



Case report: durable response of gliomatosis cerebri with concurrent tumor-treating fields (TTFields) and chemoradiotherapy treatment

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Background: Gliomatosis cerebri (GC) is a rare and aggressive form of widely disseminated glioma infiltrating at least 3 lobes of the brain. It is a diffuse pattern of growth seen in glioma rather than a distinct pathological diagnosis based on new World Health Organization (WHO) classification. Despite this, it is associated with worse prognosis than equally graded gliomas. Tumor treating fields (TTFields) treatment is a more recent advancement in glioma treatment delivered through low energy, intermediate frequency (200 kHz) electromagnetic fields, with multi-modal mechanisms of action. It is Food and Drug Administration (FDA) approved for newly diagnosed and recurrent glioblastoma (GBM). The aim of this case report is to present a durable response of GBM associated GC to concurrent TTFields with chemoradiation.

Case Description: We report a 64-year-old male with left parietal GBM, IDH wild type, WHO grade 4 with extensive GC change. After resection of the enhancing lesion, the patient received concurrent tumor-treating fields (TTFields) with radiation and temozolomide, enrolled in SPARE trial (NCT03477110). The patient had a rapid response in the areas of gliomatosis change demonstrated on the magnetic resonance imaging 1 month post-radiation treatment. The response of GC was durable. His glioma recurred 11 months after surgery with new enhancing lesions, treated with radiosurgery. He had further extensive progression of enhancing lesions 13 months after surgery, and received bevacizumab treatment. The patient ultimately passed away 17 months after surgery. Despite progression of enhancing lesions, the GC changes remained controlled. He also had favorable progression-free survival of 11 months and overall survival of 17 months.

Conclusions: This case serves as an example of how combination TTFields with chemoradiation may elicit a durable response of GC in patients with GBM.

Keywords: Glioblastoma (GBM); tumor-treating fields (TTFields); gliomatosis cerebri (GC); case report

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Introduction

Gliomatosis cerebri (GC) represents an unconventional and distinct pattern of glioma with widespread infiltration of tumor in at least three lobes of the brain. While no longer a

formal diagnosis under World Health Organization (WHO) guidelines, the term is still used to refer to its specific presentation. Two types of primary GC exist: with (type 1) and without (type 2) focal masses being involved (1,2). The

disease is characteristically variable in its manifestation and progression (3,4). The prognosis of GC compared to equally graded gliomas is worse (3,4); with a median overall survival (OS) of grade 4 gliomas with GC change being 9 months and 5-year survival rate of 18% (5). Effective treatment modalities for GC are controversial and not well agreed upon due to the rarity of the disease and corresponding paucity of data describing GC (6). Treatment varies with presentation, but can involve partial tumor resection or biopsy, chemotherapeutic agents [temozolomide (TMZ) being the most common], and targeted or whole brain radiation therapy (3,6).

Tumor treating fields (TTFields) treatment is a more recent advancement in glioma treatment delivered through low energy, intermediate frequency (200 kHz) electromagnetic fields, causing mitotic cell death (7,8). It is approved for both recurrent and newly diagnosed glioblastoma (GBM) (9,10). In patients with newly diagnosed (GBM), the addition of TTFields to maintenance TMZ significantly improved OS and progression-free survival (PFS) (11). Preclinical studies suggested synergistic effect between TTFields treatment in combination with radiation treatment. The SPARE trial (NCT03477110) was a pilot study designed to investigate the feasibility and safety of concurrent radiation treatment and TTFields treatment (12). In addition, an international phase 3 trial (EF-32 trial; NCT04471844) is currently investigating the efficacy of concurrent radiation and TTFields treatment in newly diagnosed GBM. Here we report one patient with left parietal GBM, IDH wild type, WHO grade 4 with extensive gliomatosis change who received concurrent TTFields and chemoradiation on the SPARE trial (*Figure 1*). We present this case in accordance with the CARE reporting checklist (available at <https://cco.amegroups.com/>

[article/view/10.21037/cco-23-114/rc](https://cco.amegroups.com/article/view/10.21037/cco-23-114/rc)).

