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CASE REPORT

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Virtual reality: a game-changer in the diagnosis and surgical planning of astrocytoma grade III: a case report

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Abstract

Background In the dynamic realm of modern medicine, the advent of virtual reality technology heralds a transformative era, reshaping the contours of diagnosis and surgical planning with its immersive prowess. This study delves into the groundbreaking application of virtual reality in the intricate dance of neurosurgery, particularly spotlighting its role in the management of astrocytoma grade III—a cerebral challenge of significant complexity.

Case presentation A 30-year-old Middle Eastern man from Syria grappled with the invisible tendrils of pain, manifesting as persistent headaches and a numbing sensation that crept into his neck and extremities. For two relentless months, the morning sun brought not hope but an intensification of his agony, rendering him unable to partake in the daily dance of life. The usual sentinels of relief, analgesic drugs, stood defeated, offering no respite. The neurological examination was normal, there were no pathological findings on sensory and motor examination, and he exhibited normal reflexes and neither meningeal nor cerebellar signs. He showed a family history of breast cancer. The initial foray into the enigmatic depths of his brain via computed tomography and magnetic resonance imaging imaging unveiled a finding in the right temporal lobe, a lesion that suggested something more sinister. Previous medical interventions included analgesic medications prescribed for persistent headaches, but they offered no relief. No other therapeutic interventions were administered prior to the current diagnosis. It was here that virtual reality technology emerged not as a mere tool but as a beacon of precision, casting a three-dimensional light on the shadowy intruder. This technological marvel allowed for meticulous measurement 21.8 × 14.5 mm and localization within the temporal theater, setting the stage for what was to come. With the path laid clear, the patient embarked on a surgical odyssey, a quest to excise the unwelcome guest. The operation was a triumph, a testament to human ingenuity and the symbiotic relationship between flesh and machine. The postoperative verdict was delivered through the lens of histopathology, confirming the presence of an astrocytoma grade III, a cerebral interloper known for its rapid proliferation. The battle, however, was far from over. Complementary radiotherapy and chemotherapy were enlisted as allies in this ongoing war, their potent forces working in concert to stave off the cellular insurgence. The patient's journey through the healing arts was charted by periodic clinical and neurological examinations, with laboratory tests and the vigilant gaze of brain magnetic resonance imaging ensuring a watchful eye was kept on any potential resurgence.

Conclusions In this narrative of resilience and technological prowess, we witness the harmonious fusion of human touch and digital precision, a partnership that redefines the boundaries of medicine and the art of healing, by use

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of virtual reality technology in the diagnosis of astrocytoma and enhancing the accuracy, effectiveness, and safety of neurosurgical procedures, which can ultimately benefit patients with brain tumors.

Keywords Case report, Temporal lobe, Neuro-oncology, Neurosurgery, Astrocytoma, Virtual reality

Introduction

Astrocytoma, the insurgent of the brain, defies the conventional boundaries of medical intervention. It is within this intricate labyrinth that virtual reality (VR) emerges as a beacon of precision, guiding the surgeon's hand through the neural tapestry with unparalleled clarity [1]. Recent scholarly pursuits have illuminated the efficacy of VR in enhancing diagnostic accuracy, offering surgeons a three-dimensional (3D) odyssey into the very heart of the tumor [2, 4]. This virtual voyage not only demystifies the path ahead but also carves out a safer trajectory for therapeutic conquests, ultimately elevating patient outcomes to new zeniths (Fig. 1).

Our case report is a testament to this technological marvel, weaving together a narrative of innovation, determination, and hope. It underscores the symbiotic synergy between human intellect and technological advance, charting a course through the cerebral seas with VR as our compass.

As we navigate the complexities of astrocytoma grade III, we invite readers to embark on this journey with us, exploring the potential of VR to not just illuminate the present but also to sculpt a future where the once insurmountable is now within our grasp [3].

Case presentation

A 30-year-old Middle Eastern man from Syria, who is a nonsmoker, has been experiencing persistent headaches accompanied by numbness in the neck and extremities for the past 2 months. The headaches are particularly severe in the morning and significantly impair his ability to perform daily activities. Despite taking analgesic medication, there has been no relief of symptoms.

