Medical Policy

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Title: Electrical Bone Growth Stimulation of the Appendicular Skeleton

Related Policies:	
	▪ *Low Intensity Pulsed Ultrasound Facture Healing Device* ▪ *Electrical Stimulation of the Spine as an Adjunct to Spinal Fusion Procedures*

Professional / Institutional
Original Effective Date: July 11, 2002
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Populations	Interventions	Comparators	Outcomes
Individuals: • With fracture nonunion	Interventions of interest are: • Noninvasive electrical bone growth stimulation	Comparators of interest are: • Conservative therapy • Surgery	Relevant outcomes include: • Symptoms • Change in disease status • Functional outcomes
Individuals: • With delayed fracture union	Interventions of interest are:	Comparators of interest are:	Relevant outcomes include: • Symptoms

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Populations	Interventions	Comparators	Outcomes
	• Noninvasive electrical bone growth stimulation	• Conservative therapy • Surgery	• Change in disease status • Functional outcomes
Individuals: • With fresh fracture(s)	Interventions of interest are: • Noninvasive electrical bone growth stimulation	Comparators of interest are: • Conservative therapy • Surgery	Relevant outcomes include: • Symptoms • Change in disease status • Functional outcomes
Individuals: • With stress fracture(s)	Interventions of interest are: • Noninvasive electrical bone growth stimulation	Comparators of interest are: • Conservative therapy • Surgery	Relevant outcomes include: • Symptoms • Change in disease status • Functional outcomes
Individuals: • Who have had surgery of the appendicular skeleton	Interventions of interest are: • Noninvasive electrical bone growth stimulation	Comparators of interest are: • Standard postsurgical management	Relevant outcomes include: • Symptoms • Change in disease status • Functional outcomes
Individuals: • With fracture	Interventions of interest are: • Implantable and semi-invasive electrical bone growth stimulation	Comparators of interest are: • Conservative therapy • Surgery	Relevant outcomes include: • Symptoms • Change in disease status • Functional outcomes
Individuals: • With pseudoarthroses	Interventions of interest are: • Implantable and semi-invasive electrical bone growth stimulation	Comparators of interest are: • Conservative therapy Surgery	Relevant outcomes include: • Symptoms • Change in disease status • Functional outcomes
Individuals: • Who have had surgery of the appendicular skeleton	Interventions of interest are: • Implantable and semi-invasive electrical bone growth stimulation	Comparators of interest are: • Standard postsurgical therapy	Relevant outcomes include: • Symptoms • Change in disease status • Functional outcomes

DESCRIPTION

In the appendicular skeleton, electrical stimulation with either implantable electrodes or noninvasive surface stimulators has been investigated to facilitate the healing of fresh fractures, stress fractures, delayed union, nonunion, congenital pseudarthrosis, and arthrodesis.

OBJECTIVE

The objective of this evidence review is to determine whether electrical bone growth stimulation of the appendicular skeleton improves the net health outcome in individuals with fractures or who have had bone surgery.

BACKGROUND

Treatment of Delayed and Nonunion Fractures

Individuals with recognized delayed fracture unions might begin by reducing the risk factors for delayed unions or nonunions but may progress to surgical repair if it persists.

Electrical and Electromagnetic Bone Growth Stimulators

Different applications of electrical and electromagnetic fields have been used to promote healing of delayed and nonunion fractures: invasive, noninvasive, and semi-invasive.

Invasive stimulation involves the surgical implantation of a cathode at the fracture site to produce direct current electrical stimulation. Invasive devices require surgical implantation of a current generator in an intramuscular or subcutaneous space, while an electrode is implanted within the fragments of bone graft at the fusion site. The implantable device typically remains functional for 6 to 9 months after implantation, and although the current generator is removed in a second surgical procedure when stimulation is completed, the electrode may or may not be removed. Implantable electrodes provide constant stimulation at the nonunion or fracture site but carry increased risks associated with implantable leads.

Noninvasive electrical bone growth stimulators generate a weak electrical current within the target site using pulsed electromagnetic fields, capacitive coupling, or combined magnetic fields. In capacitive coupling, small skin pads/electrodes are placed on either side of the fusion site and worn for 24 hours a day until healing occurs or up to 9 months. In contrast, pulsed electromagnetic fields are delivered via treatment coils placed over the skin and worn for 6 to 8 hours a day for 3 to 6 months. Combined magnetic fields deliver a time-varying magnetic field by superimposing the time-varying magnetic field onto an additional static magnetic field. This device involves a 30-minute treatment per day for 9 months. Patient compliance may be an issue with externally worn devices.

Semi-invasive (semi-implantable) stimulators use percutaneous electrodes and an external power supply, obviating the need for a surgical procedure to remove the generator when treatment is finished.

