



## Frontal Lobe Syndrome and Its Forensic Psychiatric Aspects Frontal Lob Sendromu ve Adli Psikiyatrik Yönleri

Mehmet Hanifi Kokaçya<sup>1</sup> , İbrahim Ortanca<sup>2</sup> 

### Abstract

Frontal lobe syndrome is a clinical entity leading to personality change that is often seen as a result of a traumatic or neoplastic frontal lobe injury. If the lesion is orbitomedially located, the clinic presents in the spectrum of amnesia confabulation, disinhibited personality changes, joking tendency, puerility, sexual disinhibition, aggression, and violence. In dorsolateral lesions clinic of apathy, instability and poor executive abilities can be seen. Traumas and neoplasia mostly cause frontal lobe syndrome; other causes are cerebrovascular events, neurodegenerative diseases, central nervous system infections, and many other diseases. Frontal lobe syndrome is remarkable by the dramatic changes in the personality of the patient, and these cases may be subject to forensic medical evaluation in various cases, mostly traumatic origin. In the reports evaluating these cases, anatomical and psychiatric components of the clinic should be examined in detail, and expert opinion should be presented by reviewing the whole case file

**Keywords:** Frontal lobe syndrome, forensic medicine, personality

### Öz

Frontal lob sendromu, genellikle travmatik ya da neoplastik bir frontal lob hasarı sonucu görülen kişilik değişikliği tablosudur. Lezyonun lokalizasyonu orbitomedial bölgede ise amnezi ve konfabulasyon (masallama), disinhibe kişilik değişiklikleri çocuk-suluk, şakacı eğilim, seksüel dishinhibisyon, saldırganlık yelpazesinde bir kliniğe neden olur. Dorsolateral lezyonlar ise kararsızlık, apati ve yürütücü işlevlerin zayıfladığı bir tabloya yol açabilmektedir. Frontal lob sendromuna en sık yol açan neden, travmalar ve tümörler olup, serebrovasküler olaylar, nörodejeneratif hastalıklar, santral sinir sistemi enfeksiyonları ve bazı başka hastalıklarda da bu tablo görülebilmektedir. Hastanın kişiliğindeki dramatik değişiklikler, frontal lob sendromunu dikkat çekici kılmakta, bu olgular, travma kökenliler çoğunlukta olmak üzere çeşitli davalarda adli tıbbi değerlendirmeye konu olabilmektedirler. Bu vakaların değerlendirildiği raporlarda söz konusu tablonun anatomik ve psikiyatrik komponentleri detayları ile irdelenmeli, dava dosyası da beraberinde incelenmek suretiyle görüş sunulmalıdır.

**Anahtar sözcükler:** Frontal lob sendromu, adli tıp, kişilik

<sup>1</sup> Hatay Mustafa Kemal University, Hatay, Turkey

<sup>2</sup> Tennessee University, Memphis, TN, USA

✉ Mehmet Hanifi Kokaçya, Hatay Mustafa Kemal University Faculty of Medicine Department of Psychiatry, Hatay, Turkey  
mhkokacya@mku.edu.tr

Frontal lobe syndrome (FLS) is the behavioral and personality changes that usually occur after a traumatic or neoplastic frontal lobe lesion. The main features of this syndrome are the inability to solve problems (e.g., focus on purpose, decision making, judgment disorder) and emotional disorders (inappropriate social behaviors) (Lima et al. 2008).

The patient may become sociopathic, boastful, hypomanic, uninhibited, exhibitionist, and subject to outbursts of irritability or violence (Mosby 2013). The Belgian Doctor De Nobele first described it in 1835. De Nobele operated 16-year-old François V., who had shot himself in the head because of a love affair. He removed the bullet core and brain tissue, which he described as the "central part of the frontal lobe". De Nobele reported that François's character had changed completely, who survived two years after the incident. He mentioned that this change made him intelligent and cheerful (Verplaetse 2009).

Dr. Harlow describes the most famous case of this entity. A railway worker Phineas P. Gage had an accident in which a 1.25-inch (3.18 cm) diameter iron bar entered into his left cheek and gone through the left eye socket and the front part of the brain, leaving the skull. After this accident, their relatives stated that Gage was a completely different person and that he became irresponsible, disrespectful, and rude (Harlow 1848, 1868). Dr. David Ferier (1878) argued that the frontal lobe was responsible for advanced executive functions, referring to the injury of Gage, one of the first articles in which the functions of the cerebral locations were defined.

FLS, in the ICD-10 classification of the World Health Organization, is classified as an "organic personality disorder (F07.1)" under the parent classification "Personality and behavioral disorders due to brain disease, damage, and dysfunction (F07)" (WHO 2016). It is subclassified among "Personality Change Due to Another Medical Conditions" under the "Other Personality Disorders" subtitle and under the "Personality Disorders" title in the Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) (APA 2013). Today, the loci of the frontal lobe are described in more detail. The regions and the symptoms and findings that occur when affected are classified according to these loci. Because of different presentations of the clinical pictures, these clinical pictures are defined under the heading of "Frontal Lobe Syndromes" (Nelson 2018). In terms of causes of FLS, a wide range of pathophysiological processes is present that exceeds the definition in the dictionary. Many factors, such as various neurodegenerative diseases, tumors, cerebrovascular events, traumatic brain injury, or encephalitis, can cause this disease (Ayđın 2009, Moore and Puri 2012).

