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Radiotherapy in selected non-oncological neurological disorders – efficacy and safety

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Abstract

Introduction:

Radiotherapy, once limited to oncology, is now emerging as a therapeutic option for non-neoplastic neurological disorders. Advances in stereotactic techniques such as Gamma Knife and CyberKnife allow for precise functional targeting, opening possibilities in diseases like Alzheimer's disease (AD), drug-resistant epilepsy, and trigeminal neuralgia (TN).

Materials and Methods: A comprehensive literature review was conducted using PubMed, Scopus, and ClinicalTrials.gov. Search terms included radiotherapy, stereotactic radiosurgery, Alzheimer's disease, epilepsy, and trigeminal neuralgia. Studies published between 2015–2025 were reviewed.

Results: In AD, low-dose radiation therapy (LDRT) has shown potential to stabilize or improve cognition, with minimal side effects in early clinical trials. In epilepsy, stereotactic radiosurgery (SRS) and fractionated stereotactic radiotherapy (FSRT) have provided seizure reduction or remission in selected cases, particularly where surgery is not viable. For TN, SRS achieves pain relief in 85–90% of patients, with long-term remission and generally mild adverse effects such as facial numbness.

Conclusions: Radiotherapy offers a promising, non-invasive approach for selected neurological conditions. Although current data are encouraging, larger randomized trials are essential to establish long-term safety, optimize dosing strategies, and validate efficacy across patient populations.

Keywords: radiotherapy; stereotactic radiosurgery; Alzheimer's disease; epilepsy; trigeminal neuralgia

1. Introduction

Traditionally associated with cancer treatment, radiotherapy is gaining increasing recognition as a therapeutic modality in neurological disorders unrelated to neoplastic processes. Modern techniques such as stereotactic radiosurgery (SRS) and stereotactic body radiotherapy (SBRT) enable the precise delivery of high radiation doses to well-defined brain structures, opening new therapeutic avenues for conditions including trigeminal neuralgia, essential tremor, epilepsy, and even early stages of neurodegenerative diseases such as Alzheimer's disease (Jacob et al. 2020, Nardone et al. 2022). In the context of non-oncological neurology, radiotherapy is most commonly applied in the form of stereotactic radiosurgery, utilizing platforms such as the Gamma Knife or linear accelerators (LINAC). The therapeutic goal is not the destruction of tissue, but rather functional modulation of specific brain regions (Jacob et al. 2020, Kolodziej et al. 2025). The application of radiotherapy in neurology requires exceptional precision and a thorough understanding of functional neuroanatomy. Treatment is conducted by multidisciplinary teams—including radiation oncologists, neurologists, neurosurgeons, and medical physicists—in order to optimize treatment planning and minimize the risk of adverse effects (Jacob et al. 2020, Nardone et al. 2025).

2. Materials and methods

To conduct a comprehensive review of the applications of radiotherapy in non-neoplastic neurological disorders, articles available in the PubMed, Scopus, and ClinicalTrials.gov databases were analyzed. The following keywords were used in the search: radiotherapy, stereotactic radiosurgery, low-dose radiation therapy, Alzheimer's disease, epilepsy, trigeminal neuralgia, Gamma Knife, CyberKnife, and neurological disorders. Studies published between 2015–2025 were included. Reference lists of selected studies were also screened to identify additional relevant sources.

