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GRAND ROUNDS

Management of a high thoracic chance fracture

Anouar Bourghli[1] · Ibrahim Obeid[2] · Louis Boissiere[2] · Jean-Marc Vital[2] · Zafer Tabboush[1] · Mohammed Al Sarawan[1]

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Abstract

Purpose Chance fracture of the high thoracic spine is rare, and its impact on the adjacent cervical spine can be important.
Methods We present the case of a 16-year-old male, who fell down from a 2 m height, in an unknown context as he has a mental retardation, and no witness saw the accident. Initial CT scan revealed a comminuted depressed fracture of the right parietal bone, associated with a chance fracture at the level of T3 with a kyphosis and bilateral lung contusion.
Results The patient underwent neurosurgical treatment for elevation and reconstruction of the parietal fracture; he also underwent, 2 days later, a posterior spinal correction and fusion with T1-to-T5 instrumentation. The patient returned to normal walking on day 7 with a satisfactory clinical and radiological result at 1 year.
Conclusion Literature is sparse on the treatment of high thoracic chance fractures. The current case shows that early surgical management should prevent a secondary kyphotic deformity that may need a more aggressive treatment at a later stage.

Keywords Chance fracture · High thoracic · Kyphosis · Sagittal alignment · Posterior approach

Case presentation

A 16-year-old male fell down from a 2 m height, in an unknown context as he has a mental retardation, and no witness saw the falling episode. The initial medical assessment made by the emergency team found a man with an altered conscious level and a Glasgow Coma Scale of 9/15 associated with a severe upper thoracic pain with hemiparesis of the left side. No other injuries were noted. The patient was transported immediately to the hospital for further evaluation and investigations. Upon arrival to the emergency room, the patient's conscious level improved and he was alert and oriented, but motor exam revealed a partial deficit of the left upper and lower extremities of 4/5 with paresthesia. A full body CT scan was performed and revealed a depressed fracture of the right parietal bone with an extradural hematoma, associated with a chance fracture of T3 with secondary kyphosis. The patient was taken to the operating room for elevation and reconstruction of the skull fracture by the neurosurgeon. After 48 h of his admission, while still intubated in the Intensive Care Unit,

✉ Anouar Bourghli
anouar.bourghli@gmail.com

[1] Orthopedic and Spinal Surgery Department, Kingdom Hospital, P.O.Box 84400, Riyadh 11671, Saudi Arabia

[2] Orthopedic Spinal Surgery Unit 1, Bordeaux Pellegrin Hospital, Bordeaux, France

he underwent posterior spinal correction and fusion with T1-to-T5 instrumentation.

Diagnostic imaging section

CT scan revealed a comminuted depressed fracture of the right parietal bone with extradural hematoma, associated with a chance fracture at the level of T3 with a kyphosis and bilateral upper lung contusion. In addition, a non-displaced proximal sternal fracture was noted. T1-to-T3 spinous processes were all fractured, and the main fracture line in T3 was running from posterior to anterior splitting the lamina, pedicles, and transverse processes bilaterally and axially through the vertebral body with wedging of the anterior wall (Figs. 1, 2, 3), creating a significant posterior bony gap, with a secondary cervicothoracic kyphosis of 40°. A compensatory hyperlordosis of the cervical spine was observed on the CT scan (Fig. 4). No posterior wall displacement or bony fragment in the spinal canal could be seen at T3 level.

Historical review, epidemiology, diagnosis, pathology, and differential diagnosis

"Chance" fracture was first described in 1948 by George Quentin Chance [1], and he noted that such a fracture was associated with extreme flexion causing a "horizontal splitting" of the vertebral body and neural arch. According to the AOSpine thoracolumbar spine injury classification system [2], and similar to the Magerl system [3], this fracture is a type B1 (osseous failure of the posterior tension band). Flexion-distraction forces generated by hyperflexion of the spine over a fulcrum are responsible for the chance fracture; thus, it is usually associated with motor vehicle accidents with patient wearing lap seat belts [4, 5], but it can also be the result of a fall from a height [6]. In

