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Research article

# The effect of radiotherapy on neurogenic speech and language disorders of patients with primary brain tumour in the early period

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**Abstract**

Within the scope of the study, it is aimed to reveal the effect of radiotherapy applied to neurogenic speech and language disorder patients diagnosed with primary brain tumour in the early period. The participants of the study consist of 35 patients selected among those with primary brain tumour who applied to the Radiation Oncology Unit of İstanbul Kartal Dr. Lütfi Kırdar Training and Research Hospital. Within the scope of the research, Gülhane Aphasia Test 2 (GAT-2) and Standardized Mini Mental Test (MMT) were applied to the participants before they received radiotherapy. GAT-2 and MMT were reapplied to the patients 30 days after they had received radiotherapy as part of the treatment process. Results of the study indicated that, before radiotherapy, tumours formed in the frontal and temporal lobes, including the dominant language centers, had a negative effect on the cognitive performance of the patients, as well as their speech and language skills. However, after radiotherapy was applied, two patients with tumours in the left parietal lobe had a decrease in their speech and language skills, while no deterioration was observed in the speech and language skills of the other participants. This may be due to the early phase of radiotherapy.

***Keywords:*** *Brain tumour; neurolinguistics; radiotherapy; speech and language disorders*

## 1. Introduction

Cancer is one of the most important health problems of the modern world; it is at the top of the list of human deaths due to disease, and its incidence is increasing day by day. Although there are many subtypes, only 2% of cancer diseases and 3% of cancer-related deaths are due to brain tumours. Glioblastoma (GB) is the most common high-grade malignant brain tumour in the adult age (Fig. 1) group with a poor prognosis, constituting approximately 35-40% of primary brain tumours (Stupp et al., 2005; Savci, 2006; Noone et al., 2015).

Tumour localization, volume, and respectability are among the prognostic factors that affect the survival of GB patients. In addition to wide surgical resection, the most ideal standard and effective treatment approach in glioblastoma is simultaneous radiotherapy (RT) and adjuvant chemotherapy (Cho et al., 2010).

Although the tumour is surgically removed with the help of radiological imaging, these glial tumour cells spread within the healthy brain tissue, and it is often accepted that microscopic tumour cells are left behind after the surgical procedure (Fig. 2 and 3). Therefore, radiotherapy is recommended after surgery to destroy the gross tumour volume, whether it is microscopic or macroscopic in size. If the tumour is in a region where critical

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and healthy organs are located and the risk of surgery is high, RT and/or chemotherapy alone can be applied (Walker et al., 1978).