3. Results

3.1. Radiotherapy in Alzheimer's Disease

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that predominantly affects the elderly. It is characterized by the accumulation of β-amyloid (Aβ) plaques and intracellular neurofibrillary tangles composed of tau protein. Current therapies focus primarily on symptomatic relief; however, there is growing interest in novel approaches, such as low-dose radiation therapy (LDRT). Although the mechanisms underlying the effects of LDRT in AD are not yet fully elucidated, several potential pathways have been proposed. These include the reduction of β-amyloid plaque burden, modulation of inflammatory responses, induction of hormetic and adaptive cellular effects, and inhibition of glycogen synthase activity, which may reduce neurotoxicity and promote neuronal survival (Thariat et al. 2024, Chung et al. 2021, Ceyzériat et al. 2020). Promising results from preclinical studies have led to the initiation of early clinical trials assessing the safety and efficacy of LDRT in patients with Alzheimer's disease. One such study by Kim et al. (2023) evaluated the effects of whole-brain low-dose irradiation in five female patients with mild to moderate AD. The treatment protocol involved six fractions of 0.5 Gy (total PTV dose of 3 Gy), administered three times per week. All patients had been receiving acetylcholinesterase inhibitors prior to the study, and three carried the APOE ε4 allele, which is associated with increased AD risk. All participants completed the full course of LDRT and the six-month follow-up period. At follow-up, 2 patients were unable to complete the Rey complex figure copying task. Neurological improvement was observed in 20% of patients, with one showing temporary improvement on the Clinical Dementia Rating–Sum of Boxes (CDR-SB) scale, and two demonstrating stabilization on the Korean Mini-Mental State Examination (K-MMSE). Subjective improvements were reported by caregivers, including improved mood and memory (e.g., patient 2 recalling a forgotten song and showing better short-term memory), and improved orientation and independence in daily activities (e.g., patient 3 navigating home alone and shopping independently). Mild adverse effects such as nausea, headache, and transient hair loss were reported by two patients and resolved after treatment completion. However, the study had several limitations: the sample size was small, there was no control group, and the six-month follow-up period was insufficient to draw definitive conclusions. Longer observation periods (ranging from 7 months to over 4 years) are necessary to assess LDRT's potential to reduce amyloid burden or alleviate symptoms in systemic amyloidosis beyond the CNS (Kim et al. 2023). Similar findings were reported by Cutler et al. (2021),

who treated four clinically stable residents of long-term care facilities with advanced AD using three sessions of LDRT (40 mGy per CT scan; the first session delivering 80 mGy). Follow-up at eight weeks post-treatment revealed significant improvements in alertness, communication, and behavior in three of the four patients. For example, one patient began singing and engaging with their environment, while another resumed independent eating and task-following. Neuropsychological testing revealed minor changes, and no serious adverse effects were observed. One patient experienced transient self-directed aggression, which resolved after treatment (Cuttler et al 2021). In another study by Rogers et al. (2023), five patients received LD-WBRT at 2 Gy × 5 over one week. MMSE scores showed improvement (n = 3) or stabilization (n = 1) in four of the five patients over the course of a year. Improvements included better naming ability, cognitive stabilization, and potential imaging-based improvements. The only reported side effect was temporary hair loss, followed by unexpected regrowth (Rogers et al. 2023). Earlier findings by Cuttler et al. (2016) documented the case of an 81-year-old woman with advanced AD who received five CT brain scans at 40 mGy each while in hospice care. Remarkable improvement was noted after just two sessions - she regained speech, attempted to stand, and resumed eating. Although a regression occurred after the fifth scan, improvement resumed in subsequent weeks. The patient ultimately improved to the extent that she no longer qualified for hospice care and was readmitted to a dementia day program. No severe adverse events were reported (Cuttler et al. 2016). Between 2016 and 2017, she continued to receive booster scans every 4–5 months, and later every 6 weeks. Improvement was noted in her sentence formulation abilities, however, her speech capacity gradually declined. In March 2017, the patient was re-admitted to hospice care. Despite some fluctuations, periodic imaging was associated with sustained behavioral and cognitive improvement (Cuttler et al. 2017, Cuttler et al. 2018). Alzheimer's disease progresses inevitably in all patients. Current treatments may alleviate some symptoms; however, no disease-modifying therapy or curative drug is currently available. For this reason, numerous ongoing clinical trials (NCT03352258, NCT03597360, NCT05635968, NCT04203121) are investigating whether low doses of ionizing radiation may improve functional status and quality of life in patients with Alzheimer's disease (source: Clinicaltrials.gov).

