

Left hand mirror writing with right alien hand syndrome in a patient following an infarct near the right genu of the corpus callosum

Mirror writing is a rare phenomenon found in few pathologic conditions, such as in children with mental impairments, focal brain lesions following stroke, and diffuse progressive brain diseases such as dementia.¹ According to Macdonald Critchley, the incidence of mirror writing in stroke patients was 36.20% (21 of 58 patients).² However, this high incidence was contradicted by Paradowski and Ginzburg who reported that only 2.44% of patients (1 of 41 patients) had shown mirror writing symptoms following stroke.³ Since mirror writing is an uncommon symptom, the specific brain areas involved and the underlying pathological mechanisms are not fully understood. We were presented with a stroke patient showing clinical manifestations of mirror writing with the left hand and right alien hand syndrome following multiple cerebral infarctions. The characteristics of the mirror writing are best explained by a combination of the previously described “motor” and “visual-dominance” hypotheses for mirror handwriting.

A previously healthy 71-year-old male consulted a neurologist for abnormal movements of the right hand 23 days after having undergone lumbar disc surgery. He complained that when he touched the left side of his body with the right hand, he was unable to remove his right hand easily, as if it was stuck. However, this did not occur when he touched the right side of his body with the left hand. When instructed to write “Masan Medical Center”, he accurately wrote the sequence with his right hand, but the words were written in reverse (left to right) with his left hand (Figure 1). Apart from