REGULATORY STATUS

In 1984, the noninvasive OrthoPak® Bone Growth Stimulator (BioElectron, now Zimmer Biomet) was approved by the U.S. Food and Drug Administration (FDA) through the premarket approval process for treatment of fracture nonunion. Pulsed electromagnetic field systems with the FDA premarket approval (all noninvasive devices) include Physio-Stim® (Orthofix), first approved in 1986, and OrthoLogic® 1000, approved in 1997, both indicated for the treatment of established nonunion secondary to trauma, excluding vertebrae and all flat bones, in which the width of the nonunion defect is less than one-half the width of the bone to be treated; and the EBI Bone Healing System® (Electrobiology, now Zimmer Biomet), which was first approved in 1979 and indicated for nonunions, failed fusions, and congenital pseudarthrosis. No distinction was made between long and short bones.

The FDA has approved labeling changes for electrical bone growth stimulators that remove any time frame for the diagnosis. In September 2020, FDA considered the reclassification of noninvasive electrical bone growth stimulators from Class 3 to the lower-risk Class 2 category..[1,] As of March 2024, however, the devices remain Class 3.

No semi-invasive electrical bone growth stimulator devices with the FDA approval or clearance were identified.

FDA product code LOF.

POLICY

A. Noninvasive electrical bone growth stimulation may be considered **medically necessary** for treatment of fracture nonunions or congenital pseudoarthroses in the appendicular skeleton (the appendicular skeleton includes the bones of the shoulder girdle, upper extremities, pelvis, and lower extremities). The diagnosis of fracture nonunion must meet **ALL** of the following criteria:

   1. at least 3 months have passed since the date of fracture; **AND**
   2. serial radiographs have confirmed that no progressive signs of healing have occurred; **AND**
   3. the individual can be adequately immobilized; **AND**
   4. the individual is of an age likely to comply with non-weight bearing for fractures of the pelvis and lower extremities

B. **Experimental / investigational** applications of electrical bone growth stimulation include, but are not limited to, delayed union, fresh fracture, immediate post-surgical treatment after appendicular skeletal surgery, stress fractures, or for the treatment of arthrodesis or failed arthrodesis.

C. Implantable and semi-invasive electrical bone growth stimulators are considered **experimental / investigational.**

POLICY GUIDELINES

A. Fresh Fracture
A fracture is most commonly defined as "fresh" for 7 days after the fracture occurs. Most fresh closed fractures heal without complications with the use of standard fracture care, i.e., closed reduction and cast immobilization.

B. Delayed Union
Delayed union is defined as a decelerating healing process as determined by serial x-rays, together with a lack of clinical and radiologic evidence of union, bony continuity, or bone reaction at the fracture site for no less than 3 months from the index injury or the most recent intervention. In contrast, nonunion serial x-rays (described next) show no evidence of healing. When lumped together, delayed union and nonunion are sometimes referred to as "ununited fractures."

C. Nonunion
There is not a consensus for the definition of nonunion. One proposed definition is failure of progression of fracture-healing for at least 3 consecutive months (and at least 6 months following the fracture) accompanied by clinical symptoms of delayed/nonunion (pain, difficulty weight bearing) (Bhandari, 2012). Patients with the following comorbidities may be at higher risk for nonunion fracture:

   1. Diabetes
   2. Steroid therapy
   3. Osteoporosis
   4. History of alcoholism
   5. History of smoking

The original FDA labeling of fracture nonunion defined nonunion as fractures that had not shown progressive healing after at least 9 months from the original injury. The original FDA labeling defined nonunion as follows: "A nonunion is considered to be established when a minimum of 9 months has elapsed since injury and the fracture site shows no visibly progressive signs of healing for minimum of 3 months." This timeframe is not based on physiologic principles but was included as part of the research design for FDA approval as a means of ensuring homogeneous populations of patients, many of whom were serving as their own controls. Others have contended that 9 months represents an arbitrary cutoff point that does not reflect the complicated variables that are present in fractures, i.e., degree of soft tissue damage, alignment of the bone fragments, vascularity, and quality of the underlying bone stock. Some fractures may show no signs of healing, based on serial radiographs as early as 3 months, while a fracture nonunion may not be diagnosed in others until well after 9 months. The current policy of requiring a 3-month timeframe for lack of progression of healing is consistent with the definition of nonunion as described in the clinical literature.

Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

RATIONALE

This evidence review has been updated regularly with searches of the PubMed database. The most recent literature update was performed through March 11, 2024.