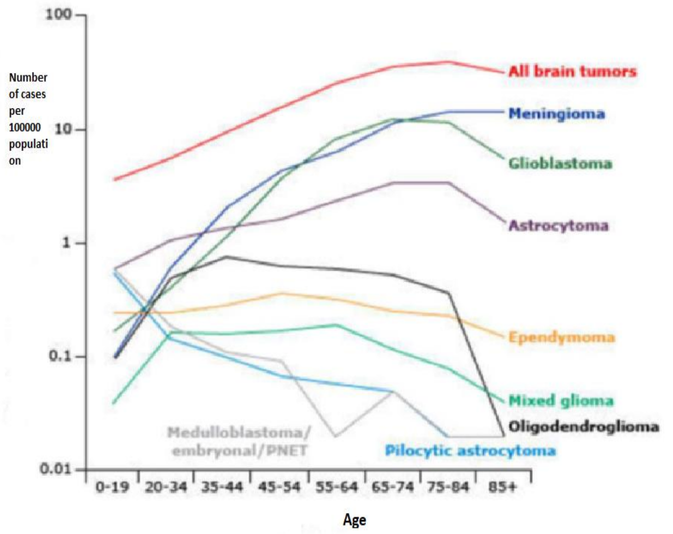


**Fig. 1.** Incidence rates of primary brain tumours (Michaud et al., 2017).

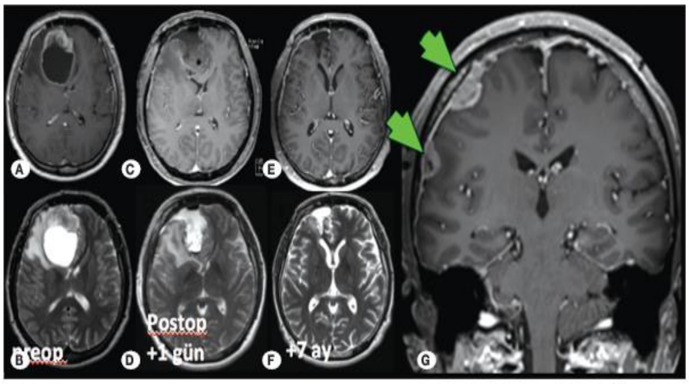


**Fig. 2.** Unexpected recurrence patterns are frequently observed in glioblastomas that do not have typical molecular genetic features. In the example, preoperative (A, B), early postoperative (C, D) and postoperative 7th month MR images (E, F, G) of a glioma patient without TERT mutation, chromosome 7 or chromosome 10 copy number changes are presented. It is observed that the resection cavity of the patient remained stable after radio-chemotherapy, but the patient developed distant, multifocal, supratentorial leptomeningeal recurrences, which are rarely observed in glioblastoma (gün=day; ay=month) (Ozduman et al., 2019).

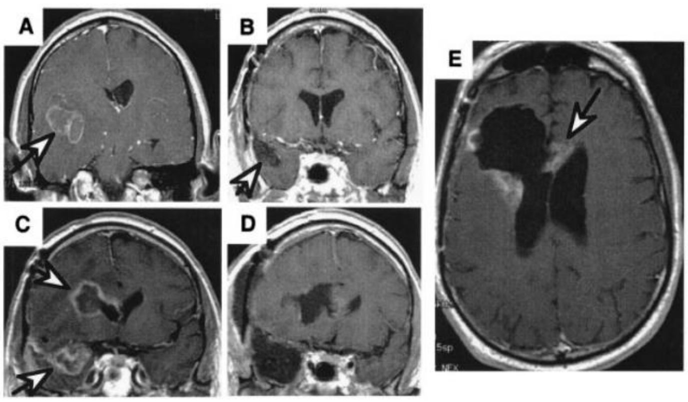


**Fig. 3.** Post-operative and 6-month computed tomography image obtained in temporal section of a GB patient (https://giemsa.net/korkulu-ruya-glioblastoma-gbm/).

In GB radiotherapy, while the healthy organs are protected at the highest level, the planned target volume is treated with high-energy ionized X-rays. With the recent developments in radiotherapy treatment techniques, the survival rate in GB has increased, especially for curative patients. However, radiotherapy-induced necrosis and late radiation toxicity are frequently encountered in these patients. Therefore, it is very important to investigate radiotherapy techniques and developments that will minimize the harmful effects of irradiation in GB radiotherapy in terms of patient dose and quality of life.

Depending on the developing technology, different models of commercial linear accelerators are frequently used in radiotherapy cancer treatments. In particular, modern techniques with high technological features can be preferred in the radiotherapy of head and neck cancers. Thanks to these modern techniques, it is aimed to protect the surrounding organs at risk while giving the prescribed dose to the tumour tissue by changing the intensity of ionized X-rays. These modern techniques are frequently used in GB radiotherapy because of the desired dose distributions over the target volume and the high degree protection of critical organs. The advantages and disadvantages of these different radiotherapy techniques in parameters such as target volume and dose distribution on healthy tissues and treatment times have been shown in many studies (Hess et al., 1994).

Aphasia is defined as an acquired language disorder that occurs as a result of brain damage in the hemisphere that is dominant in language processing, and causes problems in understanding and/or producing language in people. An individual with aphasia usually has relatively stronger non-linguistic cognitive skills such as memory, attention, and executive functions. However, problems in cognitive skills can sometimes occur with aphasia (Spreen and Risser, 2003; ASHA, 2023).

