatment of patients with prior spinal fusion failure or who are undergoing a multi-level fusion, or in patients who have one or more risk factors for nonhealing such as: smoking, obesity, diabetes, renal disease, or other metabolic disease where bone healing is poor.

There is insufficient evidence in the peer-reviewed, published scientific literature to support the use of bone growth stimulation for the treatment of any of the following nonunion conditions:

- fresh fractures (other than when using ultrasound bone stimulation for the tibia, radius or other high-risk fractures)
- toe fractures
- sesamoid fractures
- navicular fractures
- avulsion fractures
- osteochondral lesions
- displaced fractures with malalignment
- synovial pseudarthrosis
- the bone gap is either > 1 cm or > one-half the diameter of the bone

## Coding/Billing Information

**Note:** This list of codes may not be all-inclusive.

**When medically necessary:**

<b>CPT®*</b> <b>Codes</b>	<b>Description</b>
20974	Electrical stimulation to aid bone healing; non invasive (nonoperative)
20975	Electrical stimulation to aid bone healing; invasive (operative)
20979	Low intensity ultrasound stimulation to aid bone healing, noninvasive (nonoperative)

<b>HCPCS</b> <b>Codes</b>	<b>Description</b>
E0747	Osteogenesis stimulator; electrical, surgically noninvasive, other than spinal applications
E0748	Osteogenesis stimulator; electrical, noninvasive , spinal application
E0749	Osteogenesis stimulator; electrical, surgically implanted
E0760	Osteogenesis stimulator, low intensity ultrasound, noninvasive

<b>ICD-9-CM</b> <b>Diagnosis</b> <b>Codes</b>	<b>Description</b>
250.00- 250.03	Diabetes mellitus without mention of complication
275.40	Unspecified disorder of calcium metabolism
275.41	Hypocalcemia
277.9	Unspecified disorder of metabolism
278.00	Obesity, unspecified
588.1	Nephrogenic diabetes insipidus
593.9	Unspecified disorder of kidney and ureter
733.82	Nonunion of fracture
733.91	Arrest of bone development or growth
733.93	Stress fracture of tibia or fibula
733.94	Stress fracture of the metatarsals
813.00	Unspecified fracture of radius and ulna, upper end of forearm, closed
813.41	Closed Colles' fracture
814.00	Unspecified closed fracture of carpal bone
814.10	Unspecified open fracture of carpal bone
813.42	Other closed fractures of distal end of radius (alone)
815.00 -	Closed fracture of metacarpal bones

815.09	
815.10 - 815.19	Open fracture of metacarpal bones
823.00	Closed fracture of upper end of tibia
823.10	Open fracture of upper end of tibia
823.20	Closed fracture of shaft of tibia
823.30	Open fracture of shaft of tibia
823.80	Closed fracture of unspecified part of tibia
823.90	Open fracture of unspecified part of tibia
825.25	Closed fracture of metatarsal bone(s)
825.35	Open fracture of metatarsal bone(s)
996.49	Other mechanical complication of other internal orthopedic device, implant, and graft
V15.82	Personal history of tobacco use, presenting hazards to health

**Experimental/Investigational/Unproven/Not medically necessary:**

ICD-9-CM Diagnosis Codes	Description
733.90	Disorder of bone and cartilage, unspecified
733.95	Stress fracture of other bone
826.0-826.1	Fracture of one or more phalanges of foot
	Multiple/varied

**\*Current Procedural Terminology (CPT®) © 2006 American Medical Association: Chicago, IL.**

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