Case presentation

The study was approved by the institutional review board and followed the tenets set by the Declaration of Helsinki (as revised in 2013) and the Health Insurance Portability and Accountability Act. Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

The patient was a 64-year-old African American male with no significant past medical history who presented with dizziness and lightheadedness. A few days later, he further developed aphasia, left upper extremity weakness, and had two clonic-tonic seizures. He was taken to the emergency room (ER) for evaluation. Upon arriving at the ER, he suffered a second seizure and was placed on levetiracetam (1,000 mg daily) and dexamethasone (16 mg daily). Magnetic resonance imaging (MRI) of the brain was performed. This MRI revealed a ring enhancing mass on the left parietal lobe with additional small enhancing lesions anteriorly. There was a 6-mm rightward midline shift with compression of the left lateral ventricle. Broad areas T2/fluid-attenuated inversion recovery (FLAIR) hyperintense signals were noted throughout the left hemisphere of the brain and along the splenium of the corpus callosum with invasion into the right parietal, temporal, and occipital lobes resulting in gyral thickening and sulcal effacement, consistent with GC (*Figure 2*).

The patient then underwent a craniotomy resection of the enhancing mass in the left parietal lobe. The patient tolerated surgery well without any complication. The final comprehensive pathology diagnosis was GBM, IDH wild type, WHO grade 4. O6-methylguanine-DNA methyl-transferase (MGMT) promotor hypermethylation was positive, 15.4%. Further molecular evaluation showed p53 mutation and PI3KCA mutation. No other mutation was detected.

Postoperative MRI showed postsurgical change with unchanged diffuse T2/FLAIR abnormality. At this time the patient had mild anomic aphasia, and no other neurological abnormality. Karnofsky performance score (KPS) was 90. The patient enrolled in the SPARE trial (NCT03477110). The patient started radiation treatment with concurrent TMZ (155 mg daily; 80 mg/m²) and TTFields treatment 7 weeks from surgery. The radiation volume was based on EORTC guideline targeting the enhancing lesion and surgical cavity in the left parietal lobe (*Figure 3*) (13). The GC change area was not covered by radiation fields to limit

Highlight box

Key findings

- Tumor-treating fields (TTFields) with chemoradiation led to rapid and durable response of gliomatosis cerebri in a patient with newly diagnosed glioblastoma (GBM).

What is known and what is new?

- TTFields is FDA approved newly diagnosed and recurrent GBM.
- The current case demonstrated its potential effect on gliomatosis cerebri in a patient with GBM.

What is the implication, and what should change now?

- Further evaluation is needed to better define the effect of TTFields on gliomatosis.

