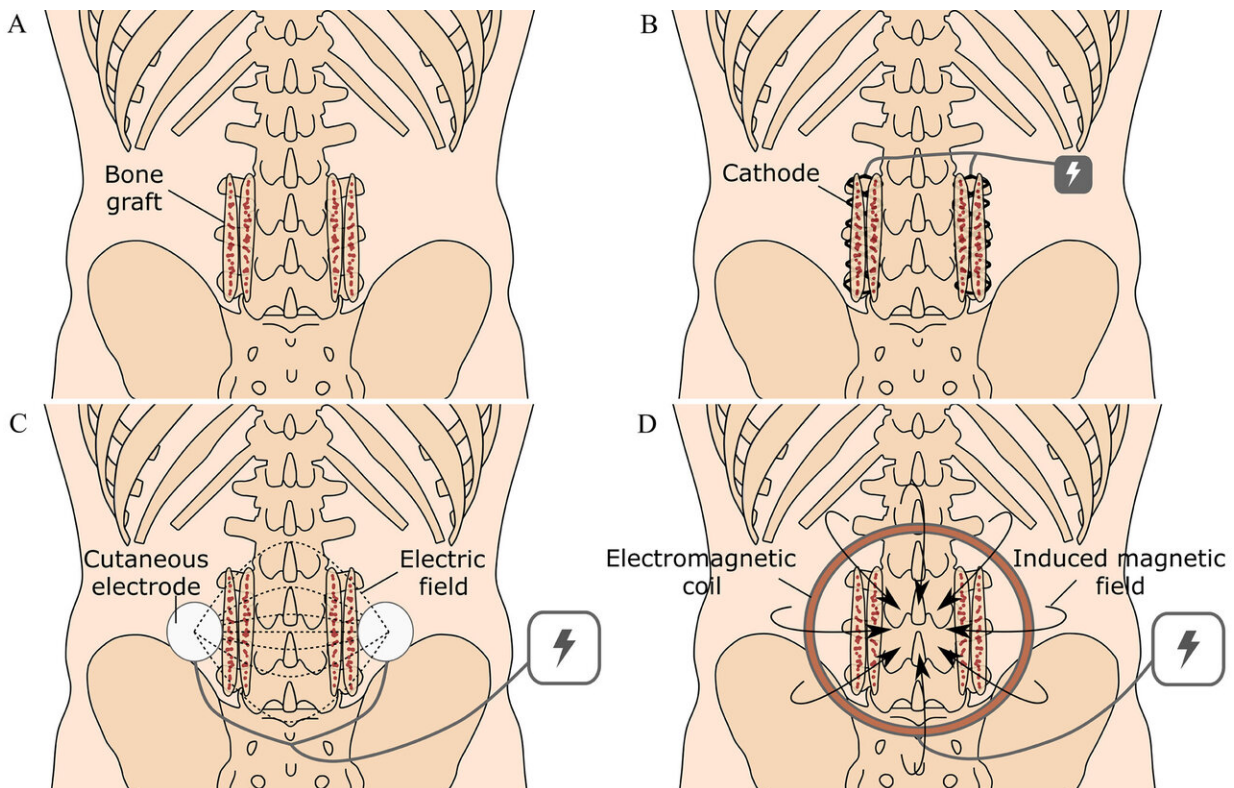


The effectiveness of electrical stimulation in producing spinal fusion

October 8 2019



Conceptual illustrations of the 3 types of electrical stimulation therapies used in spinal fusion. A: Posterolateral L3-5 inter-transverse process spinal fusion using bone graft, without electrical stimulation. B-D: Same procedure illustrating postoperative adjuvant therapy with direct current stimulation (B), capacitive coupling stimulation (C), or inductive coupling stimulation (D). In B, the electric generator is typically implanted subcutaneously. In C and D, the electric generators are externally located. Credit: Copyright 2019 Ethan Cottrill.

Researchers from The Johns Hopkins University School of Medicine performed a systematic review and meta-analysis of published data on the effect of electrical stimulation therapies on spinal fusion. They found significant improvement overall in the rates of bone fusion following a course of electrical stimulation in both preclinical (animal) and clinical (human) studies.

Detailed findings of this study can be found in a new article, "The effect of [electrical stimulation](#) therapies on [spinal fusion](#): a cross-disciplinary [systematic review](#) and meta-analysis of the preclinical and [clinical data](#)," by Ethan Cottrill and colleagues, published today in the *Journal of Neurosurgery: Spine*.