## **Neuropsychological functions of frontal lobes**

The frontal lobe is responsible for functions such as attention, planning, designing, thinking, reasoning and moral judgment, impulse control, self-monitoring, self-criticism, empathy, and analytical thinking. Purposeful, independent movements and behaviors result from the executive functions of the frontal cortex. These executive functions include planning, problem-solving, and flexibility. Besides, the frontal cortex provides the coordination of other cognitive functions such as the perception of the stimulus, transforming into information and its analysis, retention of the information, fluent speech, preventing inappropriate reactions, and attention. (Bonelli and Cummings 2007). Based on these, four primary functions of the frontal cortex can be mentioned. These are:

1. Persistence: Sustained attention, that is, concentrating attention on that task until a task is completed.
2. Inhibition: It is a suppression of any type of inappropriate response. An individual can prevent the reaction, which is not appropriate for his/her situation.
3. The ability to change the category: It defines the ability of the person to do this when they are put into a state of answering questions in a specific category and then asked to switch to another answer category with another stimulus.
4. Making necessary inferences from conditions: Features such as abstract thinking, planning, creating categories, and developing reactions against possible stimuli in the present and future are included in this definition (Tunçay 2009).

Since the clinical features of the frontal lobe syndrome vary according to the affected area of the frontal lobe, it is necessary to mention the anatomical structures of the frontal lobe and their function.

## Anatomy of frontal lobes

Frontal lobes are generally divided into three sections. These are the primary motor cortex, the premotor cortex, and the prefrontal cortex. The primary motor cortex is the primary motor region of the brain, located at precentral gyrus extending along the lateral side of the frontal lobe. This place is connected to the corticobulbar and corticospinal pathways and mediates the formation of movements (Aydın 2009). The premotor cortex is located right in front of the primary motor cortex. Broca area responsible for the control of the speech is located here. It plays a role in the initiation of movement, regulation of motor skills, and sequential learning of movements. The prefrontal cortex forms the anterior part of the frontal lobes. It has intensive connections with subcortical areas and limbic system. The prefrontal cortex is divided into two as dorsolateral and ventromedial prefrontal cortex (VMPFC) (medial and orbital cortexes). (Lishman 1998, Mesulam 2002). The dorsolateral prefrontal cortex (DLPFC) is responsible for executive functions such as planning, judgment, motivation, and behavior. VMPFC is the part of the prefrontal cortex related to emotions. It is associated with the processing of risk and fear. It also plays a role in inhibiting emotional reactions and decision-making processes (Passingham and Wise 2012).

## Frontal-subcortical circuits and clinical pictures in FLS

Reciprocal connections of the frontal cortex with basal ganglia and thalamus form frontal-subcortical cycles. These circuits organize information that comes from various areas of the brain and are related to each other. There are three frontal-subcortical circuits: dorsolateral prefrontal, orbitofrontal, and medial frontal (Bonelli and Cummings 2007). These circuits originate from the frontal lobes, project to striatal structures, extend from the striatum to the globus pallidus and substantia nigra, project from the original thalamic nuclei from these two structures and return to the frontal lobes (Cummings 1993). Each network is associated with a different aspect of executive functions (Lyketsos et al. 2004).

The dorsolateral prefrontal circuit is associated with executive functions such as designing, planning, problem-solving, and abstract thinking. Apathy, abulia, indecision, personality changes, and planning disorder are observed in their lesions. (Yener 2002,

Sunflower et al. 2003). People with executive dysfunctions usually cannot give definite answers, show cognitive flexibility, and they show disorders of reasoning. So their judgment may be disrupted. While solving a problem, they cannot determine an appropriate strategy, and they cannot make new arrangements according to changing task difficulties (Jeffrey and Cummings 2003). This situation can sometimes be confused with depressive disorder. Although the patients experience loss of pleasure and interest in the activities, they differ from depressive disorder by lack of feeling unhappy and depressed emotional state (Mesulam 2000).

The orbitofrontal cycle, on the other hand, is responsible for creating appropriate behavioral responses, the integration of emotional information, and the inhibition response. Symptoms such as impulsivity, personality changes, puerility, disinhibition, aggression, and memory problems may be seen in its lesions. The person with orbitofrontal lobe damage can ignore social rules and misbehave. Besides that, left orbitofrontal circuit lesions are associated with depressive, and right orbitofrontal circuit lesions are associated with elevated mood (Tosun et al. 2009). Patients with orbitofrontal cortex damage have been shown to have a reward-related, recognition-based learning disorder (Rolls et al. 1994).

In the medial frontal cycle, akinetic mutism is observed in the superior medial region lesions, and retrograde and anterograde amnesia and confabulation are observed in the inferior medial region lesion. Loss of motivation and apathy may be observed in the medial frontal circuit and anterior cingulate cortex lesions (Reber and Tranel 2019). Apart from these three circuits, Broca aphasia can be seen in frontal operculum lesions that include the expression centers of the tongue (Nelson 2018).