Evidence reviews assess the clinical evidence to determine whether the use of technology improves the net health outcome. Broadly defined, health outcomes are the length of life, quality of life, and ability to function, including benefits and harms. Every clinical condition has specific outcomes that are important to patients and managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and whether the magnitude of that change is clinically significant. The net health outcome is a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of technology, 2 domains are examined: the relevance, and quality and credibility. To be relevant, studies must represent 1 or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions, the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial (RCT) is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate. RCTs are rarely large enough or long enough to capture less common adverse events and long-term effects. Other types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

Promotion of greater diversity and inclusion in clinical research of historically marginalized groups (e.g., People of Color [African-American, Asian, Black, Latino and Native American]; LGBTQIA

(Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, Asexual); Women; and People with Disabilities [Physical and Invisible]) allows policy populations to be more reflective of and findings more applicable to our diverse members. While we also strive to use inclusive language related to these groups in our policies, use of gender-specific nouns (e.g., women, men, sisters, etc.) will continue when reflective of language used in publications describing study populations.

NONINVASIVE ELECTRICAL BONE GROWTH STIMULATION

FRACTURE NONUNION

Clinical Context and Therapy Purpose

There is no standard definition of a fracture nonunion.[2,]The Food and Drug Administration (FDA) labeling for 1 of the electrical stimulators included in this review defined nonunion as follows: "A nonunion is considered to be established when a minimum of 9 months has elapsed since injury and the fracture site shows no visibly progressive signs of healing for a minimum of 3 months." Others have contended that 9 months represents an arbitrary cutoff point that does not reflect the complicated variables present in fractures (i.e., the degree of soft tissue damage, alignment of the bone fragments, vascularity, quality of the underlying bone stock). Other proposed definitions of nonunion involve 3 to 6 months from the original injury, or simply when serial radiographs fail to show any further healing. Another is the failure of progression of fracture healing for at least 3 consecutive months (and for at least 6 months following the fracture) accompanied by clinical symptoms of delayed union or nonunion (pain, difficulty bearing weight).[2,]According to the FDA labeling for a low-intensity pulsed ultrasound device, "a nonunion is considered to be established when the fracture site shows no visibly progressive signs of healing." Factors contributing to a nonunion include: which bone is fractured, fracture site, the degree of bone loss, time since injury, the extent of soft tissue injury, and patient factors (e.g., smoking, diabetes, systemic disease).[3,]

Fractures at certain locations (e.g., scaphoid, proximal fifth metatarsal) are at greater risk of delayed union due to a tenuous blood supply. Systemic factors, including immunosuppression, cancer, and tobacco use, may also predispose patients to fracture nonunion, along with certain medications (e.g., nonsteroidal anti-inflammatory drugs, fluoroquinolones).

The purpose of noninvasive electrical bone growth stimulation of the appendicular skeleton in individuals with fracture nonunion is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with fracture nonunion of the appendicular skeleton.

Interventions

The therapy being considered is noninvasive electrical bone growth stimulation.

Noninvasive electrical bone growth stimulators generate a weak electrical current within the target site using pulsed electromagnetic fields, capacitive coupling, or combined magnetic fields.

Comparators

The following therapies and practices are currently being used to make decisions about electrical bone growth stimulation of the appendicular skeleton: conservative therapy and surgery.

Outcomes

The general outcomes of interest are symptoms, change in disease status, and functional outcomes.

Follow-up for the procedure would be at least 6 months or until the bone has completely healed.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

1. To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs.
2. In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
3. To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.

Studies with duplicative or overlapping populations were excluded.

Review of Evidence

The FDA approval of electrical bone growth stimulation as a treatment of fracture nonunion involving the appendicular skeleton was based on a number of case series in which patients with nonunions, primarily of the tibia, served as their controls. These studies from the 1980s have suggested that electrical stimulation results in subsequent unions in a significant percentage of patients.[4,5,6,7,8,]

Systematic Reviews

Aleem et al (2016) reported on a meta-analysis of the efficacy of electrical stimulators for bone healing.[9,] The review was reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Reviewers searched PubMed, EMBASE, CINAHL, and the Cochrane Library up to March 6, 2016, supplemented with hand searches of major orthopedic conference proceedings from March 2013 to March 2016, for RCTs comparing direct current, capacitive coupling, or pulsed electromagnetic field therapy with sham control for nonunion, delayed union, fresh fracture, osteotomy, or symptomatic spinal instability requiring fusion. Analyses were performed with the intention-to-treat principle using random-effects models. Fifteen trials were identified, of which 5 included treatment of nonunion[10,11,12,] or delayed union[13,14,] fractures. Nonunion or delayed-union fractures were combined in subgroup analyses including 174 participants. The estimated relative risk (RR) for electrical stimulators versus sham for the outcome of radiographic nonunion at the last follow-up or 12 months was 0.57 (95% confidence interval [CI], 0.29 to 1.12; I^2=76%; p=.002). Overall, reviewers found no evidence to support a difference in treatment effect due to treatment indication (interaction p=.75) and moderate quality evidence supporting electrical stimulation in reducing patient-reported pain and radiographic nonunion across indications.