These preliminary findings suggest that LDRT may hold promise as a therapeutic modality in neurodegenerative disorders such as Alzheimer's disease. However further clinical research -

particularly randomized, double-blind, placebo-controlled trials - is essential to validate its efficacy and safety. Future studies should also consider incorporating biomarkers of oxidative stress to provide objective measures of LDRT's systemic impact (Cuttler et al. 2021, Cuttler et al. 2017, Cuttler et al. 2018).

3.2. Radiotherapy in Epilepsy

Epilepsy is one of the most common neurological disorders worldwide, affecting over 50 million people. Although the majority of patients respond well to pharmacological treatment, an estimated 20–40% suffer from drug-resistant epilepsy, for whom conventional therapies may prove insufficient. In such cases, stereotactic radiosurgery (SRS) and fractionated stereotactic radiotherapy (FSRT) are emerging as viable alternatives to resective surgery and are among the most commonly used radiotherapeutic approaches in epilepsy management. SRS involves the delivery of a single high-dose radiation treatment to ablate the epileptogenic focus, with Gamma Knife being a notable example used particularly in mesial temporal lobe epilepsy. FSRT, on the other hand, delivers radiation in multiple smaller fractions, reducing the risk of damage to adjacent healthy brain tissue. Radiotherapy exerts its therapeutic effects by gradually inducing structural changes in the seizure focus, such as gliosis and decreased activity of neurons involved in pathological discharges. Additionally, studies suggest that SRT may influence neurotransmitter balance, potentially preserving cognitive functions better than resective procedures (Feng et al. 2016, Boström et al. 2016, Eekers et al. 2018). A review of the literature confirms that radiotherapy can significantly reduce seizure frequency, with efficacy depending on the radiation dose and precise localization of the epileptogenic zone (Eekers et al. 2018). Supporting this, Savateeva et al. (2022) evaluated the efficacy of SRS in treating epilepsy associated with hypothalamic hamartoma (HH) in a retrospective analysis of 19 patients. The mean radiation dose was 18±2.0 Gy with an average isodose of 48±4.2%, and the mean follow-up period was 14.8 months. Complete seizure remission was achieved in 15.8% of patients, while one patient (5.3%) exhibited dramatic improvement with resolution of generalized seizures and only occasional emotional seizures. A significant reduction in seizure frequency was observed in 57.8% of patients, while 21.1% showed no clinical change. The best outcomes were associated with target doses above 20–22 Gy, minimum doses over 7–10 Gy, and therapeutic coverage of at least 70–80% of the hamartoma volume. Importantly, no patients experienced

serious neurological, endocrine, or visual complications. The study suggests that children with HH volumes less than 3 cm^3 and hypothalamic contact areas smaller than 150 mm^2 are ideal candidates for this treatment (Savateev et al. 2022). Similar findings were reported by Boström et al. (2016), who evaluated SRS and hypofractionated SRT (hfSRT) as alternative treatments for pharmacoresistant epilepsy located in eloquent brain regions. The study included six patients with epileptogenic foci in functionally critical areas such as the motor cortex, visual cortex, and insular cortex. Four patients received SRS (13 Gy), while two underwent hfSRT (36 Gy in 12 fractions). With a median follow-up of 16.3 months (range: 6–27 months), two patients (33%) were seizure-free, including one who discontinued antiepileptic medication. One patient experienced a reduction in seizure frequency, while three showed no clinical change. Notably, none of the patients developed neurological complications or adverse effects, despite the treatment targeting eloquent cortical regions (Boström et al. 2016). These findings indicate that both SRS and hfSRT may serve as effective and safe alternatives to resective surgery in selected cases of epilepsy. However, the authors emphasize the need for further studies with larger cohorts and extended follow-up periods to better define the long-term efficacy and mechanisms of action of radiotherapy in epilepsy treatment. Ongoing clinical trials (NCT05182437, NCT00860145) are currently evaluating the use of radiotherapy in the treatment of epilepsy (source: Clinicaltrials.gov).