Symptoms seen clinically in FLS are generally described as two different syndromes: "dorsolateral syndrome" and "orbitomedial syndrome" (Malloy et al. 1993). Mesulam (1986) noted the differences in the findings and defined the orbitomedial frontal area as the paralimbic cortex and the dorsolateral frontal area as the heteromodal cortex.

In orbitomedial FLS, anosmia, amnesia, and confabulation, dyskinesia, personality changes, puerility, sexual dysfunction, and aggression are observed (Malloy et al. 1993; Paradiso et al. 1999). The orbital cortex receives secondary olfactory projections from the temporal lobe regions as well as direct projections from the olfactory pathway (Turner and 1978, Potter and Butters 1980). Weakened odor discrimination has been reported in experimental animals with orbitofrontal cortex lesions (Tanabe et al. 1975). Therefore, insensitivity to odors and inability to smell should suggest an orbitofrontal lesion in cases where FLS is considered. Irresponsible behavior and unstable mood are other symptoms (Damasio and Van Hoesen 1983).

In dorsolateral cortex injuries, impairments occur in temporal and sensorial integration, planning, maintenance of targeted functions, and behavioral flexibility. An indecisive, apathetic personality who is unable to do his work is seen (Stuss and Benson 1983).

## **Causes of FLS**

### **Traumas**

Trauma injuries are common causes of FLS (Sebit et al. 1996, Rommel et al. 1999, Sugden et al. 2006). Cognitive and behavioral problems, which can be observed commonly after traumatic brain injury, maybe persistent (Kurowski et al. 2013). In our country, a case of FLS, which wakes up from a deep coma after trauma and progresses with intel-

lectual dysfunction and behavioral impairment despite a complete improvement in motor deficit, has been reported (Çevik et al. 2015). Kartalçı et al. (2011), on the other hand, reported a case with FLS, which was observed with slowness, emotional disability, and apathy, and was not aware of his condition despite a marked deterioration in social behavior. Besides, there might be a defect in executive functions due to loss of function in the frontal-subcortical circuits after trauma, despite the lack of apparent frontal lesion (Metin et al. 2017).

## **Tumors**

Frontal lobe syndrome can be seen not only after the trauma but also after any organic pathology affecting the frontal lobe (Tosun et al. 2016). The most common tumors causing frontal lobe syndrome are olfactory cleft meningiomas. Anosmia, headache, and memory impairment may be clinical symptoms. Frontal areas are also one of the various sites for primary and metastatic brain tumors. (Aydın 2009). Several cases presenting with FLS findings due to olfactory groove meningioma have been reported (Ozan et al. 2010, Mumoli et al. 2013). Zeman and King (1958) reported an anterior midline structure syndrome with abnormal affective behavior caused by tumors of septum pellucidum and adjacent structures.

## **Cerebrovascular events**

Another cause of frontal lobe syndrome is pathologies in the vessels supplying the frontal cortex. Upper anterior branches of the middle cerebellar artery feed the prefrontal cortex. As a result of the infarction of these arteries, symptoms such as functioning memory disorders, planning difficulties, and apathy may be seen. Infarcts of basal forebrain can be seen in some cases of anterior communicating artery bleeding and aneurysm. In those cases, permeant personality changes, akinesia, and severe amnesia and confabulation can also be seen (Aydın 2009). In a 49-year-old male patient with FLS findings after lenticular capsular hematoma, hyperfusion of ipsilateral striatum, dorsolateral, and orbito-frontal cortex were demonstrated by Technetium-99m-hexamethyl propylene amine oxime single-photon emission computed tomography (99mTc-HMPAO SPECT) method (Ferreira-Garcia et al 2014).

## **Neurodegenerative diseases**

Progressive frontotemporal lobe degenerations such as frontotemporal dementia, primary progressive aphasia, and semantic dementia can also cause FLS (Aydın 2009). Spitzer et al. (2014) reported a rapid progressive FLS picture in a 35-year-old female patient with “Hereditary Diffuse Leukoencephalopathy” (HDLS). In a study conducted in Sweden, among 415 individuals of 85 years old, 86 of them (19%) fulfilled the criteria for FLS (Gislason et al. 2003).

## **Other causes**

Apart from the above, many different conditions can cause FLS. For example, a case of post-encephalitic FLS that has improved after infection treatment and appropriate anti-psychotics has been reported (Coşkun et al. 2012). Gökmen et al. (2014) reported a patient with FLS findings accompanied by systemic mastocytosis after a bee sting. Cases of FLS caused by intracranial mass effect due to a pituitary abscess and a mucocele

formed in the frontal sinus have been reported. (Hazra et al. 2012; Weidmayer 2015). In addition, diseases such as amyloidosis, tuberculosis, and polycythemia vera have been reported in the literature as causes of FSL picture (Labro et al. 2009, Ahmad et al. 2011; Severs et al. 2012). Amin (2012) reported a case of Fahr's Disease associated with frontal lobe-like dysfunction, that showed bilateral partial symmetrical calcifications in the white matter of basal ganglia, thalamus, deep cerebellar nucleus and cerebral hemisphere in the computerized brain tomography. He described the case as frontal lobe-like cognitive dysfunction, which represents memory weakness, rapid irritability, insomnia, social isolation, and anhedonia, for the last six years. He used the definition of "frontal lobe-like" since it did not fully meet the anatomical criteria that were emphasized. Since FLS developing after infections are temporary, it is more suitable for the definition of "F07.1 postencephalitic syndrome", not "F07.0 organic personality disorder" in ICD-10 classification. However, in these cases, FLS, as an additional diagnosis, points out the area affected by the infection and gives an idea about the clinical picture (Coşkun et al. 2012).