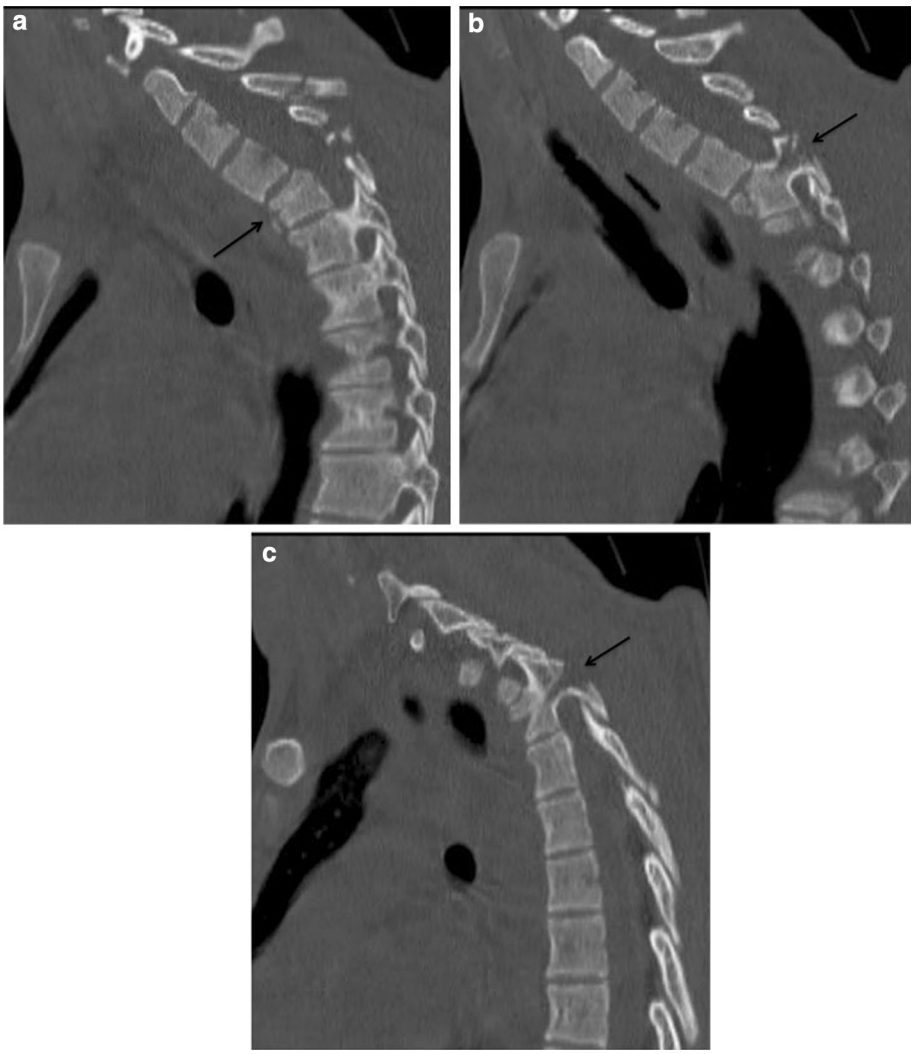

Fig. 1 CT scan sagittal view showing the chance fracture line through T3 (**a** *black arrow*) with secondary kyphosis and the pedicle split on the *right* and *left* sides (**b** and **c** respectively, *black arrows*)