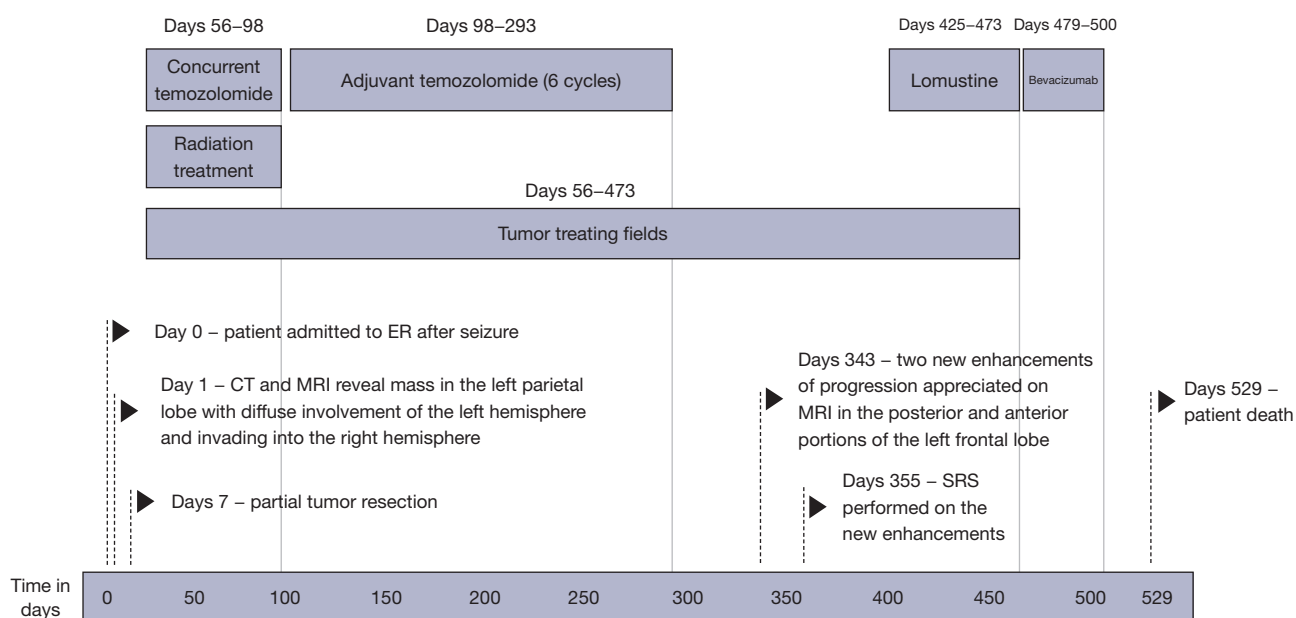


Figure 1 This timeline details significant events and treatment modalities used in the course of the patient's disease. ER, emergency room; CT, computed tomography; MRI, magnetic resonance imaging; SRS, stereotactic radiosurgery.

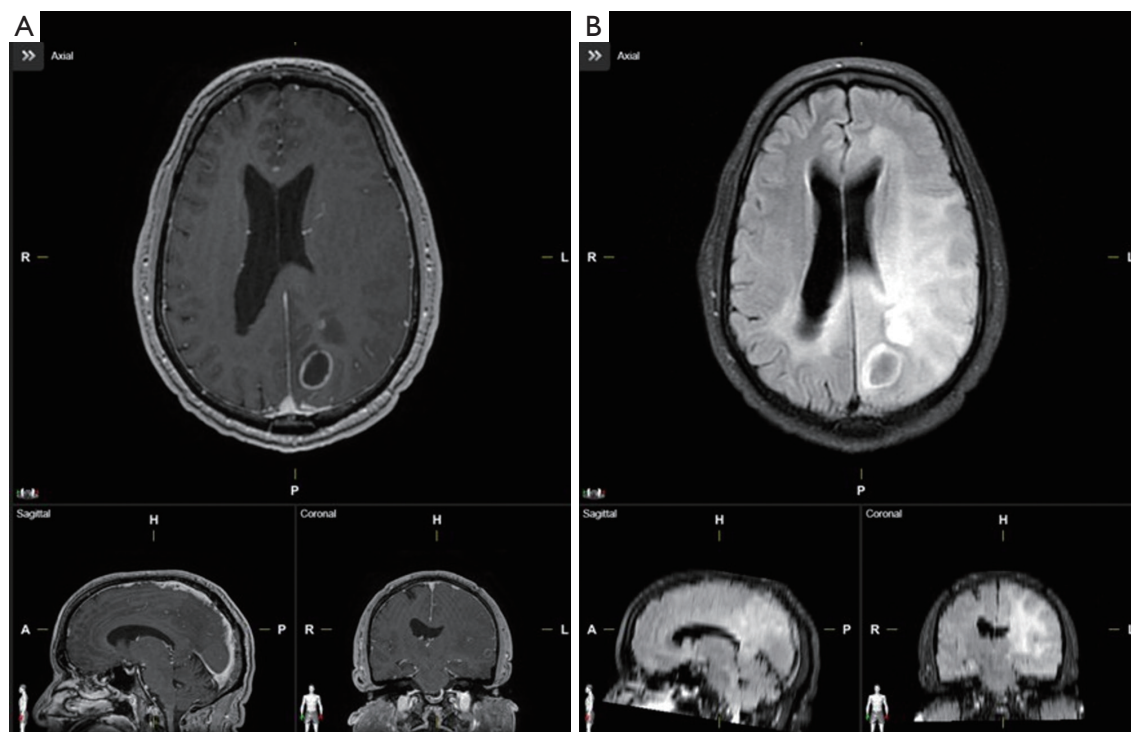


Figure 2 Preoperative MRI. (A) T1 post-contrast sequence showing an enhancing mass on the left parietal lobe; (B) T2/FLAIR sequence showing hyperintense signals throughout the left hemisphere of the brain and along the splenium of the corpus callosum with invasion into the right parietal, temporal, and occipital lobes resulting in gyral thickening and sulcal effacement, consistent with GC. MRI, magnetic resonance imaging; FLAIR, fluid-attenuated inversion recovery; GC, gliomatosis cerebri.