## Reward system and frontal lobe

The reward system is essential for people and animals to survive (Şahpolat et al. 2014). The mesolimbic pathway, one of the most critical dopamine pathways in the brain, while extending from the ventral tegmental area (VTA) to the ventral striatum, amygdala, and hippocampus, sends projections from the mesocortical pathway to the prefrontal cortex (Margolis et al. 2012, Pistillo et al. 2015). The mesocorticolimbic system, which is a combination of these two pathways, is an integral part of the reward system (Kaya et al. 2019). "Natural rewards" such as eating and sex and "unnatural rewards" created with addictive substances cause dopamine to be released from the frontal lobe, and the mid-brain nucleus accumbens. Thus, the request and the desire arise to fulfill the requirements (Volkow et al. 2013). The limbic system, which forms the basis of the reward system in the brain, controls emotions and behaviors and forms the basis for pleasure perception, and also controls important functions such as motivation, memory, and learning. (Suhara et al. 2001) It is also known that the reward memory is found in DLPFC (Türe et al. 2006), that patients with orbitofrontal cortex damage have a reward-related learning disorder (Rolls et al. 1994). In the FLS, this reward system in the brain is likely to be damaged. In this case, the understanding of the person to evaluate and judge the events with the help of his previous knowledge and memory may be disrupted.

## Memory, attention and frontal lobe

In people with frontal lobe damage, behavioral changes such as impulsivity, difficulty in self-control are more prominent so that memory impairment can be overlooked (Simons and Spiers 2003). However, in frontal lobe damage, especially if there is a significant disruptive effect among recalled stimuli, inadequate memory function is observed (Incisa Della Rocchetta and Milner 1993).

DLPFC plays a major role in executive functions such as the integration of hidden information for decision making, updating, and recalling information (Rodriguez et al. 2014). Working memory is a temporary storage and processing system that processes information (Türkoglu et al. 2019). Although memory problems are generally not ob-

served in patients with DLPFC damage, there is a significant deficiency in the working memory of these patients (Ayçiçeği et al. 2003).

Short term memory or working memory is related to the parietal cortex and PFC, especially the posterior-lateral part (dorsolateral PFC), and these structures keep the information up to date. Working memory is represented by a frontoparietal network that includes DLPFC, anterior cingulate cortex, and parietal cortex (Owen et al. 2005, Chein et al. 2011, Kim et al. 2015). The coding and consolidation of information, storage, and recall of information are related to the prefrontotemporopolar network. It was observed that those with damage in the right frontotemporal region could not recall the eventual information, while those with left hemisphere damage had difficulty in accessing semantic information (Mesulam 2000).

The anterior cingulate cortex acts as an "attention checker" that evaluates the needs for organizing information during an ongoing task (Osaka et al. 2003). The parietal cortex is considered to be the area for sensory or perceptual processing (Andersen and Cui 2009, Chai et al. 2018). Therefore, damage to the frontoparietal network can negatively affect one's will and comprehension, as it will impair attention and working memory.

Confabulation and impaired customization of recalled information, observed in frontal lobe dysfunction, were associated with ventrolateral PFC, while disruption in verification and monitoring of remembered information were associated DLPFC. Therefore, patients may have false information and beliefs about themselves or events and distortions in their memories (Burges and Shallice 1996). In other words, deterioration in the judgment of the patient can be observed.

## Forensic psychiatric approach to FLS

Forensic psychiatry is a frequently referred area in criminal cases. According to Turkish Penal Code (TPC), it is evaluated that, due to mental disorder, whether a person cannot comprehend the legal meaning and consequences of the act he has committed or if, in respect of such act, his ability to control his behavior was significantly diminished (TPC, art.32).

In addition to moderate and severe mental retardation, schizophrenia, and other psychotic disorders, chronic organic brain syndromes with cognitive disorders are also accepted as diseases that can sometimes reduce or eliminate criminal liability in international jurisdictional practice (Oral 2011). FLS falls under the category of organic brain syndrome.

Although surviving a potentially fatal brain injury and dramatic changes in the patient's personality traits make this disease remarkable, a prominent dimension of FLS is its judicial results. When FLS is the result of injury to the victim in a criminal case, this will be considered as a life-threatening injury and permanent loss or weakening of organ function according to its severity (Güzel et al. 2005). In civil cases, laws and regulations demand significant compensation for the person who led to FLS injury or the insurance company. Sometimes, if one of the spouses suffers a mental disease, the marriage becomes intolerable to the other spouse due to such disease, the other spouse will be entitled to file a lawsuit for divorce. (Turkish Civil Code [TCC], art. 165). FLS not showing improvement by treatment can be considered in this category.