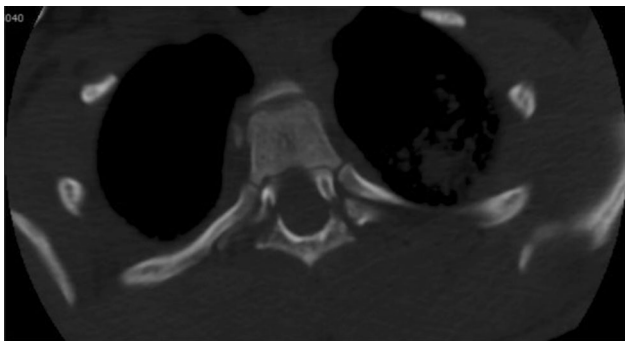

Fig. 2 CT axial view showing the chance fracture lines

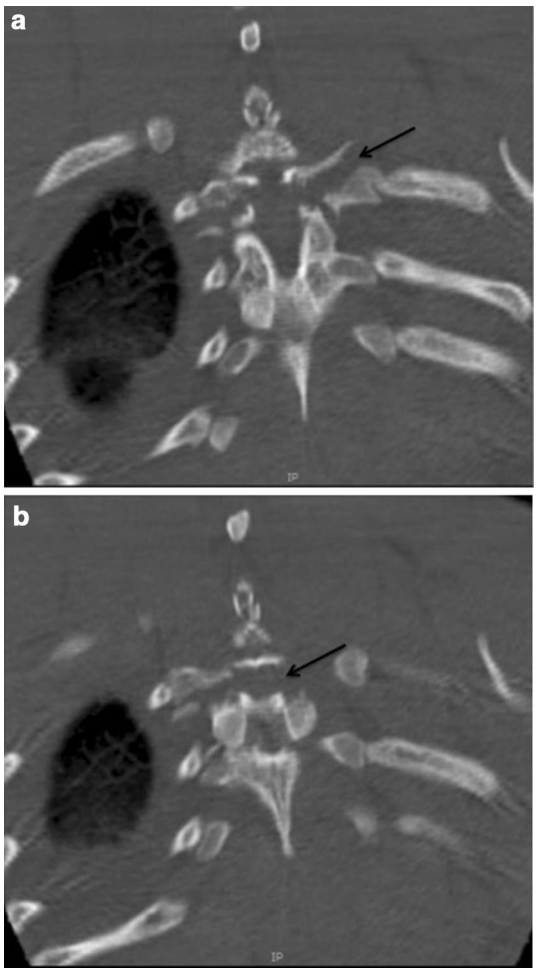

Fig. 3 CT coronal reconstruction showing the split of the pedicles and transverse processes (**a** *black arrow*) and the lamina (**b** *black arrow*)

fact, the brutal deceleration that occurs in an automobile crash or a fall when the person hit the ground leads to a hyperflexion mechanism, creating a posterior distraction with tension stress on all spinal components, resulting in the disruption of either the soft tissues (ligaments, discs), or the bone (chance fracture), or both. Therefore, the aforementioned horizontal splitting propagates from the posterior spinal elements (spinous process, lamina, and pedicles) to the anterior vertebral body, with no lateral displacement or rotation of the fracture.

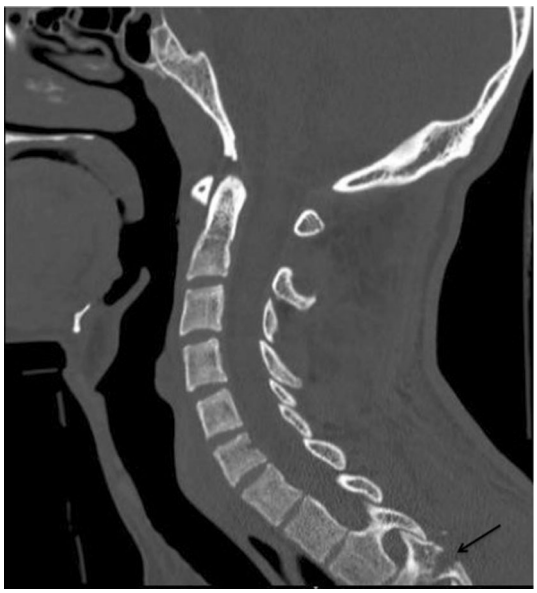

Fig. 4 Sagittal cervical CT scan showing compensatory hyperlordosis above the fracture site (*black arrow*)

Rarely chance fracture can be a complication of pedicle screw instrumentation proximally [7] leading to proximal junctional kyphosis or distally [8] leading to distal junctional kyphosis, in long constructs for spinal deformities.

It was also reported in extreme sports like rodeo [9] or snowboarding [10] and in military activities during attacks on armored vehicles with the use of explosives [11]. Hyperflexion was described as the main mechanism of injury for the aforementioned etiologies.

Usually, chance fractures are located in the thoracolumbar junction (T10–L2), rarely in the upper thoracic spine [12, 13].