He reports an unintentional weight loss of about 5 kg (11 lbs) over the month preceding his hospital visit. Neurological examination revealed no abnormalities.

Medical history

The patient has a history of bilateral varicocele diagnosed in 2016, and a surgical history of nasal septum deviation correction performed in 2014.

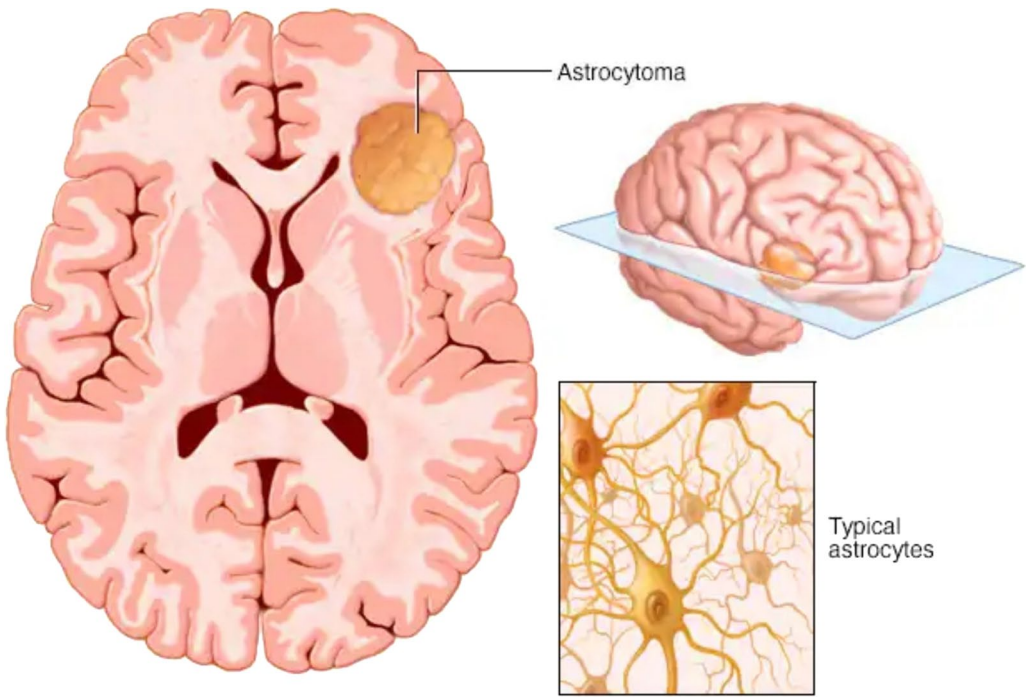

Fig. 1 Illustration of an intracranial astrocytoma—Mayo Clinic

Family history

There is a notable family history of breast cancer and type II diabetes mellitus (DMII).

Social and occupational history

The patient works in construction and real-estate offices. He leads an active lifestyle but has been significantly impaired by his symptoms over the past 2 months.

Timeline: a 30-year-old man with grade III astrocytoma

The complete timeline of the patient is illustrated in Fig. 2.

Diagnostic assessment

The diagnostic journey of gliomas typically commences with a neurological examination, and ophthalmology consultation followed by imaging studies.

Ophthalmology consultation for the patient

- Examination of visual acuity was within normal in the eyes.
- Retinal examination showed no bilateral papilledema.

Diagnostic methods

Magnetic resonance imaging (MRI) and computed tomography (CT) scans were used to evaluate the patient's condition. Additionally, virtual reality (VR) technology was employed to visualize the tumor and plan the surgery.

Challenges

We faced financial challenges related to the cost of advanced imaging techniques, as well as linguistic and cultural challenges in communicating with the patient and his family.

Prognostic characteristics

The tumor's stage and characteristics were assessed using established criteria, and it was determined to be an astrocytoma grade III.

A noncontrast computed tomography (CT) scan was performed (Fig. 3) that revealed a hypodense area within the brain's parenchyma, prompting further investigation with MRI [4–6].

The MRI sequences in Figs. 4, 5, 6, 7) provide a more detailed landscape of the tumor.