According to the National Aphasia Association, aphasia is observed in approximately 25-40% of people who have had a stroke. About 35-40% of adults who apply to hospitals with a stroke are diagnosed with aphasia when they are discharged (Pedersen, 1995; Dickey et al., 2010; NAA, 2023).

With the increase in studies and findings related to aphasia, many aphasia classifications have been included in the literature. The most frequently used classification in scientific research and clinics is the "Boston Classification System" which is based on impaired language skills. According to this classification system, aphasia is initially classified as fluent and halting (non-fluent) according to the characteristics of spoken language features. Types of aphasia in the Boston system are Broca's aphasia, Wernicke's aphasia, anomic aphasia, conduction aphasia, global aphasia, and the less common transcortical aphasia. There are also aphasia types in the literature that do not fully meet the clinical features of this widely used classification system. These aphasias consist of Primary Progressive Aphasia (PPA), Crossed Aphasia, and Subcortical Aphasia (Helm-Estabrooks et al., 2004; Davis, 2007; ASHA, 2023).

PPA is a syndrome caused by a neurodegenerative disease and characterized by the progressive deterioration of language skills despite the relative preservation of cognitive skills. It is similar to other types of aphasia in the sense that it leads to loss of language skills due to a neurological cause, while it is similar to neurodegenerative dementia types in terms of its progressive nature. While PPA is caused by a neurodegenerative condition, other types of aphasia are mostly caused by a stoppage of blood flow, mainly due to stroke (Mesulam, 2001; Hallowell, 2017). Furthermore, PPA has an insidious onset and occurs frequently before the age of 65, and its symptoms tend to get worse over time (Ardila, 2014). The first symptoms of PPA to be recognized are characterized by linguistic impairments, particularly word-finding problems, although cognitive skills are relatively intact. Over time, people with PPA often develop mild cognitive impairment followed by dementia (Ceccaldi et al., 1996; Hallowell, 2017).

Crossed aphasia is a rare type of aphasia that occurs with language impairment in a person as a result of damage to the dominant side of the body. For example, crossed aphasia may occur in a right-handed person who develops aphasia after right hemisphere damage. Many people with crossed aphasia also have accompanying symptoms such as left visual neglect and visuospatial problems typically associated with right hemisphere lesions (Fischer et al., 1991; Hund-Georgiadis et al., 2001).

Subcortical aphasia is a condition characterized by a partial or complete loss of verbal communication ability that develops as a result of damage to subcortical brain regions without loss of cortical function in Broca's or Wernicke's zones (Table 1). Subcortical aphasia can be caused by lesions in the basal ganglia, thalamus, or cerebellum (Hallowell, 2017; Kang et al., 2017). As a function of the affected subcortical brain region, various language disorders may occur after a stroke (Mega and Alexander, 1994).

Speech disorders of neurological origin include, but are not limited to, dysarthria, apraxia of speech, acquired neurogenic stuttering, palilalia, echolalia, forms of mutism, foreign accent syndrome, and aprosody associated with right hemisphere dysfunction (Duffy, 2013). Dysarthria is a neurogenic-based motor speech disorder characterized by abnormalities in the strength, speed, rate, range, stability, tone, or accuracy of movements required for some or all of the respiration, articulation, phonation, resonation, and prosodic components of speech due to neuromotor damage in the peripheral or central nervous system (Freed, 2011; Duffy, 2013; ASHA, 2023).

Among the causes of dysarthria are congenital disorders (e.g. cerebral palsy), neurodegenerative diseases (e.g. Parkinson's disease, ALS), vascular diseases (e.g. stroke), infectious diseases, demyelinating diseases (e.g. multiple sclerosis), toxic/metabolic diseases, neoplastic diseases (e.g. brain tumour), trauma, encephalitis, and many other conditions. The differences in the nature and location of the pathology give rise to different types of dysarthria (Roseberry-McKibbin and Hegde, 2006; Duffy, 2013; Hegde and Freed, 2016). Common lesion zones associated with dysarthria include the lower motor neuron, unilateral or bilateral upper motor neuron, cerebellum, and basal ganglia (Rampello et al., 2016; ASHA, 2023).