The Turkish Civil Code states that "Every mature person possessing distinguishing

power and not in the state of disability is deemed to possess the full legal capacity." (TCC, art.10). Then it attributes the distinguishing power to not being beyond self-control by any reason (TCC, art.13) and states that any act by a person's lack of distinguishing power may not lead to legal consequences (TCC, art.15). According to TCC, art.13, "every person who is not minor, or mentally defective or suffering from mental illness, or intoxicated, or beyond self-control by similar reasons, is deemed to possess distinguishing power." The distinguishing power in the concept refers to having the mental power to distinguish between good and evil, useful, and harmful.

According to TCC ART.15, "Provided that the cases indicated explicitly in the law are being reserved, any act by a person lack of distinguishing power may not lead to legal consequences. In the absence of distinguishing power, individuals are deprived of the competency that constitutes the capacity to act. In other words, they cannot exercise their rights with their actions. Not all mental illnesses cause people to lack the capacity to discriminate. In order for mental illness to affect the person's ability to discriminate, it must be affecting the person's ability to act reasonably. In order to mention the lack of distinguishing power, structural disorders with continuity should be considered (Koçhisarlioğlu 2004).

Two elements of the power of distinguishing are will and realization. The clinical appearance of patients with FLS may vary. As is known, disorders related to brain damage may change over time. For this reason, FLS is listed under the heading "Mental illnesses that cause temporary loss of function" on disability rates tables of "Regulation On Disability Assessment For Adults," which was published on official gazette in 2019 (Official Gazette 2019). It is stated that these disorders should be evaluated one year later. The subheading of FLS in this regulation is "behavioral disorders due to brain damage and brain dysfunction, and they are divided into three groups with disability percentages:☒

1. 0% improved full functionality with treatment
2. 20% partial improvement of functionality with treatment
3. 40% diminished functionality that does not improve with treatment

Due to this diverse and time-varying clinical appearance, psychiatric evaluation should be performed separately for each forensic case and situation, and it should be decided whether the person has criminal responsibility (Biçer et al. 2011).

The law states how individuals will be restricted and will be put under guardianship in the following way: Every adult who is unable to do his / her work because of mental illness or who needs constant help for his protection and care or endangers the safety of others is restricted (TPC, art. 405). As a result, these items tell us that due to mental illness, one can be deemed to be unable to distinguish and be restricted.

Having distinguishing power is also a condition for marriage (TCC, art. 125). Besides, the law makes it mandatory for individuals with mental illness to report that there is no medical objection in getting married (TCC, art.133). Even a formally realized marriage can be considered invalid if one of the spouses lacks the distinguishing power permanently during the marriage or has a mental illness that prevents marriage (TCC, art. 145). Sometimes, if one of the spouses suffers a mental disease, the marriage becomes intolerable to the other spouse due to such disease, the other spouse will be entitled to file a lawsuit for divorce (TCC, art. 165). The forensic psychiatrist does the evaluation of all these situations, and FLS is a disease that may concern all the law items we



mentioned. FLS can make a marriage unbearable. However, according to TCC, which contains many regulations, each case should be evaluated under its conditions. Another legal issue that we may encounter with FLS is disability/loss of working power in the profession cases. In Turkey, there is not a specific table for calculation of the disability ratios after a traffic accident. (Kadı et al., 2018).

In determining the disability rate caused by the injury by work accidents, traffic accidents, or criminal cases, "Legislation on Determination Procedures of Loss Ratio of Workforce in Occupation" is used (Official Gazette No. 27021 dated 11.10.2008 is used). In this legislation, "Frontal Lobe Syndrome" is classified under the heading "Non-psychotic specific disorders occurring after organic brain injury," and the fault degree measure is 65. This measure corresponds to the loss of 100% work power in the profession. For this reason, the clinic and diagnostic criteria of FLS should be well known, and a psychiatrist must be included in the board to prepare this report.

## Conclusion

When the pathophysiology and clinical appearance are evaluated together, FLS consists of anatomic and psychiatric components. For the diagnosis of FLS, the syndrome-specific symptoms or test results in the patient should be determined first. Along with the damage in the frontal lobe should be imaged and reported. Also, it should be argued that the lesion in a different region of the brain did not cause these symptoms and that the clinical picture originates from the frontal lobe. It should be remembered that frontal lobe syndrome may appear as two different clinics. In orbitomedial FLS, amnesia, and confabulation, verbal and sexual disinhibition, and anosmia are seen; therefore, evaluation of sense of smell would support the diagnosis. Dorsolateral FLS presents as an undecided, apathetic person who cannot do his work. Imaging methods should be used in forensic cases, and clinical findings should be included in the reports. As with any disease after making diagnosis, the report should be written in such a way to answer the question of the court or public attorney by evaluating conditions of the event and patient's characteristics, not the disease. While preparing the forensic report, each FLS case should be evaluated by considering its specific clinical symptoms.☒