T1-weighted images without contrast (Fig. 4) might show a low-intensity area, while T2-weighted and Fluid-Attenuated Inversion Recovery (FLAIR) sequences (Figs. 5, 6) light up the lesion with high intensity [7]. The absence of contrast uptake on post-contrast T1 images (Fig. 7) often signifies a nonenhancing tumor, which can be characteristic of lower-grade gliomas [4].

In our landmark case, VR technology was employed to visualize a lesion within the right temporal lobe. The 3D rendering provided by the VR environment (Fig. 8; recorded videos 1 and 2), which allowed for precise measurements (21.8×14.5 mm) and localization (right temporal lobe), were instrumental to the successful resection of the tumor [5].

The postoperative diagnosis of a grade III astrocytoma was confirmed histopathologically.

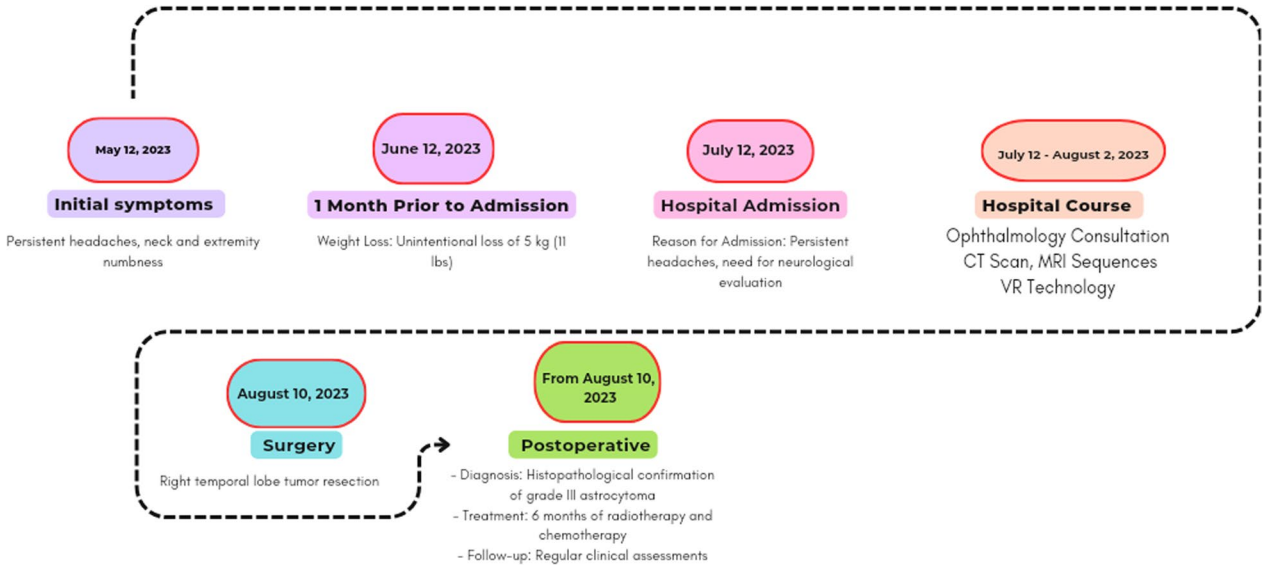

Fig. 2 Complete timeline of the patient

Fig. 3 A noncontrast head computed tomography (CT) scan revealing a small hypodense area in the right temporal lobe. The hypodensity point is indicated with an arrow, indicating the location of the astrocytoma

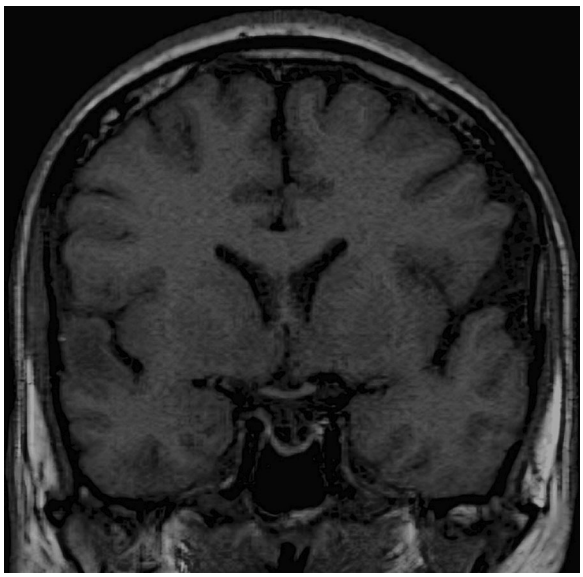

Fig. 4 Magnetic resonance imaging (MRI) scan revealing T1-weighted images without contrast, indicating a small, low-intensity area in the right temporal region