Apraxia of speech is a disorder in the timing-sequencing ability of motor commands required to properly position the articulators during voluntary speech production (Freed, 2011; Roth and Worthington, 2015). Although it is a neurologically based motor speech disorder similar to dysarthria, there is no muscle weakness or paralysis in apraxia, and there is a problem with motor planning and programming of speech movements (Freed, 2011; Duffy, 2013). This problem can affect any system that requires the purposeful sequencing of muscle movement (Roth and Worthington, 2015). Thus, a problem arises in the ability to perform articulatory movements at the right time and in the correct ordering of phonemes. Therefore, impairments in articulation and prosody usually occur. Although it is a result of damage to the central nervous system, the movement problem in apraxia of speech is not caused by muscle weakness or slowness (Freed, 2011).

**Table 1**
Clinical characteristics and classification of aphasia (Goodglass and Kaplan, 1972; Davis, 2007).

| **Non-fluent Aphasia** | | **Fluent Aphasia** | |
|---|---|---|---|
| Speech production is static and effortful. Grammar is poor; content vocabulary can be preserved. | | The person can produce coherent speech. Sentence structure is relatively preserved, but there are distortions in meaning. | |
| Auditory comprehension skills are relatively better. | Auditory comprehension skills are poor. | Auditory comprehension skills are relatively better. | Auditory comprehension skills are poor. |
| **Broca's aphasia;** repetition of words and sentences is poor. | **Global aphasia;** severe expressive and receptive language disorder is available. Communication can be established using facial expression, intonation and gestures. | **Conductive aphasia;** there are difficulties in finding words and repetition of words and sentences is poor. | **Wernicke's aphasia;** repetition of words/sentences is poor. |
| **Transcortical motor aphasia;** repetition skills are preserved. | | **Anomic aphasia;** repetition of words/sentences is good; word finding difficulties are present. | **Transcortical sensory aphasia;** repetition of words/sentences is preserved; may repeat questions instead of answering them. |

Apraxia of speech is considered in two subtypes: developmental and acquired apraxia of speech (ASHA, 2023). Developmental apraxia of speech may be idiopathic or of neurological origin, whereas acquired apraxia of speech results from damage to the motor programming areas of speech in the left cerebral hemisphere. Generally, Broca and supplementary motor areas are affected. Among some types of pathology, vascular lesions that cause strokes particularly affect speech programming structures and pathways (Roseberry-McKibbin and Hegde, 2006; Hegde and Freed, 2016). The most common causes of acquired apraxia of speech include stroke, traumatic brain injury, tumours of the left hemisphere usually involving the frontal lobe, surgical trauma (for example, tumour resection), or degenerative diseases (Duffy, 2006; 2013). Apraxia of speech is sometimes referred to as primary progressive apraxia of speech in the literature because it is a symptom of degenerative conditions (Duffy et al., 2020).

The key characteristics of apraxia of speech include errors in the production of consonant and/or vowel sounds, substitutions or additions of sounds, inconsistent sound errors, decreased speech speed, use of equal stress on adjacent syllables, error awareness, searching behavior, error correction effort, and often failure of this effort. (McNeil et al., 2009; Duffy, 2013; Hegde and Freed, 2016; Allison et al., 2020).

This study aims to determine the effect of radiotherapy on neurogenic speech and language disorders in the early period in patients diagnosed with a primary brain tumour and receiving radiotherapy.

## 2. Materials and methods

In this multidisciplinary study, a descriptive research design was used. The ethics committee approval of our research was obtained from the University of Health Sciences Hamidiye

Scientific Research Ethics Committee, with the decision dated May 27, 2022, and numbered 22/301. The study aims to reveal the effect of radiotherapy applied to patients diagnosed with a primary brain tumour on neurogenic speech and language disorders in the early period.

The participants of the study consist of 35 patients selected among patients diagnosed with a primary brain tumour who applied to the Radiation Oncology Unit of İstanbul Kartal Dr. Lütfi Kırdar Training and Research Hospital. The selection and exclusion criteria for the participants included in the study are as follows:

1) Having been diagnosed with a primary brain tumour,

2) Radiotherapy will be applied as part of the treatment processes,

3) Being age ranging from 20 to 85 years,

4) Not having any speech and language disorders before the disease,

5) Not having severe intelligibility and hearing problems.