Griffin et al (2008) reported on a systematic review of electromagnetic bone growth stimulation that included 49 studies, 3 of which were RCTs.[15,]

The 2 largest and most recent trials of nonunion fractures are described in the following section.

Randomized Controlled Trials

An RCT by Scott and King (1994) compared capacitive coupled electric fields with sham treatment (dummy unit) in 23 patients who had a nonunion fracture (at least 9 months old and without clinical or radiographic signs of progression to union within the last 3 months) of a long bone.[12,] In this trial, electrodes were passed onto the skin surface through holes in the plaster cast. Twenty-one patients completed the protocol (10 treatment, 11 controls). Six months after patients began treatment, an orthopedic surgeon and a radiologist, neither of whom were involved in patient management, examined radiographs and determined that 6 of 10 in the treatment group healed, while none of those in the control group healed (p=.004).

Simonis et al (2003) compared pulsed electromagnetic field stimulation with placebo treatment for tibial shaft fractures ununited at least 1 year after fracture, with no metal implant bridging the fracture gap and no radiographic progression of healing in the 3 months before treatment.[10,] All 34 patients received surgical treatment with osteotomy and unilateral external fixator before randomization. Treatment was delivered by external coils; control subjects received sham treatment using identical machines not passing current through the coils. Patients were assessed monthly for 6 months, and clinical and radiographic assessments were conducted at 6 months. Treatment was considered a failure if union was not achieved at 6 months. In the treatment group, 89% (16/18) of fractures healed compared with 50% (8/16) in the control group (p=.02). While a larger percentage of smokers in the treatment group healed compared with those in the control group, there was an imbalance in the number of smokers in each group, and the difference in healing rates between groups was not statistically significant. The authors concluded the available evidence supported the use of pulsed electromagnetic field therapy in the treatment of nonunion of the tibia and suggested that future trials consider which electromagnetic stimulation modality and for which anatomic sites the treatment is most effective.

Section Summary: Fracture Nonunion

Sham-controlled randomized trials with fewer than 60 patients in total have concluded that noninvasive electrical stimulators improve fracture healing for patients with fracture nonunion. Pre-post studies of patients with nonhealing fractures have also suggested the efficacy of this treatment. There are few nonsurgical options in this population.

DELAYED FRACTURE UNION

Clinical Context and Therapy Purpose

Most bone fractures heal spontaneously over a few months postinjury. Approximately 5% to 10% of all fractures have delayed healing, resulting in continued morbidity and increased utilization of health care services.[3,3,]

Delayed union is generally considered a failure to heal between 3 and 9 months post-fracture, after which the fracture site would be considered a nonunion. Delayed union may also be defined as a decelerating bone healing process, as identified in serial radiographs. In contrast, nonunion serial radiographs show no evidence of healing. Together, delayed union and nonunion are sometimes referred to as "ununited fractures." To determine fracture healing status, it is important to include both radiographic and clinical criteria. Clinical criteria include the lack of ability to bear weight, fracture pain, and tenderness on palpation.

The purpose of noninvasive electrical bone growth stimulation of the appendicular skeleton in individuals with delayed fracture union is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with delayed fracture union of the appendicular skeleton.

Interventions

The therapy being considered is noninvasive electrical bone growth stimulation.

Noninvasive electrical bone growth stimulators generate a weak electrical current within the target site using pulsed electromagnetic fields, capacitive coupling, or combined magnetic fields.

Comparators

The following therapies and practices are currently being used to make decisions about electrical bone growth stimulation of the appendicular skeleton: conservative therapy and surgery.

Outcomes

The general outcomes of interest are symptoms, change in disease status, and functional outcomes.

Follow-up for the procedure would be at least 6 months or until the bone has completely healed.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

1. To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs.
2. In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
3. To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.

Studies with duplicative or overlapping populations were excluded.

REVIEW OF EVIDENCE

Systematic Reviews

The Aleem et al (2016) review (discussed previously) reported on a combined meta-analysis of delayed and nonunion fractures.[9,] Similarly, the Griffin et al (2008) review also combined delayed and nonunion fractures.[15] Both included RCTs (N=92 patients) of delayed fractures, which are described in the following section.

Griffin et al (2011) published a Cochrane review of electromagnetic field stimulation (including 3 specifically on pulsed electromagnetic field) for treating delayed union or nonunion of long bone fractures in adults.[16] In addition to the RCTs reviewed in the following section, the systematic review included a study by Barker et al (1984) that randomized 17 participants with tibial nonunion to electromagnetic field stimulation or sham treatment.[11] Thus, 4 studies (total N=125 participants) were analyzed. The primary outcome measure was the proportion of participants whose fractures had united at a fixed time point. For this outcome, the overall pooled effect size was small and not statistically significant (RR, 1.96; 95% CI, 0.86 to 4.48). Interpretation is limited due to the substantial clinical and statistical heterogeneity in the pooled analysis. Also, there was no reduction in pain found in 2 trials, and none of the studies reported functional outcomes. Reviewers concluded that electromagnetic stimulation might offer some benefit in the treatment of delayed union and nonunion but the evidence was inconclusive to inform current practice.