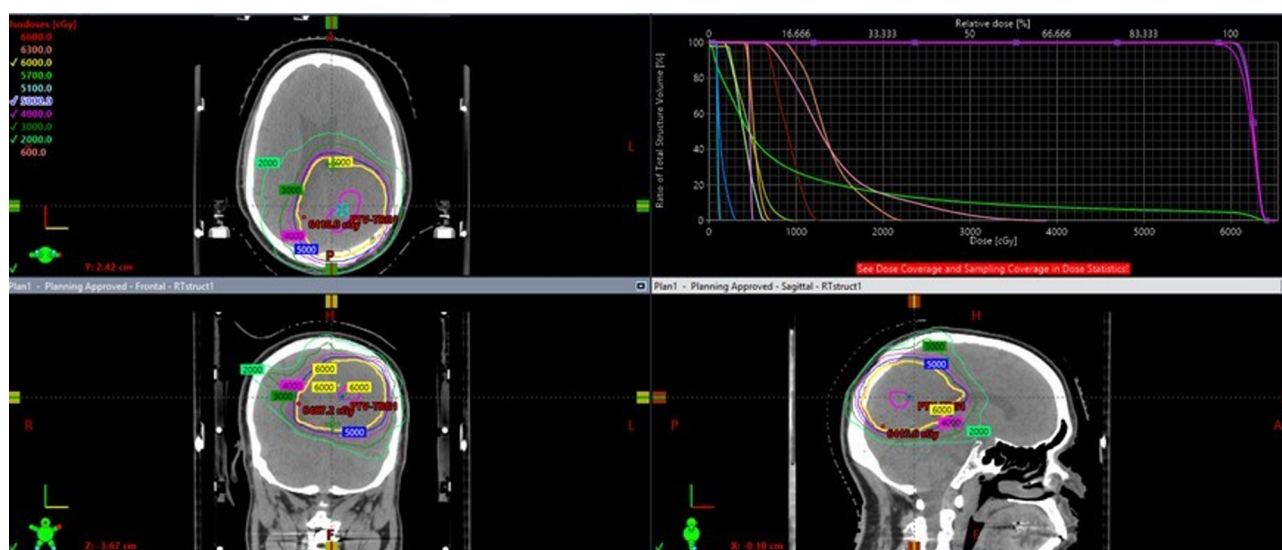


Figure 3 The radiation treatment plan showing radiation volume targeting the enhancement lesion and surgical cavity in the left parietal lobe only.

radiation induced side effects.

The patient tolerated the 6-week radiation with concurrent TMZ and TTFields well with no toxicity higher than grade 1 (scalp rash). He had no delays or breaks in radiation treatment. During the second week of treatment, a scattered papular rash outside of the TTFields placement developed and was intermittently present throughout the course managed with hydrocortisone as needed. The patient's compliance with TTFields usage so far had been excellent (93%). Three weeks after finishing radiation treatment MRI showed a similar small curvilinear focus of enhancement along the inferomedial aspect of the surgical cavity, and mildly more prominent small clustered ring enhancing lesions anteriorly (*Figure 4*). There was significant resolution of the T2/FLAIR signal abnormality, and interval resolution of the left lateral ventricle compression (*Figure 4*). The patient remained on TTFields treatment and started maintenance TMZ treatment 1 month after finishing radiation. He tolerated treatment well with no significant toxicity. Follow up MRI showed stable findings (*Figure 4*).

The patient continued to do well, with KPS of 90. However, 11 months after surgery, follow up MRI showed two small new enhancing lesions in the left anterior (6 mm) and posterior frontal lobe (8 mm), consistent with progression. The T2/FLAIR hyperintensity attributed to the GC changes remained resolved on MRI. TMZ treatment was discontinued. He received stereotactic radiosurgery (SRS, 21 Gy in 1 fraction) to these two new lesions. After the SRS treatment,

he was started on lomustine treatment. Unfortunately, 2 months later, the patient experienced significant deterioration, becoming wheelchair bound, developing left hemiparesis with corresponding ataxic gait, slurred speech, and anomic aphasia. His KPS score at this time was 50. MRI (13 months after surgery) showed significant progression of disease with multiple new enhancing lesions in the splenium of the corpus callosum crossing the midline to the right, left ventricular margin of occipital horn, genu of corpus callosum, and left frontoparietal area, with local mass effect but no midline shift. Despite this deterioration clinically, there was no recurrence of GC changes (*Figure 4*). Due to the patients' continually worsening condition, treatment with TTFields was discontinued. The patient overall received 11.5 months of TTFields treatment, with overall compliance of 19.8 h/day, 82.4%. Bevacizumab treatment was initiated. However, the patient only had limited improvement in symptoms for a short time. Two months after initiation of bevacizumab treatment, the patient's condition declined rapidly, he was placed on hospice care and later passed away. The OS was 17 months from diagnosis.