## References

- Ahmad MT, Chan LL, Prakash KM (2011) Frontal lobe syndrome due to "A bunch of grapes". *Ann Acad Med Singapore*, 40:336–337.
- Amin O (2012) Fahr's disease and frontal lobe-like cognitive dysfunction: A case report. *Journal of Mood Disorders*, 2:119–122.
- Andersen RA, Cui H (2009) Intention, action planning, and decision making in parietal-frontal circuits. *Neuron*, 63:568–583.
- APA (2013) *Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5)*. Washington DC, American Psychiatric Association.
- Ayçiçeği A, Dinn W, Harris C (2003) Prefrontal lob nöropsikolojik test bataryası: sağlıklı yetişkinlerden elde edilen test sonuçları. *Psikoloji Çalışmaları*, 23:1–26.
- Aydın N (2009) Frontal lob sendromu. *Türkiye Klinikleri Psikiyatri Özel Dergisi*, 2:47–55.
- Biçer Ü, Tırtıl L, Kurtaş Ö, Aker T (2011) Adli psikiyatri. In *Birinci Basamakta Adli Tıp*, 2nd ed. (Eds S Koç, M Can):31. İstanbul, İstanbul Tabip Odası.
- Bonelli RM, Cummings JL (2007) Frontal-subcortical circuitry and behavior. *Dialogues Clin Neurosci*, 9:141–151.
- Burges PW, Shallice T (1996) Confabulation and the control of recollection. *Memory*, 4: 359–411.

- Çevik B , Yıldırım A, Aksoy D , Özer E, Kurt S (2015) Kafa travması sonrası gelişen frontal lob sendromu: Olgu sunumu. *Anadolu Psikiyatri Derg*, 16:223–226.
- Chai WJ, Abd Hamid AI, Abdullah JM (2018) Working memory from the psychological and neurosciences perspectives: A review. *Front Psychol*, 9:401.
- Chein JM, Moore AB, Conway AR (2011) Domain-general mechanisms of complex working memory span. *Neuroimage*, 54:550–559
- Coşkun M, Alyanak B, Yapıcı Z (2012) Kluver-Bucy and frontal syndromes following meningoencephalitis in a young boy: patophysiological and clinical considerations. *Noro Psikiyatr Ars*, 49:163–166.
- Cummings JL (1993) Frontal-subcortical circuits and human behavior. *Arch Neurol*, 50:873–880.
- Cummings JL (2003) *Nöropsikiyatri ve Davranış Nörolojisi*, (Çeviri Ed. G Akdal, GG Yener) Ankara, Çizgi Yayınevi.
- Damasio AR, Van Hoesen GW (1983) Emotional disturbances associated with focal lesions of the limbic frontal lobe. In *Neuropsychology of Human Emotion*, (Eds P Satz, KM Heilman):85–110. New York, Guilford Press.
- Dubois B, Slachevsky A, Litvan I, Pillon B (2000) The FAB: a frontal assessment battery at bedside. *Neurology*, 55: 1621–1626.
- Ferreira-Garcia R, Fontenelle LF, Moll J, de Oliveira-Souza R (2014) Pathological generosity: An atypical impulse control disorder after a left subcortical stroke. *Neurocase*, 20:496–500.
- Ferrier D (1878) The Goulstonian lectures on the localization of cerebral diseases. *BMJ*, 1:443–447.
- Gislason TB, Sjögren M, Larsson L, Skoog I (2003). The prevalence of frontal variant frontotemporal dementia and the frontal lobe syndrome in a population based sample of 85 year olds. *J Neurol Neurosurg Psychiatry*, 74: 867–871.
- Gökmen NM, Evyapan AD, Güllüoğlu H, Jara M, Sanchez L, Özsan N et al. (2014) Frontal lobe like syndrome due to bee sting. *Journal of Neurological Sciences*, 31:398–407.
- Grace, J, Malloy P (1992) *Frontal Lobe Personality Scale*. Providence, RI, Brown University,
- Güzel S, Balcı Y, Çetin G. (2005) Türk Ceza Kanunu'nda tanımlanan yaralama suçlarının Adli Tıp açısından değerlendirilmesi. *Adli Tıp Kurumu Başkanlığı, Adli Tıp Uzmanları Derneği, Adli Tıp Derneği. Güncelleme: Gündoğmuş ÜN, Balcı Y, Akın MH. 2013.*
- Harlow JM (1848) Passage of an iron rod through the head. *Boston Med Surg*, 39:389–393.
- Harlow JM (1868) Recovery from the passage of an iron bar through the head. *Publications of the Massachusetts Medical Society*, 2:327–347.
- Hazra S, Acharyya S, Acharyya K (2012) Primary pituitary abscess in an adolescent boy: A rare occurrence. *BMJ Case Rep*, 2012: pii: bcr2012007134.
- Incisa della Rochetta A, Milner B (1993) Strategic search and retrieval inhibition: the role of the frontal lobes. *Neuropsychologia*, 31:503–524.
- Kadı MR, Kadı G, Balcı Y, Göçeoğlu ÜÜ (2018) Meslekte kazanma gücü kaybı oranları ile takdir oranlarının değerlendirilmesi: Muğla Sıtkı Koçman Üniversitesi Tıp Fakültesi Adli Tıp Anabilim Dalı olguları. *Adli Tıp Bülteni*, 23:77–88.
- Kartalcı Ş, Ünal S, Özdemir S (2011) Adli yönden frontal lob sendromu: Bir olgu sunumu. *Anadolu Psikiyatri Derg*, 12:160–162.
- Kaya E, Akpınar D, Akpınar, H. (2019) Bağımlılığın patofizyolojisi. *Muğla Sıtkı Koçman Üniversitesi Tıp Dergisi*, 6:166–170.
- Kim C, Kroger JK, Calhoun VD, Clark VP (2015) The role of the frontopolar cortex in manipulation of integrated information in working memory. *Neurosci Lett*, 595:25–29.
- Koçhisarlioğlu C (2004) Kusurun objektifleştirilmesinin ayırt etme gücüne etkilemesi. *Ankara Üniversitesi Hukuk Fakültesi Dergisi*, 53(3):1–17.
- Kurowski BG, Wade SL, Kirkwood MW, Brown TM, Stancin T, Cassidy A et al. (2013) Association of parent ratings of executive function with global and setting-specific behavioral impairment after adolescent traumatic brain injury. *Arch Phys Med Rehabil*, 94:543–550.
- Labro H, Al-Kadhimi Z, Djmil M, Oghlakan R, Alsheklee A (2009) Brain amyloidoma with cerebral hemorrhage. *J Am Osteopath Assoc*, 109:372–375.
- Lima CF, Meireles LP, Fonseca R, Castro SL, Garret C (2008) The frontal assessment battery (FDB) in Parkinson's disease and correlations with formal measures of executive functioning. *J Neurol*, 255: 1756–1761.
- Lishman WA (1998) *Organic Psychiatry: The Psychological Consequences of Cerebral Disorder*, 3rd ed. Oxford, Blackwell Science.
- Lyketsos CG, Rosenblatt A, Rabins P (2004) Forgotten frontal lobe syndrome or "executive dysfunction syndrome". *Psychosomatics*, 45:247–255.