Randomized Controlled Trials

Shi et al (2013) reported on a randomized sham-controlled trial that included 58 patients with delayed union of surgically reduced long bone fractures (femur, tibia, humerus, radius ulna).[13] Delayed union was defined as a failure to heal after at least 16 weeks and not more than 9 months following surgical reduction and fixation of the fracture. Patients with fracture nonunion, defined as failure to heal after more than 9 months, were excluded from the trial. Treatment with 8 hours of pulsed electromagnetic field per day was stopped when no radiographic progression was observed over 3 months or when union was achieved, with union defined as no pain during joint stressing or during motion at the fracture site and callus bridging for 3 of 4 cortices on blinded assessment. Three months of treatment resulted in a slight, but not statistically significant, improvement in the rate of union between pulsed electromagnetic field treated patients (38.7%) and controls (22.2%). The success rate was significantly greater with pulsed electromagnetic field (77.4% vs. 48.1%) after an average of 4.8 months of treatment. The time to union did not differ significantly between pulsed electromagnetic field therapy patients (4.8 months; range, 2 to 12 months) and sham controls (4.4 months; range, 2 to 7 months).

In a double-blind RCT by Sharrard (1990), pulsed electromagnetic field stimulation was compared with a sham procedure using a dummy device in 45 patients with delayed union of the tibia.[14] Stimulators were positioned on the surface of the plaster cast. Treatment began 16 to 32 weeks after injury. Patients with fracture gaps greater than 0.5 cm after reduction, systemic disease, or who were taking steroids were excluded, as were patients with marked bony atrophy or hypertrophy. Fifty-one patients were recruited; 45 completed the protocol (20 treatment, 25 control). In the treatment group, 3 patients achieved union, 2 achieved probable union, 5 showed progression to union, and 10 showed no progress after 12 weeks. In the control group, none had united, 1 had probably united, 3 progressed toward union, and 17 showed no progress.

Section Summary: Delayed Fracture Union

Randomized sham-controlled trials and systematic reviews have been identified in the treatment of delayed union with pulsed electromagnetic field. In the Sharrard (1990) trial, radiographic healing was improved at 12 weeks but there were no statistically significant differences between groups for clinical outcomes. In the Shi et al (2013) trial, only the rate of healing at an average of 4.8 months was statistically significant, and it is not clear if this was a prespecified endpoint. The time to healing was not reduced by pulsed electromagnetic field. Additional studies are needed to permit greater certainty on the effect of this technology on delayed unions.

FRESH FRACTURE(S)

Clinical Context and Therapy Purpose

The purpose of noninvasive electrical bone growth stimulation of the appendicular skeleton in individuals with fresh fractures is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with fresh fractures of the appendicular skeleton.

Interventions

The therapy being considered is noninvasive electrical bone growth stimulation.
Noninvasive electrical bone growth stimulators generate a weak electrical current within the target site using pulsed electromagnetic fields, capacitive coupling, or combined magnetic fields.

Comparators

The following therapies and practices are currently being used to make decisions about electrical bone growth stimulation of the appendicular skeleton: conservative therapy and surgery.

Outcomes

The general outcomes of interest are symptoms, change in disease status, and functional outcomes.

Follow-up for the procedure would be at least 6 months or until the bone has completely healed.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

1. To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs.
2. In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
3. To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.

Studies with duplicative or overlapping populations were excluded.

REVIEW OF EVIDENCE

Systematic Reviews

The Aleem et al (2016) systematic review (described previously) also included subgroup analyses for fresh fractures with the outcome of radiographic nonunion at last reported follow-up (to 12 months) for electrical stimulators versus sham.[9] Five trials (N=366 patients) were included.[17,18,19,20,21] The combined RR of radiographic nonunion was 0.83 (95% CI, 0.51 to 1.35; I^2=11%; p=.35). The selected trials were of moderate-to-high quality. The 2 largest are summarized below.

Randomized Controlled Trials

Adie et al (2011) reported on results of a multicenter, double-blind, sham-controlled, randomized trial, which evaluated 12 weeks of pulsed electromagnetic field stimulation for acute tibial shaft fractures.[17] The endpoints examined were secondary surgical interventions, radiographic union, and patient-reported functional outcomes. Approximately 45% of patients were compliant with treatment (>6 hours daily use), and 218 (84%) of 259 patients completed the 12-month follow-up. The primary outcome (the proportion of participants requiring a secondary surgical intervention because of delayed union or nonunion within 12 months postinjury) was similar for the 2 groups (15% active vs. 13% sham). A per-protocol analysis comparing patients who received the prescribed dose of pulsed electromagnetic field stimulation with sham treatment also showed no significant differences between groups. Secondary outcomes, which included surgical intervention for any reason (29% active vs. 27% sham), radiographic union at 6 months (66% active vs. 71% sham), 36-Item Short-Form Health Survey Physical Component Summary scores at 12 months (44.9 active vs. 48.0 sham), and the Lower Extremity Functional Scale scores at 12 months (48.9 active vs. 54.3 sham), also did not differ significantly between the groups.