For the data collection part of the study, consent was obtained from the participants/proxies by filling out the consent form; an anamnesis file was created for each participant, and they were informed that they could withdraw from the study at any time. Within the scope of the research, Gülhane Aphasia Test 2 (GAT-2) and Standardized Mini Mental Test (MMT) were applied to the participants before they received radiotherapy. GAT-2 and MMT were reapplied to the patients 30 days after they had received radiotherapy as part of the treatment process. The purpose of using GAT-2 is to determine the speech and language skills of patients with brain tumor before and after radiotherapy. Likewise, the purpose of using MMT is to determine patients' mental status before and after radiotherapy. At the end of the study, the GAT-2 and MMT scores of the participants obtained before and in the early period after radiotherapy application were interpreted, and the results were obtained.

## 3. Results and discussion

A total of 35 participants, 21 male and 14 female, diagnosed with primary brain tumour were included in the study. The mean age of the patients is 55. 17 of the participants are primary school graduates, 10 are high school graduates, and 8 are university graduates. 30 patients are right-handed, and 5 patients are left-handed. Of the primary brain tumours detected in the patients, 21 are located in the right hemisphere and 14 in the left hemisphere, predominantly in the frontal, temporal, and parietal lobes.

GAT-2 was applied to the patients before radiotherapy. While 28 patients showed normal results, low scores were obtained in 7 cases with brain tumours localized in the frontal and temporal lobes. Similar results were obtained in the MMT part of the application. While the MMT results of 28 patients are normal, the MMT scores of 7 patients with low GAT-2 scores also show a low course.

The patients were called to the hospital on the 30th day after the RT application, and GAT-2 and MMT were applied again. While 26 of the 28 patients with high scores in the GAT-2 application before RT achieved similar high scores, 2 patients with the tumour localized in the left parietal lobe achieved lower scores than before the GAT-2 test applied after RT. It is seen that 7 cases with low GAT-2 scores before RT had similarly low scores after RT. When the MMT results were examined, 28 patients who received MMT before RT and got high scores had similar scores at the repetition of the test, while patients with low MMT results in the first application were able to obtain low scores after RT.

## 4. Conclusion

Primary brain tumours show a progressive course in the disease process and cause different accompanying health problems in patients depending on the areas they are localized in the brain. Neurogenic speech and language disorders are also diseases that can occur due to brain tumours. In brain tumour treatments, radiotherapy is applied in addition to wide surgical resection, and together with adjuvant chemotherapy that, also affects the patient's survival. Necrosis and late radiation toxicity that may occur in brain tumour radiotherapy applications can also cause various types of damage to the brain after the application.

This study aims to determine the effect of radiotherapy on neurogenic speech and language disorders in the early period in patients diagnosed with a primary brain tumour and receiving radiotherapy. In this context, 35 patients diagnosed with a primary brain tumour and receiving radiotherapy were studied. GAT-2 and MMT were applied to the patients before and after radiotherapy in the early period and evaluated according to the localization of the tumour in the brain.

When the data obtained after the applications were interpreted, it was determined that tumours formed in the frontal and temporal lobes, including the dominant language centers, before radiotherapy had a negative effect on the cognitive performance of the patients, as well as their speech and language skills. After radiotherapy was applied to the patients during the treatment process, two patients with tumours in the left parietal lobe had a decrease in their speech and language skills, and no deterioration was observed in the speech and language skills of the other participants. We think that this may be due to the early phase of radiotherapy.

In other studies, especially considering the effects of radiotherapy on cancer and healthy tissues, it is predicted that the difference in scores between these test scores for the late effects of 6 months and above may increase in cases before and after irradiation.

**Conflict of interest:** The authors declare that they have no conflict of interests.

**Informed consent:** The ethics committee approval of our research was obtained from the University of Health Sciences Hamidiye Scientific Research Ethics Committee, with the decision dated May 27, 2022, and numbered 22/301.

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