Discussion

GC is a rare and aggressive form of glioma with diffuse brain involvement. Research on GC is sparse, despite the rise in recognized incidence in the preceding decades (5). GC was reclassified as a diffuse pattern of growth within

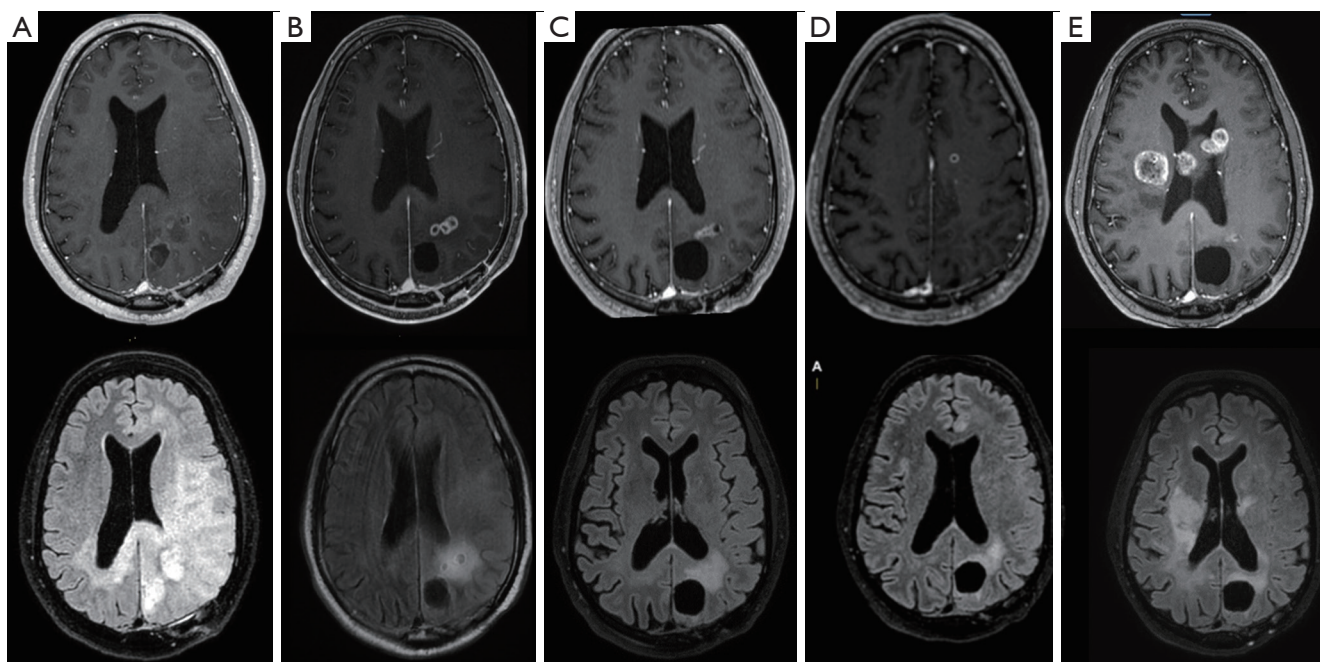


Figure 4 MRI scans of the patient. (A) Postoperative/pre-radiation MRI. Top: T1 post-contrast sequence showing surgical cavity and cluster of small enhancing lesions anteriorly (arrow). Bottom: FLAIR sequence showing diffuse FLAIR abnormality consistent with GC. (B) MRI 3 weeks after finishing radiation treatment. Top: mild enlargement of cluster of small enhancing lesions anteriorly, consistent with post-radiation change (arrow). Bottom: significant resolution of GC change. (C) MRI 8 months after finishing surgery. Top: stable enhancing lesions. Bottom: persistent significant resolution of GC change. (D) MRI 11 months after surgery. Top: new enhancing lesion (arrow), consistent with progression. Bottom: persistent significant resolution of GC change. (E) MRI 13 months after surgery. Top: significant progression of disease with multiple new enhancing lesions in splenium of corpus callosum crossing the midline to the right, left ventricular margin of occipital horn, genu of corpus callosum, and left frontoparietal area. Bottom: prior GC changes remain in response. New FLAIR abnormality due to progression. MRI, magnetic resonance imaging; FLAIR, fluid attenuated inversion recovery; GC, gliomatosis cerebri.

glioma in 2016 because of multiple studies identifying a lack of molecular distinction between GC and glioma (14). Analysis of methylation patterns in GC revealed similar signature seen in multiple pre-defined glioma subgroups (1). This finding was corroborated in pediatric GC which corresponded to known glioma methylation profiles as well as both genetic and epigenetic characteristics (15).