Hannemann et al (2014) reported on a multicenter, double-blind, randomized, sham-controlled trial (N=102) conducted in the Netherlands; they found little advantage to 6 weeks of pulsed electromagnetic field therapy for fresh scaphoid fractures (≤5 days from injury).[20] Outcomes included the time to clinical and radiologic union and functional outcome at 6, 9, 12, 24, and 52 weeks. Radiologic union measured by computed tomography did not differ significantly between groups. The median time to clinically defined union was 6 weeks in both groups. The return to normal range of motion at the wrist was 12 weeks in both groups. Grip strength of the dominant hand returned to normal sooner with pulsed electromagnetic field therapy but there was no significant difference in return of grip strength of the nondominant hand. Functional outcomes were reported in 2015.[20] There were no significant differences in either the pain or the function subscales of the Patient-Rated Hand/Wrist Evaluation between the pulsed electromagnetic field group and the sham group at any of the 5 follow-up time points. Each of the 5 domains of the EuroQol-5D as well as the EuroQoL visual analog scale was also compared at each time point. There was a single marginally significant difference in these domain scores (anxiety/depression domain at week 24), which would have been expected by chance given the number of statistical tests performed. The mean number of working days lost was similar in the 2 groups (10 days vs. 13 days; p=.65), and the total mean quality-adjusted life years was 0.84 for pulsed electromagnetic field and 0.85 for sham (difference, 0.01; 95% CI, -0.01 to 0.04), respectively.

Section Summary: Fresh Fracture(s)

Five RCTs including 366 participants have compared electrical stimulators with sham in the treatment of fresh fractures. A systematic review and meta-analysis of these trials found moderate-quality evidence that the risk of radiographic nonunion is about 17% lower in participants treated using electrical stimulators compared with sham, but this difference was not statistically significant. No differences in functional outcomes were reported between electrical stimulators and sham.

STRESS FRACTURE(S)

Clinical Context and Therapy Purpose

The purpose of noninvasive electrical bone growth stimulation of the appendicular skeleton in individuals with stress fractures is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with stress fractures of the appendicular skeleton.

Interventions

The therapy being considered is noninvasive electrical bone growth stimulation.

Noninvasive electrical bone growth stimulators generate a weak electrical current within the target site using pulsed electromagnetic fields, capacitive coupling, or combined magnetic fields.

Comparators

The following therapies and practices are currently being used to make decisions about electrical bone growth stimulation of the appendicular skeleton: conservative therapy and surgery.

Outcomes

The general outcomes of interest are symptoms, change in disease status, and functional outcomes.

Follow-up for the procedure would be at least 6 months or until the bone has completely healed.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

1. To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs.
2. In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
3. To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.

Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Beck et al (2008) reported on a well-conducted RCT (N=44) of capacitively coupled electric fields (OrthoPak) for healing acute tibial stress fractures.[22,] Patients were instructed to use the device for 15 hours each day, and usage was monitored electronically. Healing was confirmed when hopping 10 cm high for 30 seconds was accomplished without pain. Although an increase in the hours of use per day was associated with a reduction in the time to healing, there was no difference in the rate of healing between treatment and placebo. Power analysis indicated that this number of patients was sufficient to detect a difference in healing time of 3 weeks, which was considered to be a clinically significant effect. Other analyses, which suggested that electrical stimulation might be effective for the radiologic healing of more severe stress fractures, were preliminary and a beneficial effect was not observed for clinical healing.

Section Summary: Stress Fracture(s)

The evidence on the use of noninvasive electrical bone growth stimulation to treat stress fracture(s) consists of an RCT. In this well-conducted trial, there was no difference in the healing rates between the stimulation and placebo groups.

APPENDICULAR SKELETAL SURGERY

Clinical Context and Therapy Purpose

The purpose of noninvasive electrical bone growth stimulation in individuals who have had appendicular skeletal surgery is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals who have had appendicular skeletal surgery.

Interventions

The therapy being considered is noninvasive electrical bone growth stimulation.

Noninvasive electrical bone growth stimulators generate a weak electrical current within the target site using pulsed electromagnetic fields, capacitive coupling, or combined magnetic fields.

Comparators

The following therapies and practices are currently being used to make decisions about electrical bone growth stimulation for patients who have had appendicular skeletal surgery: standard postsurgical management by an orthopedic surgeon.