3.3. Radiotherapy in the Treatment of Trigeminal Neuralgia

Trigeminal neuralgia (TN) is one of the most debilitating forms of neuropathic pain, characterized by sudden, paroxysmal episodes of intense facial pain, typically affecting one side of the face. It predominantly affects elderly individuals and women. TN significantly impairs quality of life, and resistance to pharmacological treatment poses a considerable therapeutic challenge (Rashid et al. 2018, Lovo et al. 2019). The first-line standard of care remains pharmacotherapy, most commonly carbamazepine or oxcarbazepine. In cases where drug treatment is ineffective, invasive neurosurgical interventions such as microvascular decompression (MVD) or percutaneous ablative procedures may be considered. However, not all patients are suitable candidates for surgery, particularly those of advanced age or with significant comorbidities. In this context, stereotactic radiosurgery (SRS), especially with the Gamma Knife (GK) system, has emerged as a safe and effective alternative. This technique allows for the precise delivery of high-dose radiation to targeted neural structures while

minimizing exposure to adjacent tissues, thereby reducing the risk of complications (Rashid et al. 2018, Dong et al. 2024, Yomo et al. 2024). Current evidence indicates that the analgesic efficacy of SRS reaches 85–90% within the first few months post-treatment, with the potential for sustained long-term pain control in a substantial proportion of patients (Deora and Tripathi 2024).

Table 1. Studies describing the effects of radiotherapy in the treatment of neuralgia

Author	Naświetlane miejsce	Number of patients (n)	Dose	Effectiveness	Adverse effects
Régis et al., 2016	cisternal segment of TN	497	mean dose 85 Gy	Pain relief in 91.75% (median onset 10 days), 45.3% remained pain-free at 10 years	0.6% disabling hypoesthesia; no other complications
Taich et al., 2016	TN, 2–4 mm anterior to pons	263	Single fraction: most commonly 85–90 Gy (1 session)	79% achieved pain relief (BNI < 3); median time to relief: 2.5 months; ~70% had relief >36 months	Facial numbness in 20–35%, more frequent with 90 Gy and in repeat SRS; no serious complications reported
Martínez Moreno et al., 2016	Distal, cisternal portion of TN	117	Single session; mean 86.5 Gy (range 80–90 Gy)	81% complete pain relief (BNI I–II); 94% improved (incl. BNI III); median time to relief: 2 months; 76% pain-free at 7 years	Facial numbness: 32.5% (mostly mild); no anesthesia dolorosa; higher risk in those with previous surgery or re-irradiation
Zhao et al., 2017]	TN root entry zone (REZ) + distal segment	247	84–90 Gy in 2 isocenters; 50% isodose curve; ≤20 Gy to brainstem; single session	87.9% initial pain relief (BNI I–III); 64% complete remission (BNI I); median time to relief: 2 months; 49.7 months pain-free	Facial numbness (32%, bothersome in 3.6%), dry eyes (12.9%), dysmasesia (3.7%)
Gagliardi et al., 2017	Anterior part of the cisternal portion of TN	166 (TTN: 130, ATN: 36)	Single dose: 90 Gy max (45 Gy at 50% isodose); one session	79% (TTN) and 60% (ATN) pain-free (BNI ≤ IIIb) at 5 years; KPS ↑ to 94.2 (TTN), 86.4 (ATN); SF-36: significant improvement in all domains	Facial numbness: 28.5% (TTN), 8.3% (ATN); painful anesthesia: 3.8% (TTN); no severe complications