- Malloy P, Bihle A, Duffy J, Cimino C (1993) The orbitomedial frontal syndrome. *Arch Clin Neuropsychol*, 8:185-201.
- Margolis EB, Toy B, Himmels P, Morales M, Fields HL (2012) Identification of rat ventral tegmental area GABAergic neurons. *PLoS One*, 7:e42365
- Mesulam M (2000) *Principles of Behavioral Neurology*. 2nd ed. New York, Oxford University Press.
- Mesulam MM (1986) Frontal cortex and behavior. *Ann Neurol*, 19:320–325.
- Metin Ö, Tufan AE, Binici NC, Saraçlı Ö, Atalay A, Tahiroğlu AY (2017) Frontal lob sendromunda yönetici işlevler: bir olgu sunumu. *Türk Psikiyatri Derg*, 28: 135-138.
- Moore DP, Puri BK (2012) *Textbook of Clinical Neuropsychiatry and Behavioral Neuroscience*, 3rd Ed. Roca Raton, CRC Press, Taylor and Francis.
- Mosby (2013) *Mosby's Medical Dictionary*, 9th edition. Oxford, Elsevier Health Sciences.
- Mumoli N, Pulerà F, Vitale J, Camaiti A (2013) Frontal lobe syndrome caused by a giant meningioma presenting as depression and bipolar disorder. *Singapore Medical J*, 54(8):e158–e159.
- Nelson SL (2018) Frontal lobe syndromes. *Medscape eMedicine*, article 1135866.
- Official Gazette (2008) Çalışma Gücü ve Meslekte Kazanma Gücü Kaybı Oranı Tespit İşlemleri Yönetmeliği, 10.11.2018. Ankara, TC Başbakanlık Resmi Gazete.
- Official Gazette (2019) Özürlülük Ölçütü Sınıflandırması ve Özürlülere Verilecek Sağlık Kurulu Raporları Hakkında Yönetmelik 20. Şubat 2019. Ankara, T.C. Cumhurbaşkanlığı Resmi Gazete
- Oral G (2011) Adli tıp ve ruhsal bozukluklar: Adli psikiyatri. In *Adli Tıp Ders Kitabı* (Ed K Sermet):559. İstanbul, İstanbul Üniversitesi Yayınları.
- Osaka M, Osaka N, Kondo H, Morishita M, Fukuyama H, Aso T et al. (2003) The neural basis of individual differences in working memory capacity: an fMRI study. *Neuroimage*, 18:789-797.
- Owen AM, McMillan KM, Laird AR, Bullmore E (2005) N-back working memory paradigm: A meta-analysis of normative functional neuroimaging studies. *Hum Brain Mapp*, 25:46-59.
- Ozan E , Deveci E , Kırpınar İ , Tehli Ö (2010) Olfaktor oluk menenjiyomuna bağlı frontal lob sendromu: Gözden geçirme. *Anadolu Psikiyatri Derg*, 11:279–284.
- Paradiso S, Chmerinski E, Yazici KM, Tartaro A, Robinson RG (1999) Frontal lobe syndrome reassessed: comparison of patients with lateral or medial frontal brain damage. *J Neurol Neurosurg Psychiatry*, 67:664–667.
- Passingham RE, Wise SP (2012) *The neurobiology of the prefrontal cortex: anatomy, evolution, and the origin of insight*. Oxford, Oxford University Press.
- Pistillo F, Clementi F, Zoli M, Gotti C (2015) Nicotinic, glutamatergic and dopaminergic synaptic transmission and plasticity in the mesocorticolimbic system: Focus on nicotine effects. *Prog Neurobiol*, 124:1-27
- Potter H, Butters N (1980) An assessment of olfactory deficits in patients with damage to prefrontal cortex. *Neuropsychologia*, 16: 621–628.
- Reber J, Tranel D (2019). Frontal lobe syndromes. In *Handbook of Clinical Neurology*, Vol. 163 3rd series. (Eds MD'Esposito, JH Grafman):147-164. Oxford, Elsevier.
- Rodriguez Merzagora AC, Izzetoglu M, Onaral B, Schultheis MT (2014) Verbal working memory impairments following traumatic brain injury: an fNIRS investigation. *Brain Imaging Behav*, 8:446-459.
- Rolls ET, Hornak J, Wade D, McGrath J (1994) Emotion-related learning in patients with social and emotional changes associated with frontal-lobe damage. *J Neurol Neurosurg Psychiatry*, 57:1518-1524
- Rommel O, Widdig W, Mehrtens S, Tegenthoff M, Malin JP (1999) Frontal lobe syndrome' caused by severe head trauma or cerebrovascular diseases. *Der Nervenarzt*, 70:530–538.
- Şahpolat M, An M, Kocaçaya MH, Çöpoğlu ÜS (2014) Ödül eksikliği sendromu. *Bağımlılık Dergisi*, 15:85-90.
- Sebit MB, Acuda W, Chibanda D (1996) A case of the frontal lobe syndrome following head injury in Harare, Zimbabwe. *Cent Afr J Med*, 42:51-53.
- Severs M, Boelens HM, Diraoui SB, Schuur J (2012) Chorea and a frontal lobe syndrome: A rare neurological presentation of polycythemia vera; a case report. *J Am Geriatr Soc*, 60:589–590.
- Simons JS, Spiers HJ (2003) Prefrontal and medial temporal lobe interactions in long-term memory. *Nature Rev Neurosci*, 4:637-648