Outcomes

The general outcomes of interest are symptoms, change in disease status, and functional outcomes.

Follow-up for the procedure would be at least 6 months or until the bone has completely healed.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

1. To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs.
2. In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
3. To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.

Studies with duplicative or overlapping populations were excluded.

Review of Evidence

A comprehensive search found 2 small RCTs on noninvasive electrical bone growth stimulation after orthopedic surgery. Borsalino et al (1988) reported on a randomized double-blind, sham-controlled trial of pulsed electromagnetic field stimulation (8 h/d) in 32 patients who underwent femoral intertrochanteric osteotomy for osteoarthritis of the hip.[23,] Radiographic measurements at 90 days revealed significant increases in the periosteal bone callus and trabecular bone bridging at the lateral, but not the medial, cortex. The trial lacked clinical outcomes and enrolled few patients.

The trial by Dhawan et al (2004) randomized 64 patients (144 joints with triple arthrodesis or subtalar arthrodesis) to pulsed electromagnetic field stimulation for 12 hours a day or an untreated control condition.[24,] Patients at high risk of nonfusion (rheumatoid arthritis, diabetes, or on oral corticosteroids) were excluded from the trial. The blinded radiographic evaluation found a significant decrease in the time to union (12.2 weeks for talonavicular arthrodesis vs. 17.6 weeks for controls; p=.003; 13.1 weeks for calcaneocuboid fusion vs. 17.7 weeks for controls; p=.01). Clinical outcomes were not assessed.

Section Summary: Appendicular Skeletal Surgery

The evidence on the use of noninvasive electrical bone growth stimulation to treat those who have had surgery of the appendicular skeleton consists of 2 RCTs. The trials showed some benefit of stimulation treatment, but clinical outcomes of interest were not assessed, limiting conclusions that can be drawn about treatment efficacy.

IMPLANTABLE AND SEMI-INVASIVE BONE GROWTH STIMULATION

Clinical Context and Therapy Purpose

The purpose of implantable and semi-invasive electrical bone growth stimulation in individuals who have fracture, pseudoarthrosis, or have had surgery of the appendicular skeleton is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals who have fracture, pseudoarthrosis, or have had surgery of the appendicular skeleton.

Interventions

The therapy being considered is implantable or semi-invasive electrical bone growth stimulation.

Invasive stimulation involves the surgical implantation of a cathode at the fracture site to produce direct current electrical stimulation. Invasive devices require surgical implantation of a current generator in an intramuscular or subcutaneous space, while an electrode is implanted within the fragments of a bone graft at the fusion site.

Semi-invasive (semi-implantable) stimulators use percutaneous electrodes and an external power supply, obviating the need for a surgical procedure to remove the generator when treatment is finished.

Comparators

The following therapies and practices are currently being used to make decisions about electrical bone growth stimulation for individuals who have fracture, pseudoarthrosis, or have had surgery of the appendicular skeleton: conservative therapy, surgery, or standard postsurgical management.

Outcomes

The general outcomes of interest are symptoms, change in disease status, and functional outcomes.

Follow-up for the procedure would be at least 6 months or until the bone has completely healed.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

1. To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs.
2. In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
3. To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.

Studies with duplicative or overlapping populations were excluded.

Review of Evidence

A comprehensive search for implantable bone stimulators identified a small number of case series, all of which focused on foot and ankle arthrodesis in patients at high-risk for nonunion (summarized in Petrisor and Lau [2005][25]). Risk factors for nonunion included smoking, diabetes, Charcot (diabetic) neuroarthropathy, steroid use, and previous nonunion. The largest case series is Lau et al (2007), who described outcomes of the foot or ankle arthrodesis in 38 high-risk patients.[26] Union was observed in 65% of cases by follow-up evaluation (n=18) or chart review (n=20). Complications were reported in 16 (40%) cases, including 6 cases of deep infection and 5 cases of painful or prominent bone stimulators necessitating stimulator removal. A multicenter retrospective review by Saxena et al (2005) described outcomes from 28 high-risk patients with arthrodesis of the foot and ankle.[27] Union was reported for 24 (86%) cases at an average of 10 weeks; complications included breakage of the stimulator cables in 2 patients and hardware failure in another. Five patients required additional surgery.

Section Summary: Implantable and Semi-Invasive Bone Growth Stimulation

The evidence on the use of implantable and semi-invasive electrical bone growth stimulation to treat fractures, pseudoarthroses, or those who have had surgery of the appendicular skeleton consists of a small number of case series, reporting on small numbers of patients. Prospective controlled trials are needed to evaluate this procedure.

SUPPLEMENTAL INFORMATION

The purpose of the following information is to provide reference material. Inclusion does not imply endorsement or alignment with the evidence review conclusions.