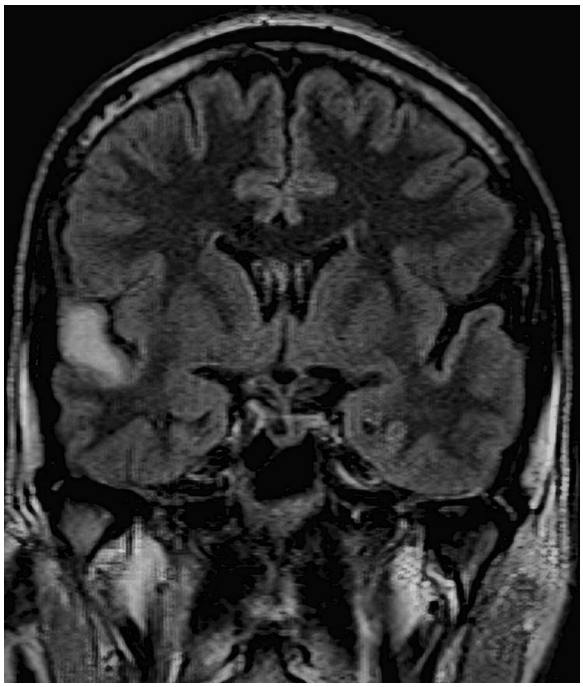

Fig. 5 Magnetic resonance imaging (MRI) T2-weighted imaging of the brain revealing a small high-intensity lesion in the right temporal lobe

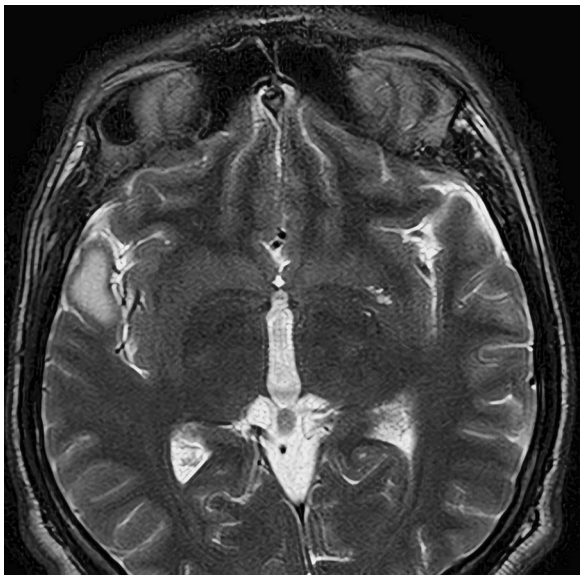

Fig. 6 Magnetic resonance imaging (MRI) T2-weighted imaging of the brain revealing no uptake of contrast

An astrocytoma grade III is a malignant brain tumor characterized by its rapid proliferation.

Postoperative care, including radiotherapy and chemotherapy for 6 months, was guided by periodic

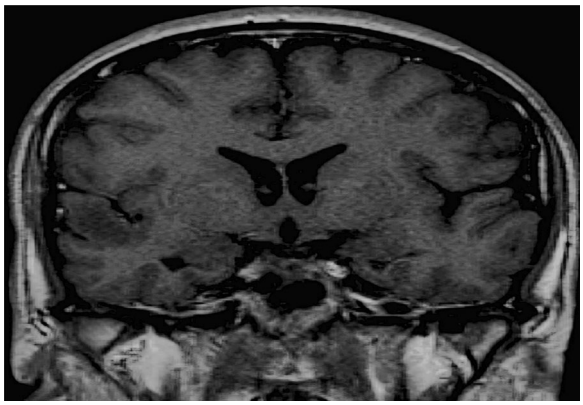

Fig. 7 Magnetic resonance imaging (MRI) T1-weighted image of the brain post-contrast revealing a small high-intensity lesion in the right temporal lobe