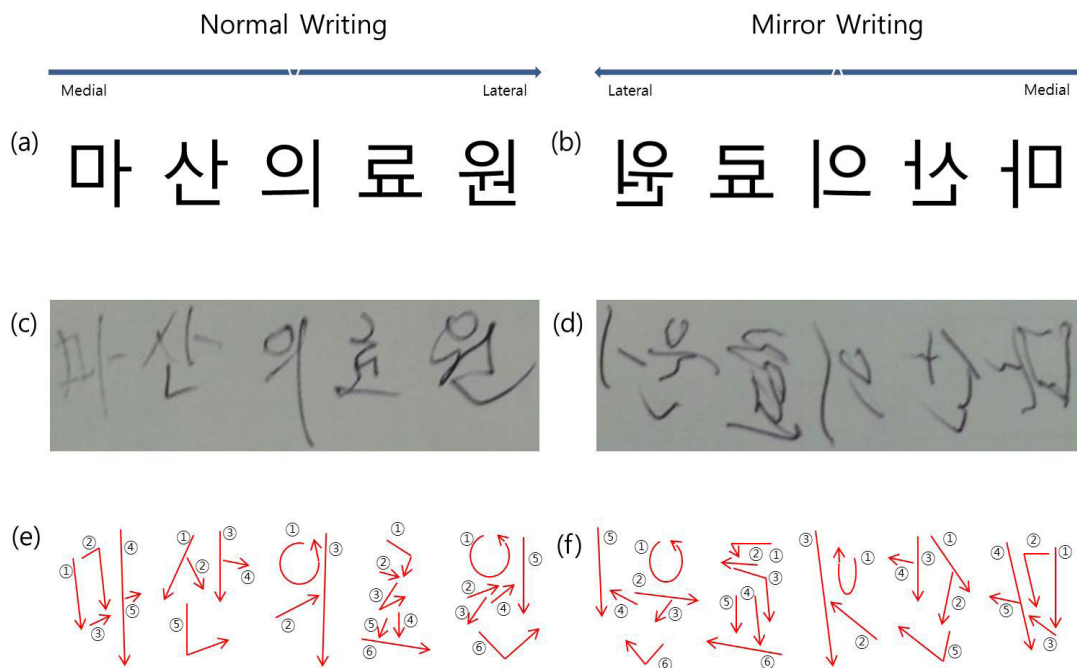


Figure 1: A 71-year-old male patient writing “Masan Medical Center” in the Korean language with both hands. The word “마산” stands for the city name (Masan), and “의료원” stands for “Medical Center”. (a) Normal Korean writing for “Masan Medical Center”. (b) Right-to-left reversed direction of “Masan Medical Center” in Korean. (c) Patient’s writing “Masan Medical Center” in the Korean language with his right hand. (d) Patient’s writing “Masan Medical Center” with his left hand. Note that the word is reversed from right-to-left. (e) Writing direction and writing sequence with the patient’s right hand. This corresponds to a normal Korean writing direction and sequence. (f) Writing with the left hand where the writing direction is reversed. Writing sequence of 1st to the 3rd letter is also reversed. However, the writing sequence of 4th and 5th letters is neither reversed nor normal.

the right alien hand syndrome and the left-hand mirror writing, all other neurological examinations and laboratory tests were within normal limits. A brain MRI was performed one day after symptom onset; multiple cerebral infarctions were identified in the right genu, left insular, left splenium, and right parieto-temporal areas (Figure 2). The patient was treated with aspirin and cilostazol. Three days later, the patient's alien hand symptoms resolved. The mirror writing with the left hand subsided one week after consultation. We received consent for publication of this report from patient and caregivers.

Our patient presented with clinical manifestations of mirror writing involving his left hand (Figure 1) and with symptoms in his right hand consistent with alien hand syndrome. Brain MRI revealed multiple cerebral infarctions in the right genu (which extended into the medial frontal lobe), left insula, left splenium, and right parieto-temporal areas (Figure 2).

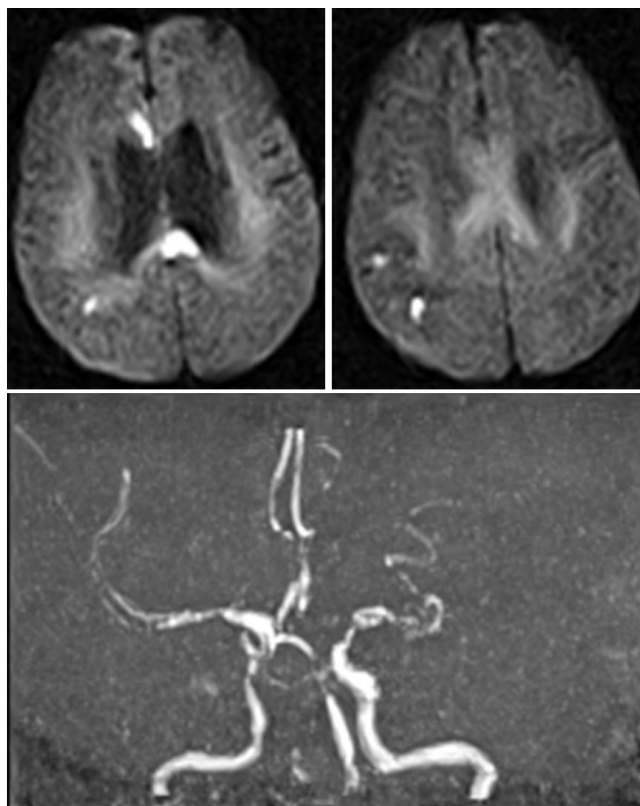


Figure 2: MRI and MRA findings of the 71-year-old male patient. Multiple infarction lesions are observed in the right genu, left insular, left splenium, and right parieto-temporal areas. Multiple moderate to severe stenosis are observed at both MCA and right ACA segments.

Most previous reports of left-hand mirror writing in stroke patients presented with associated symptoms of right hemiparesis/hemiplegia.¹ Previous brain imaging reports of patients presenting with mirror writing suggest that damage anywhere along the writing pathway has potential for inducing mirror writing (Table 1).⁴⁻⁸ Only one previous study reported a stroke patient presenting with mirror writing and alien hand syndrome (both in the left hand).⁷ The combined lesions to the corpus callosum and the left medial frontal lobe lesion were thought to be responsible for both sets of symptoms. Our patient also had a cerebral infarction near the corpus callosum (genu) area, and the lesion extended into the right medial frontal lobe; although there were multiple lesions in other brain areas as well. Nonetheless, we believe the brain insult near the genu to likely be responsible for our patient's mirror writing and alien hand syndrome.