Diagnosis can be done on good quality radiographs in two planes (anteroposterior and lateral). CT scan confirms the nature of the lesion [14], and it demonstrates a horizontal fracture completely traversing the posterior elements and the vertebral body with distraction at the fracture site making the superior facets separated from the inferior facets through the pars interarticularis, creating a gap through the fractured elements. MRI may show, if soft tissues are injured, disruption of the interspinous ligament, stripping of the posterior longitudinal ligament, disc injury, or spinal cord edema. Associated intra-abdominal or intra-thoracic injuries are frequent, and a sternal fracture represents an additional sign of instability.

Rationale for treatment

As soon as the fracture pattern is recognized, management will mainly depend on the fracture displacement. If the transverse bony lesion is displaced with important gap, surgical treatment is indicated. Only non-displaced bony lesion can be treated conservatively with a rigid brace or hyperextension cast for 12 weeks. If the fracture anatomy is not a pure osseous chance fracture, revealing a disruption of the posterior ligamentous complex, brace treatment should be avoided as the soft-tissue injuries will not heal, and instability will remain without surgical stabilization.

Posterior approach is recommended for the reconstruction of the posterior tension band. Realignment of the spine, anatomical reduction, and stabilization are the goals of the surgical treatment. Surgery can be done through a classical open approach [15] or through a percutaneous approach [16, 17]. Percutaneous surgery has the advantage of minimal tissue disruption, preservation of normal anatomy, and reduced blood loss; it may be advised in the case

