

Table 3 Neuromodulation devices for primary headache disorders: approved and in development

Name	Description	Indications	Availability	When to consider	Ongoing studies	Refs
SpringTMS (eNeura Inc., Sunnyvale, California, USA)	Single-pulse occipital transcranial magnetic stimulation	Acute treatment of migraine with aura in the US; acute and preventive treatment of migraine with or without aura in the EU	Available by prescription for rent in the UK and USA	Patients with side effects to current treatments, cardiovascular risk factors, and frequent migraines who are at risk for medication overuse headache. May be helpful for patients with prominent visual aura	Acute treatment of migraine without aura and migraine prevention	90
Cefaly (Cefaly Technology, Gr�ce-Hollogne, Belgium)	Transcutaneous electrical nerve stimulation for trigeminal branches	Migraine prevention	Available for purchase with a prescription in the USA and without a prescription in Australia, Canada, Europe and the UK	Patients averse to oral or percutaneous preventive medications	Acute migraine treatment	100,101
OSTNS Neurostimulator (Neurolief Ltd, Herzliya, Israel)	Transcutaneous pericranial peripheral nerve stimulator	Acute migraine treatment	Not available	Potential alternative or adjuvant to pharmacological acute treatments	Results of RCT of 40 patients have not yet been reported	105
Medtronic (Fridley, Minnesota, USA and Dublin, Ireland)	Implantable occipital nerve stimulator	Medically intractable chronic migraine and cluster headache	Available for implantation, but obstacles to insurance coverage exist	Controversial; patients with medically refractory headache disorders	The ICON study, a double-blind RCT for chronic cluster headache, is ongoing.	118,119
Precision System (Boston Scientific Corporation Marlborough, Massachusetts, USA)	Implantable occipital nerve stimulator	Refractory chronic migraine	Available for implantation, but obstacles to insurance coverage exist	Controversial; patients with medically refractory headache disorders	The OPTIMISE trial, a double-blind RCT for chronic migraine, is ongoing	127
The StimRelieve Halo Migraine System (Stimwave LLC, Fort Lauderdale, Florida, USA)	Percutaneously placed leads which are powered by a wireless external unit	Treatment of migraine	Available for implantation, but obstacles to insurance coverage exist	Controversial; patients with medically refractory headache disorders	Two RCTs are planned	128,129
The Pulsante SPG Neurostimulator (Autonomic Technologies, Inc., Redwood City, California, USA)	A tiny, wireless, remote-controlled SPG stimulator	Migraine and chronic cluster headache	Approved in Europe for the treatment of primary headache disorders	Controversial; patients with medically refractory headache disorders	Pathway CH-2 study for chronic cluster headache and Pathway M-1 study for chronic migraine	132,133
GammaCore (electroCore LLC, Basking Ridge, New Jersey, USA)	Transcutaneous vagal nerve stimulator	Acute and preventive treatment of migraine and cluster headache	Available for purchase in Australia, Brazil, Canada, Colombia, Europe, India, Malaysia, New Zealand and the UK	Cluster headache or migraine inadequately controlled with medical therapy	Acute and preventive migraine treatment	166,167
Scion Neurostim (Raleigh, North Carolina, USA)	Delivers in-ear thermoelectric caloric stimulation to the external auditory canal	Migraine prevention	Not available	A completed prospective, open-label pilot study enrolled seven participants	A sham-controlled RCT for episodic migraine prevention is ongoing	168,169
The Cefaly Arnold Kit (Cefaly Technology, Gr�ce-Hollogne, Belgium)	Greater occipital nerve transcutaneous electrical nerve stimulation device	Chronic migraine prevention	Available for sale in Europe	Chronic migraine patients refractory to or not tolerating standard of care	The OSCRO study for chronic migraine is ongoing	170

CGRP, calcitonin gene-related peptide; GI, gastrointestinal tract; mAb, monoclonal antibody; RCT, randomized controlled trial; SPG, sphenopalatine ganglion.

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