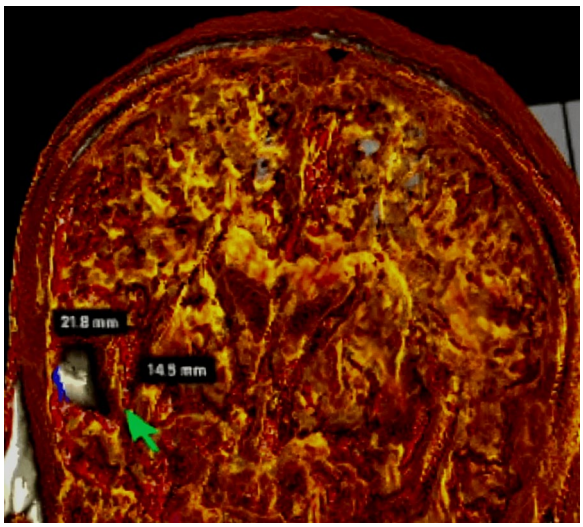

Fig. 8 Using a virtual reality (VR) environment allowed for precise localization of a 21.8 × 14.5 mm mass in the right temporal lobe. The green arrow indicates the precise location and size of the tumor as measured using VR technology

clinical assessments and follow-up MRI scans, ensuring a comprehensive treatment strategy [4].

Treatment

The patient received postoperative care that included radiotherapy and chemotherapy for approximately 6 months. Treatment was guided by periodic clinical assessments and follow-up MRI scans, ensuring a comprehensive treatment strategy [4–6].

Current clinical status

The patient currently maintains a stable clinical condition with complete resolution of symptoms. Neurological

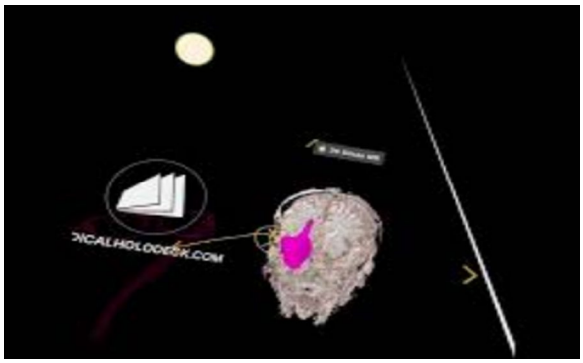

Fig. 9 We acknowledge that detecting a tumor can be a frightening and overwhelming experience. At our hospital, we have a video that can help demonstrate how virtual reality can be used to detect tumors in our case study patients. We hope that this resource can provide some peace of mind and comfort during this challenging time. View video here: https://youtu.be/mJUgLRp_Uwg?si=wb_cFG2odO-Gk_MI

Fig. 10 The recorded video provides a detailed guide on how to navigate a virtual reality environment to detect a tumor in a patient. The tutorial is based on the findings of our comprehensive case report and offers a step-by-step demonstration of the process. View video here: https://youtu.be/ItcOgOuq57o?si=-H6VokQAMLhGGVLD

examination is unremarkable, and there are no focal neurological signs. Regular follow-up is maintained, and the patient undergoes frequent clinic visits to monitor for any signs or symptoms of tumor recurrence (Figs. 9, 10).

Follow-up visits

The patient's condition was monitored over several months through periodic clinical and neurological examinations, laboratory tests, and regular MRI scans to ensure there was no tumor recurrence.

Discussion

Gliomas, the insidious inhabitants of the brain's glial cells, account for a significant portion of brain tumors. These neoplasms, often interwoven with the brain's normal parenchyma, present a formidable challenge in neuro-oncology [4].

Among them, astrocytoma stands out as the most common primary intraaxial brain tumor, with their spectrum ranging from the benign pilocytic astrocytoma in children to the dreaded glioblastoma multiform in adults [5].

Virtual reality (VR) has transcended its origins from Morton Heilig's Sensorama and Ivan Sutherland's head-mounted display to become a pivotal tool in modern medicine. In neurosurgery, VR's immersive capabilities allow for the meticulous preoperative planning and rehearsal of complex procedures. The Medicalholodeck program, for instance, enables surgeons to visualize and interact with patient-specific 3D models, derived from actual patient scans, facilitating a deeper understanding of the tumor's spatial relationships and surgical approach [4].