Clinic management of GC is therefore often similar to glioma due to the lack of a standard treatment regime for GC (6). Due to GCs diffuse nature, surgery has little role. Radiation treatment and chemotherapy are the primary treatments. Historically, whole brain radiation treatment is the most common radiation approach. The doses range from 20 to 59 Gy (6). However, it has limited efficacy and significant neurotoxicity (16). The pattern of failure study suggested it may be treated with partial brain radiation with limited margin (17). Thus in this case, in a patient with GBM and GC pattern, the decision was made to treat the

enhancing lesion and surgical cavity with margin only per the EORTC guideline (13). As a result, the GC involvement area was not covered by radiation (*Figure 3*). The rapid and durable response of GC, thus, was unlikely due to the benefit from radiation treatment.

Chemotherapy is often used in patients with GC, either alone or with radiation treatment. NOA-05 prospectively evaluated the efficacy of chemotherapy in GC (18). The median PFS was 14 months and median OS was 30 months, suggesting initial treatment with procarbazine and lomustine may have potential clinical benefit for patients with GC (18). TMZ is widely used for gliomas and is often used in GC. Retrospective studies indicating TMZ may have a PFS and OS ranging from 9–18 and 14–37.3 months, respectively (6). MGMT promotor methylation is a predictive factor for treatment response to TMZ (19). This patient had a methylated MGMT promotor, the observed the response of GC can be at least partially contributing to

TMZ.

TTFields treatment is a new modality for the management of GBM. It is FDA approved for newly diagnosed and recurrent GBM, based on phase 3 randomized trials (EF14 and EF11) (11,20). The mechanism of action of TTFields is anti-mitosis (7,8). However, TTFields treatment has other complex functions, including anti-migration, inhibition of DNA damage repair, affects on cell membrane permeability, disruption of the blood brain barrier (BBB), immunological effects, and more (21). Besides GBM, TTFields should have similar biological effects on G3 and low-grade glioma, though the data is limited. Like radiation, as a field treatment, TTFields has a wide treatment distribution. Dosimetric studies showed TTFields distribute throughout large regions of the brain in a heterogeneous manner (22–24). However, the planning system for acute modeling the TTFields field strength through the brain is not yet commercially available (23). Nonetheless, the current findings do support TTFields can be effective at targeting larger volumes of gross and subclinical disease safely (24). Moreover, when TTFields treatment is combined with radiation and chemotherapy they may achieve synergistic effects (7,25). The patient in this case received concurrent TTFields with chemoradiation on the SPARE trial (NCT03477110) (12,26). The rapid and durable response of GC was likely a benefit from the combination therapy. Lastly, TTFields treatment is delivered over long periods of time. The compliance with TTFields therapy is directly associated with the dose of TTFields treatment. Evaluation of patients receiving TTFields treatment on the EF14 trial demonstrated a compliance threshold of 50% with TTFields/TMZ correlated with significantly improved OS and PFS versus TMZ alone (27). Patients with compliance >90% showed extended median and 5-year survival rate close to 30% (27). The patient presented in this study had excellent compliance during the concurrent TTFields with chemoradiation treatment (93%). This may have contributed to the rapid response of GC as observed 3 weeks after finishing radiation treatment. The patient continued to have a favorable compliance rate (>80%), and this may have further contributed to his durable response of GC.

Conclusions

In this GBM patient with extensive GC change, concurrent TTFields with chemoradiation induced a rapid and durable

response of the GC. This finding suggests the benefits of TTFields treatment in patients with GC. Further evaluation is needed to better understand the role of TTFields in patients GC.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the institutional review board and followed the tenets set by the Declaration of Helsinki (as revised in 2013) and the Health Insurance Portability and Accountability Act. Written informed consent was obtained from the patient for publication of this case report and accompanying

images. A copy of the written consent is available for review by the editorial office of this journal.

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