Clinical Input From Physician Specialty Societies and Academic Medical Centers

While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the physician specialty societies or academic medical centers, unless otherwise noted.

2012 Input

In response to requests, input was received from 5 academic medical centers while this policy was under review in 2012. Input supported the use of noninvasive electrical bone growth stimulation for the treatment of fracture nonunions or congenital pseudarthrosis of the appendicular skeleton. Input concurred that noninvasive electrical bone growth stimulation is investigational for the treatment of fresh fractures and immediate postsurgical treatment after appendicular skeletal surgery. Most reviewers considered the use of noninvasive electrical bone growth stimulation to be investigational for the treatment of delayed union, arthrodesis, or failed arthrodesis.

Practice Guidelines and Position Statements

Guidelines or position statements will be considered for inclusion in 'Supplemental Information' if they were issued by, or jointly by, a US professional society, an international society with US representation, or National Institute for Health and Care Excellence (NICE). Priority will be given to guidelines that are informed by a systematic review, include strength of evidence ratings, and include a description of management of conflict of interest.

No guidelines or statements were identified.

U.S. Preventive Services Task Force Recommendations

Not applicable.

Ongoing and Unpublished Clinical Trials

A search of ClinicalTrials.gov in March 2024 did not identify any ongoing or unpublished trials that would likely influence this review.

CODING

The following codes for treatment and procedures applicable to this policy are included below for informational purposes. This may not be a comprehensive list of procedure codes applicable to this policy.

Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

The code(s) listed below are medically necessary ONLY if the procedure is performed according to the "Policy" section of this document.

CPT/HCPCS	
20974	Electrical stimulation to aid bone healing; noninvasive (nonoperative)
20975	Electrical stimulation to aid bone healing; invasive (operative)
E0747	Osteogenesis stimulator, electrical, noninvasive, other than spinal applications
E0749	Osteogenesis stimulator, electrical, surgically implanted

REVISIONS	
03-26-2013	Policy added to the bcbsks.com web site.
05-07-2013	Effective for Institutional providers 30 days after the Revision Date
	In Policy section: • In Item A, bullet #2, added "and" to read "…healing have occurred; and" • In Item A, removed bullet #3, "the fracture gap is 1 cm or less; and"
03-07-2014	In Policy section: ▪ In Item C, added "stress fractures," to read "Experimental / Investigational applications of electrical bone growth stimulation include, but are not limited to, immediate post-surgical treatment after appendicular skeletal surgery, stress fractures, or for the treatment of fresh fractures or delayed union."
	Updated Rationale section.
	In Coding section: ▪ Added ICD-10 Diagnosis *(Effective October 1, 2014)*
	Updated Reference section.
12-22-2015	Description section updated
	In Policy section: ▪ In Item A 4 add "for fractures of the pelvis and lower extremities" to read "is of an age likely to comply with non-weight bearing for fractures of the pelvis and lower extremities" ▪ Updated Policy Guidelines
	Rationale section updated
	In Coding section: ▪ Removed all ICD-9 and ICD-10 codes due to the volume of codes applicable to the policy topic. ▪ Added "The appropriate ICD-9 or ICD-10 diagnoses consistent with the medical criteria and intent of the policy should be used."
	References updated
10-17-2016	Updated Description section.
	In Policy section:

REVISIONS	
	▪ Removed previous Item B, "Noninvasive electrical bone growth stimulation is considered medically necessary as a treatment of joint fusion." ▪ In new Item B, added "arthrodesis or failed arthrodesis" to read "Experimental / investigational applications of electrical bone growth stimulation include, but are not limited to, delayed union, fresh fracture, immediate post-surgical treatment after appendicular skeletal surgery, stress fractures, or for the treatment of arthrodesis or failed arthrodesis." ▪ In Policy Guidelines Item 3, added "Patients with the following comorbidities may be at higher risk for nonunion fracture: a) Diabetes b) Steroid therapy c) Osteoporosis d) History of alcoholism e) History of smoking"
	Updated Rationale section.
	Updated References section.
05-24-2017	Updated Description section.
	Updated Rationale section.
	Updated References section.
05-23-2018	Updated Description section.
	Updated Rationale section.
	In Coding section: ▪ Removed references to ICD-9 coding.
	Updated References section.
05-21-2019	Updated Description section.
	Updated Rationale section.
	Updated References section.
02-01-2021	Updated Description section
	Updated Rationale section
	Updated References
06-16-2021	Updated Description Section
	Updated Rationale Section
	Updated References Section
06-01-2022	Updated Description Section
	Updated Rationale Section
	Updated References Section
05-23-2023	Updated Description Section
	Updated Rationale Section
	Updated Coding Section ▪ Removed ICD-10 Diagnoses Box
	Updated References Section
05-28-2024	Updated Description Section
	Updated Rationale Section
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