In our pioneering case, VR technology was used to visualize a grade III astrocytoma in the right temporal lobe. The 3D VR rendering allowed for precise tumor measurements and localization, crucial for its successful surgical removal [5].

The potential of VR in neurosurgery is vast, yet it is not without its challenges. The cost of implementation, the need for quality enhancement, data security concerns, and the potential for adverse health effects are significant barriers to its widespread adoption [8, 9]. Moreover, the rapid pace of technological advancement demands continuous education and adaptation among medical professionals.

In the discussion of integrating virtual reality (VR) in the medical landscape of Arab countries, we encounter a multifaceted array of challenges that must be navigated with both precision and cultural sensitivity. The scarcity of infrastructure—including the essential technological backbone of internet connectivity, electricity, and VR-specific hardware—poses a significant barrier to the adoption of VR in medical practice [8]. This is compounded by the absence of robust legislation that would delineate the rights and responsibilities of all stakeholders, from healthcare providers to patients and technology vendors.

Moreover, the paucity of research tailored to the Arab context limits our understanding of VR's potential impact on patient care, necessitating a concerted effort to foster studies that illuminate the benefits and implications of VR in medicine. This gap in knowledge is further exacerbated by a lack of collaborative initiatives that would bridge the divide between academia, industry, and governance, essential for nurturing an ecosystem conducive to VR's growth [10].

Resistance to change is a human trait, and in the Arab medical community, this manifests as hesitancy toward VR adoption. Overcoming this requires building trust through education, demonstrating efficacy and ensuring cultural congruence in VR applications [8].

Comparison between traditional and VR approaches

Traditional imaging techniques such as MRI and CT scans can be limited in some cases owing to the inability to accurately visualize the precise relationships between the tumor and surrounding structures. However, VR provides a precise 3D visualization, facilitating surgical planning and reducing potential complications. Studies show that the use of VR can improve the accuracy and safety of surgery by enabling surgeons to plan meticulously and better visualize complex tissue relationships.

Addressing the delay in diagnosis, particularly in pediatric brain tumor cases, is paramount. The study "Factors associated with delayed diagnosis among Filipino pediatric brain tumor patients: a retrospective review" sheds light on the myriad factors contributing to diagnostic delays [11]. Incorporating VR into diagnostic protocols could serve as a catalyst for earlier detection and intervention, potentially improving prognosis and survival rates [7].

Early diagnosis using virtual reality

The study "Factors associated with delayed diagnosis among Filipino pediatric brain tumor patients: a retrospective review" highlights various factors contributing to diagnostic delays. Integrating VR into diagnostic protocols could serve as a catalyst for earlier detection and intervention, potentially improving prognosis and survival rates. In our case, the use of VR helped precisely locate the tumor and effectively plan the surgery, leading to improved therapeutic outcomes.

In essence, the integration of VR in neuro-oncology within Arab countries is not merely a technological upgrade but a complex interplay of infrastructure, legislation, research, collaboration, and cultural adaptation. It is a journey that, if embarked upon thoughtfully, could redefine the horizons of patient care and medical education in the region.

The case of the grade III astrocytoma underscores the transformative power of VR, suggesting a future where virtual simulations and reality coalesce to elevate the standards of healthcare delivery [12].

Conclusions

The integration of VR in neuro-oncology represents a paradigm shift in the diagnosis, planning, and execution of neurosurgical interventions. As we navigate the complexities of this technology, it is crucial to address the challenges it presents to unlock its full potential in enhancing patient outcomes in the realm of neurosurgery.

The case of the grade III astrocytoma serves as a testament to the transformative impact of VR, heralding a new era in medical practice where virtual and reality converge for the improvement of patient care.

Abbreviations

VR Virtual reality
3D Three-Dimensional
MRI Magnetic Resonance Imaging
CT Computed Tomography

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Author contributions
All authors contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the manuscript, and revising it critically for important intellectual content. All authors have read and approved the final manuscript.

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Availability of data and materials
All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
The Ethics Committee of Medical Military Services/ Tishreen Military Hospital approved the protocol used for this study.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests
The authors declare that they have no competing interests.

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