Background: Each year in the United States approximately 400,000 persons undergo spinal fusion surgery for spinal instability, pain, and/or loss of function. For some of these people, surgery alone does not produce complete spinal fusion. In those cases, adjuvant therapies must be instituted to aid in the process of bone healing.

One of these therapies is electrical [stimulation](#). There are three types of electrical stimulation therapy in use today: direct current stimulation, capacitive coupling stimulation, and inductive coupling stimulation (also known as pulsed electromagnetic field).

Direct current stimulation requires implantation of a stimulation device, which is usually done at the time of spinal fusion surgery. The device is small and is placed under the skin on the patient's back. Via electrodes, the device delivers a small direct current of electricity to the area where fusion needs to occur. The battery powering the device is good for 6 to 12 months; after that time, it can be removed or remain in place as the patient or physician deems appropriate.

Capacitive and inductive coupling stimulation therapies are noninvasive.

With capacitive coupling stimulation, two small electrode pads are placed on the skin over the region of desired bone fusion. These pads produce an electrical field surrounding that region when powered by an external alternating current generator. This device is worn by the patient for 6 to 9 months and operates approximately 24 hours per day.

Inductive coupling stimulation involves the use of electromagnetic coils placed on the skin over the site of anticipated bone fusion. Alternating current produces an electromagnetic field to induce bone fusion. This device need only be used for 30 minutes to 2 hours per day until fusion is confirmed.

Each therapy has a particular mechanism of action and carries advantages and disadvantages. These are all described and compared in the paper by Cottrill and colleagues.

Present Study: Application of direct or alternating electrical current has been shown to induce and speed up the process of bone healing following spine fusion surgery. Evidence for this has come from small studies. Cottrill and colleagues set out to pool the data from small studies on the effects of electrical stimulation therapies and to comprehensively assess these effects overall and in specific subgroups.

The authors performed a systematic review of all English-language articles describing the effects of electrical stimulation therapies on spinal bone fusion. Applying specific inclusion criteria, they narrowed the studies down to 17 preclinical and 16 clinical studies. Meta-analyses of data from all of the studies that included a control group were also performed (11 preclinical studies [257 animals] and 13 clinical studies [2,144 patients]).

The authors found, overall, that electrical stimulation was effective at augmenting spinal fusion. They found nearly a fivefold increase in the odds of successful bone fusion in animals and a greater than twofold

increase in patients treated with electrical stimulation therapy.

With respect to the various types of stimulation therapy, the authors found that in animals the effects of direct current stimulation on spinal fusion were very beneficial, whereas the effects of inductive coupling stimulation were little different from no electrical stimulation at all. (No [preclinical studies](#) involved the use of capacitive coupling stimulation.)

In humans, both [direct current stimulation](#) and inductive coupling stimulation were highly effective in aiding spinal fusion. The authors were unable to find a difference in efficacy between these two types of electrical stimulation therapies. Only one study of capacitive coupling stimulation therapy in humans fit the inclusion criteria of the systematic review, and that paper showed no statistically significant difference between fusion rates in patients who received electrical stimulation and those who did not ([control group](#)).

In a subgroup analysis of clinical studies, the authors found that the number of spinal levels that were fused and whether instrumentation was used did not change the effectiveness of electrical stimulation devices. They also found that these devices improved the rates of fusion in patient groups prone to have difficulty in achieving total spinal fusion, such as patients with difficult-to-treat spines and smokers.

When asked about the importance of the study, the senior author, Daniel Sciubba, MD, said, "We were surprised by how large an effect these therapies have on spinal fusion. It was also encouraging to see that the preclinical data aligned with the clinical evidence, which supports future translational research efforts in spine surgery. Ultimately, we hope our findings will help to inform patients and providers to enhance outcomes following spinal [fusion](#)."

More information: Cottrill E, Pennington Z, Ahmed AK, Lubelski D,

Goodwin ML, Perdomo-Pantoja A, Westbroek EM, Theodore N, Witham T, Sciubba D: The effect of electrical stimulation therapies on spinal fusion: a cross-disciplinary systematic review and meta-analysis of the preclinical and clinical data. *J Neurosurg Spine*, published ahead of print October 8, 2019. [DOI: 10.3171/2019.5.SPINE19465](https://doi.org/10.3171/2019.5.SPINE19465)

Provided by Journal of Neurosurgery

Citation: The effectiveness of electrical stimulation in producing spinal fusion (2019, October 8) retrieved 1 May 2024 from

<https://medicalxpress.com/news/2019-10-effectiveness-electrical-spinal-fusion.html>

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