Lee et al., 2018 [21]	REZ of TN	108	Median max dose: 90 Gy; 20% isodose line	90% with pain relief (BNI I–IIIB); median latency to relief: 4 weeks; recurrence in 26% at median 17 months	Facial numbness in 55% (BNI II–IV); 1% severe (BNI IV); no serious complications like anesthesia dolorosa
Rashid et al., 2018	Dorsal Root Entry Zone (DREZ) i Retrogasserian (RG)	55	Single dose 90 Gy	DREZ more effective ($p = 0.01$); better outcomes with larger 70 Gy treatment volumes ($p = 0.07$)	No brainstem toxicity or masseter weakness
Romanelli et al., 2019	Retrogasserian portion of TN	527	60 Gy in 80% isodose, retreatment 45 Gy	61% pain-free without medication after 6 months	No serious neurological complications were observed, the highest risk of side effects was observed in patients who underwent retreatment – as many as 85.7% of cases of more troublesome hypesthesia appeared after the second procedure.
Lovo et al., 2019	Centromedian i Parafascicular Complex (CM-Pf) thalamus	14	140 Gy	≥50% pain reduction in 60%, complete remission in 30%	No serious complications; 60% transient neuromodulatory effect
Helis et al., 2019	REZ of TN	77	Initial: 85 Gy, Repeat: 80 Gy; single session	Initial GKRS: 82% BNI ≤ IIIb, median relief: 1.1 yrs; Repeat GKRS: 88% BNI ≤ IIIb, median relief: 4.0 yrs	Numbness: Initial: 26.3% (bothersome 4.1%); Repeat: 78.8% (bothersome 2.9%), corneal dryness: up to 8.6%, no anesthesia dolorosa
Kundu et al., 2022	REZ of TN	41	80-90 Gy	72% pain relief; median recurrence after 30 months	1 patient: persistent hypoesthesia
Okunlola et al., 2023	REZ of TN	153	80 Gy (96.1% patients), 70 Gy (rest of them)	94.8% improvement after 6 months; 85% long-term relief	4.6% complications (mostly transient facial numbness)
Nugroho et al., 2023	TN (SRS) or tumor area (chirurgia)	517	mean dose 28.7 Gy (tumor SRS), 90 Gy (nerve SRS)	Pain relief: 93.3% (nerve), 79.1% (tumor), 92.2% (surgery)	6.6% pain worsening (SRS); 83 transient hypoesthesia cases (surgery)
Öztürk Özlük et al., 2024	Cisternal segment of TN	28	Median 80 Gy	71.4% initial relief; 31.2% long-term (5 years)	35.7% of patients had complications: Hypoesthesia (14.3%), corneal reflex loss (14.3%), jaw weakness (7.1%)
Warnick et al., 2024	REZ lub Retrogasserian segment of TN	871	80 Gy (range 62.5–95 Gy)	81.8% pain relief; 42.3% recurrence (median 44 months)	25.3% sensory disturbances; mainly facial numbness
Akcakaya et al., 2024	REZ of TN	53	Median 87.5 Gy	80% pain relief; 44.4% complete remission (mean 72.4 months)	66.7% hypoesthesia
Yomo et al., 2024	Retrogasserian segment of TN	51	80-85 Gy (retreatment: 70-75 Gy)	83% pain relief; FPS score reduced from 4.1 to 1.1	Dysesthesia 40%, FPS worsening ≥2 19%
Guillemette et al., 2024	Cisternal segment of TN	33	Median 60 Gy	87.9% initial relief; 58.2% maintained after 36 months	21.2% facial sensory disorders
Stergioula et al., 2024	Cisternal segment of TN	50	Median 60 Gy (range 50-60 Gy), 80% isodose	74% pain control (BNI I–III); 55% complete remission	62% new or worsening hypoesthesia
Dong et al., 2024	REZ of TN	158	Median 70-90 Gy, 50% isodose	62% long-term relief; 31.6% complete remission	43.5% hypoesthesia in cases with continuous facial pain