- Spitzer P, Kohl Z, Golitz P, Coras R, Blumcke I, Bruck W et al. (2014) Biochemical markers of neurodegeneration in hereditary diffuse leucoencephalopathy with spheroids. *BMJ Case Rep*, 2014:bcr2012008510.
- Stuss DT, Benson DF (1983) Frontal Lobe Lesion and Behavior. In *Localization in Neuropsychology* (Ed. A Kertesz.):429-454. New York, Academic Press.
- Sugden SG, Kile SJ, Farrimond DD, Hilty DM, Bourgeois JA (2006) Pharmacological intervention for cognitive deficits and aggression in frontal lobe injury. *NeuroRehabilitation*, 21:3–7.
- Suhara T, Yasuno F, Sudo Y, Yamamoto M, Inoue M, Okubo Y et al. (2001) Dopamine D2 receptors in the insular cortex and the personality trait of novelty seeking. *Neuroimage*, 13: 891-895.
- Tanabe T, Yarita H, Iino M, Ooshim Y, Takagi SF (1975) An olfactory projection area in orbitofrontal cortex of the monkey. *J. Neurophysiol*, 38:1269–1283.
- Tosun DG, Eşsizöğlü A, Köşger F, Güleç G (2016) Frontal lob sendromu ayırıcı tanısı: Vaka sunumu. *Journal of Mood Disorders*, 6:74-78.
- Tunçay N (2009) FAB (Frontal Assessment Battery) Testinin Türk toplumunda geçerlilik ve güvenilirliği. (Uzmanlık tezi) İzmir, Dokuz Eylül Üniversitesi.
- Türe M, Kurt İ, Aktürk Z (2006) Relationship of cigarette and alcohol consumption of medicine students with Frontal Lobe Personality Scale. *Balkan Med J*, 1:19-27.
- Türkoğlu S, Çetin FH, Tanır Y, Karatoprak S (2019) Çalışma belleği ve nörogerişimsel hastalıklar. *Çocuk ve Gençlik Ruh Sağlığı Dergisi*, 26:52-62.
- Turner BH, Gupta KC, Mishkin M (1978) The locus and cytoarchitecture of the projection areas of the olfactory bulb in Macaca Mulatta. *J Comp Neurol*, 177:381–396.
- Verplaetse J (2009) *Localizing the Moral Sense: Neuroscience and the Search for the Cerebral Seat of Morality, 1800-1930*. Heidelberg, Springer.
- Volkow ND, Wang GJ, Tomasi D, Baler RD (2013) Obesity and addiction: neurobiological overlaps. *Obes Rev*, 14:2-18.
- Weidmayer S (2015) Frontal mucocele with intracranial extension causing frontal lobe syndrome. *Optom Vis Sci*, 92:138-142.
- WHO (2016) *International Statistical Classification of Diseases and Related Health Problems 10th version (ICD-10)*. Geneva, World Health Organisation.
- Yener GG (2002) Beyin-sinir ağları ve ilişkili klinik özellikler. *Klinik Psikiyatri Dergisi*, 5:135-138
- Zeman W, King FA (1958). Tumors of septum pellucidum and adjacent structures with abnormal affective behavior: An anterior midline structure syndrome. *J Nerv Ment Dis*, 127: 490–502.

**Authors Contributions:** All authors attest that each author has made an important scientific contribution to the study and has assisted with the drafting or revising of the manuscript.

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** No conflict of interest was declared by the authors.

**Financial Disclosure:** The authors declared that this study has received no financial support.