Various hypotheses have been proposed to explain the underlying mechanism of the mirror writing phenomenon. For instance, the "motor hypothesis" states that the writing process is natural when the direction of the hand movement is toward the outside of the body (abduction movement).^{5,9} Chan

Table 1: Description of brain lesions and associated mirror writing symptoms in stroke patients from previous case reports

Age / Sex	Brain Lesion	Duration of Mirror Writing	Associative Symptom	Journal, Year	Author
57 / M	Left Basal Ganglia ICH	2 years	Right hemiplegia	J Neurol Neurosurg Psychiatry, 1987	Chia <i>et al.</i> ⁴
59 / M	Right ACA territory infarction (sparing corpus callosum)	8 months	Right hemiparesis	Neurology, 1988	Chan <i>et al.</i> ⁵
43 / F	Right Putamen ICH	44 days	Left hemiparesis	J Korean Neurol Assoc, 1989	Kim <i>et al.</i> ⁶
45 / M	Right Frontal ICH	2 days	Headache	J Korean Neurol Assoc, 1989	Kim <i>et al.</i> ⁶
43 / M	Left ACA territory infarction (involving corpus callosum and left medial frontal lobe)	5 years	Left Alien Hand Syndrome	Surg Neurol, 1991	Hanakita <i>et al.</i> ⁷
65 / M	Left temporo-parietal infarction	2-4 months	Right hemiplegia	J Korean Neurol Assoc, 2004	Roh <i>et al.</i> ⁸

and Ross described the motor hypothesis for mirror writing as follows: “For instance, with the right hand one may draw a ‘J’ by first moving the pen laterally, vertically down, then medially. If the same untransformed motor program is used to innervate the muscles guiding the left hand, producing a movement sequence of lateral down, and medial a mirror figure ‘[‘ will be drawn.”⁵ Another hypothesis is the “visual-dominance hypothesis”.^{5,9} Through experiments of chiasm-sectioned monkeys, Orton hypothesized that visual images from each eye are stored in each hemisphere in mirror form.¹ However, Corballies and Beale later corrected this by demonstrating that the left (dominant) hemisphere stores images from both eyes in their correct form, whereas the right (non-dominant) hemisphere stores them in a left-right reverse direction.¹ Under the visual-dominance theory, when writing with the left hand, the dominant image is transferred to the premotor cortex of the contralateral hemisphere through the corpus callosum.⁵ When this pathway is damaged, mirror writing can occur with the left hand because the premotor cortex now receives information from the non-dominant hemisphere where images are stored in reverse.

The analysis of our patient’s writing did not allow us to conclude that either of these hypotheses by themselves could explain the writing pattern. Thus, we believe that both mechanisms are likely at play. For instance, Figure 1 (panels a, c, and e) show the patterns when writing ‘Masan Medical Center’ with the right hand, which corresponds to a regular Korean writing sequence. However, Figure 1 (panels b, d, and f) show mirror writing with the left hand. The motor hypothesis is applicable for what is observed in the first three letters (right to left direction) because the sequence of writing is exactly reversed compared with normal Korean writing. If the visual engram was the main reason for the mirror writing, the writing sequence would not be reversed. However, the motor hypothesis cannot be applied to the fourth and fifth letters because the writing sequence is not reversed; rather, it appears similar to the drawing of a complex image that would be best explained by drawing a reversed visual image from the non-dominant hemisphere, thus providing support for the visual-dominance hypothesis.

In conclusion, we present a stroke patient displaying clinical manifestations of left-hand mirror writing and right alien hand syndrome following multiple cerebral infarctions. The lesions to the right corpus callosum (genu) area, which extended into the right medial frontal lobe, are likely the cause of the symptoms. The exact manifestation of the mirror writing is best explained by elements from both the motor hypothesis and the visual dominance hypothesis for mirror hand writing.

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