Tang et al., 2025	Cisternal segment of TN	548	Median 86-90 Gy, 70% isodose	62.77% pain relief within 1 month; 83.76% discontinued medication	9.85% facial hypoesthesia; associated with high BED near S1
Düzkalir et al., 2025	Arteriovenous malformation (AVM) in contact with trigeminal nerve	4	Marginal dose: 21.5 Gy (18-30 Gy), in one case 5 fractions of 6 Gy	100% AVM obliteration and pain relief	No radiation-induced complications

Legend: TN: trigeminal nerve, ATN: Atypical trigeminal neuralgia, TTN: Typical trigeminal neuralgia, REZ: root entry zone, BNI: Barrow Neurological Institute, KPS: Karnofsky Performance Status

Long-term outcomes - even up to 10 years - have been confirmed in the studies by Régis et al. and Rashid et al., with a low risk of neurological complications (Régis et al. 2016, Rashid et al. 2018). Zhao et al. observed that the best outcomes were achieved in younger patients (<60 years), without prior surgical interventions, and with a shorter duration of symptoms (Zhao et al. 2017). Similar conclusions were drawn by Lee et al., who demonstrated that a shorter duration of symptoms (≤5 years) correlated with higher treatment efficacy and a shorter time to pain relief (Lee CC et al. 2018). In the study by Gagliardi et al., treatment of typical trigeminal neuralgia (TTN) yielded better outcomes compared to atypical trigeminal neuralgia (ATN). Patients with TTN more frequently achieved long-term pain relief, demonstrated superior SF-36 scores (Short Form Health Survey), higher functional performance, lower recurrence rates, and greater treatment satisfaction. Although these differences did not reach statistical significance, a clear trend toward more favorable prognosis in TTN patients was observed (Gagliardi et al. 2017). Taich et al. were likewise in agreement that the presence of typical trigeminal neuralgia was a key prognostic factor (Taich et al. 2016). Romanelli et al. and Guillemette et al. demonstrated that repeat stereotactic radiosurgery (SRS), whether performed with Gamma Knife or CyberKnife, can be effective in cases of symptom recurrence - particularly in patients who initially responded but experienced pain relapse over time. This confirms the flexibility of SRS as a multistage therapeutic modality (Romanelli et al. 2019, Guillemette et al. 2024). Both Lovo and Dong observed that in patients with secondary neuralgia or continuous facial pain (CCP), conventional SRS targeting may be less effective. In such cases, thalamic irradiation has shown promise as an alternative approach, leading to complete remission in selected individuals (Lovo et al. 2019, Dong et al. 2024). Analyses by Kundu and Okunlola revealed that prior surgical treatment does not reduce the efficacy of Gamma Knife radiosurgery (GKRS), although it may increase the risk of recurrence. In patients with multiple sclerosis, treatment efficacy was reduced, suggesting the need for tailored strategies in this subgroup (Kundu et al. 2022, Okunlola et al. 2023).

Treatment planning plays a critical role - Warnick and Tang both emphasized the importance of achieving an appropriate biologically effective dose (BED), which determines the balance between therapeutic efficacy and the risk of complications, such as hypoesthesia (Warnick et al. 2024, Tang et al., 2025). Yomo through analysis of patient-reported outcomes and neuroimaging, showed that the presence of neurovascular compression and changes in grey matter may correlate with clinical response. Up to 85% of patients reported satisfaction with the treatment, highlighting the substantial impact of GKRS on quality of life (Yomo et al. 2024). In a study by Stergioula, CyberKnife proved highly effective over several years of follow-up, although approximately 30% of patients experienced recurrence (Stergioula et al. 2024). Akcakaya et al. confirmed that previous surgical interventions increase the likelihood of symptom relapse, despite the high initial efficacy of radiosurgery (Akcakaya et al. 2024). Düzkalir and colleagues described successful use of GKRS in trigeminal neuralgia secondary to arteriovenous malformations—achieving complete pain relief and AVM obliteration in all cases, without any adverse effects (Düzkalir et al. 2025). In the studies by Öztürk Özlük G and Helis, trigeminal neuralgia was associated with multiple sclerosis (MS). The authors recognized Gamma Knife radiosurgery (GKRS) as an effective treatment; however, its long-term efficacy was lower compared to trigeminal neuralgia not associated with MS, which may be attributed to differing underlying pathophysiological mechanisms. The authors noted that repeat radiosurgery may provide a more durable therapeutic effect (Öztürk Özlük et al. 2023, Helis et al. 2019).

Detailed guidelines based on a systematic review of predominantly retrospective studies have been published by the International Stereotactic Radiosurgery Society. Among 6,461 patients, 88% were treated with GammaKnife, 8% with a linear accelerator, and 4% with CyberKnife. The average maximum doses were: 71–90 Gy (prescription isodose: 100%) for GammaKnife, 70–90 Gy (isodose: 80%) for LINAC, and 64.3–80.5 Gy (isodose: 90%) for CyberKnife. According to most authors, the maximum time to onset of pain relief after SRS may be up to 180 days (Mücke R et al. 2022). Stereotactic radiosurgery, particularly with Gamma Knife and CyberKnife technology, demonstrates high efficacy in treating trigeminal neuralgia—even in patients refractory to pharmacological therapy or with prior surgical history. Significant pain reduction is observed in the majority of patients, and long-term symptom remission is achieved in a substantial proportion. The safety profile of SRS is favorable—transient hypoesthesia is the most frequently reported adverse effect, while severe

complications are rare. However, the effectiveness and tolerability of treatment depend on multiple factors, including target location, radiation dose, and individual patient characteristics such as comorbidities.

4. Conclusions

Radiotherapy in non-neoplastic neurological diseases, although historically underutilized, is now demonstrating growing therapeutic potential—particularly due to advancements in stereotactic technology. A review of current clinical data suggests that in neurodegenerative diseases such as Alzheimer's, as well as in drug-resistant epilepsy and trigeminal neuralgia, radiotherapy can be a safe and effective therapeutic option or adjunct to standard care. In Alzheimer's disease, low-dose radiation therapy (LDRT) may help alleviate cognitive symptoms, likely through mechanisms such as amyloid reduction, anti-inflammatory modulation, and adaptive cellular responses. While early findings are promising, limitations such as small sample sizes, short follow-up durations, and lack of control groups highlight the need for further well-designed clinical trials. In medically refractory epilepsy, SRS and fractionated stereotactic radiotherapy (FSRT) offer viable alternatives to surgery, particularly when epileptogenic foci are located in eloquent brain regions. Both partial and complete seizure remission have been achieved in a significant proportion of patients, with a low risk of complications, especially when proper dosing and targeting are applied. For trigeminal neuralgia—especially in patients resistant to pharmacotherapy or those with unsuccessful prior surgeries—SRS using Gamma Knife or CyberKnife achieves pain control rates of 85–90%. The procedure provides not only rapid but also long-lasting pain relief, with adverse effects like transient hypoesthesia typically being mild. However, treatment efficacy is influenced by various factors, including isocenter location, prescribed dose, prior treatments, and individual patient characteristics. In summary, radiotherapy represents a promising approach in the management of selected non-oncological neurological disorders. While current results are encouraging, further multicenter, randomized clinical trials are essential to establish clear indications, optimal dosing strategies, and long-term safety profiles for this evolving treatment modality.

5. Disclosure

Author Contribution Statement

Conceptualization: KK, MW, KB, KS; methodology: MW, KK, AW; software: n/a; check: KK, PZ; formal analysis: AK; investigation: MW, KK, AW, KB, AR, KD; resources: KK, KS; data curation: MW, KB; writing - rough preparation: MW, KK, AW, KB, PZ, MP, KS, KD, DS, AR; writing - review and editing: KK, AR; visualization: KK; supervision: KK; project administration: KK; receiving funding: n/a. All authors have read and agreed with the published version of the manuscript.

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