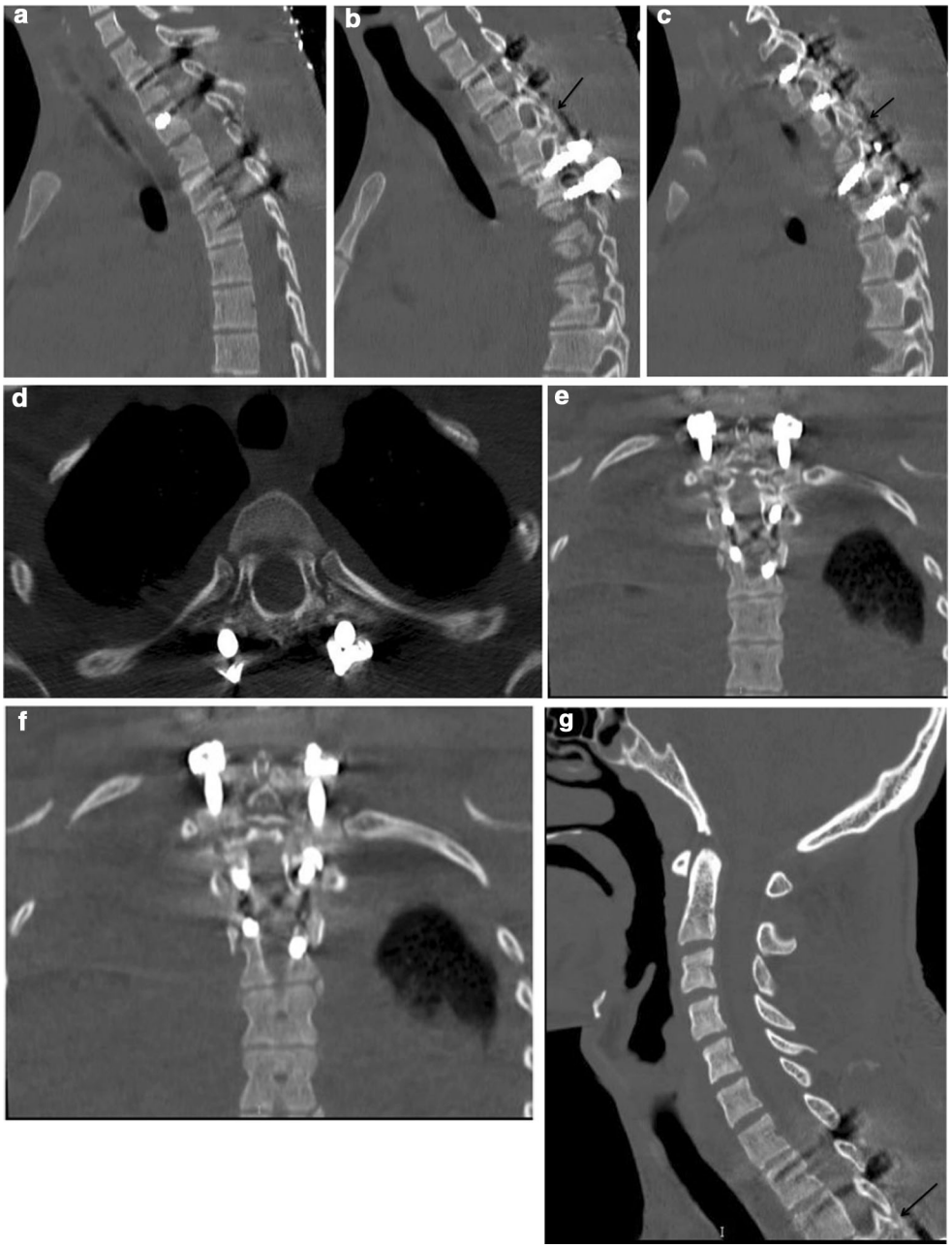

Fig. 5 Postoperative CT scan confirming the correction of the kyphosis (**a**) with closure of the bony gap in all planes, sagittal right and left (**b**, **c**), axial (**d**), and coronal (**e** pedicle and transverse process; **f** lamina) with restoration of a normal cervical lordosis (**g**)

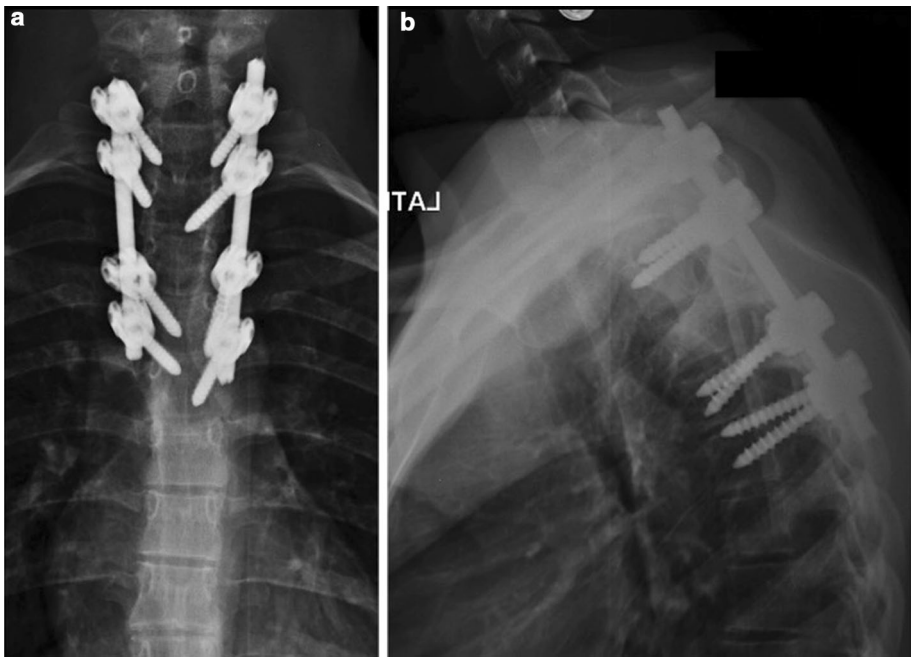

Fig. 6 1-year X-ray showing a stable construct with satisfactory cervicothoracic alignment

of a non-displaced chance fracture, especially in a patient not willing to keep a cast for 3 months, therefore, acting as an internal stabilization system and connecting pedicle screws from the vertebra above the fracture to the vertebra below the fracture. Removal of the screws may be performed 6 months to 1 year after the surgery when healing of the chance fracture is demonstrated on follow-up CT and, therefore, avoiding non-necessary arthrodesis. However, if a ligamentous injury is associated with the fracture, fusion should be the final goal of the surgery.

Open surgery is done through a classical midline incision, with instrumentation extending 1 or 2 levels above and below the fracture, the main advantage of such approach is the ability to reduce an important kyphosis with the use of the different reduction techniques and with direct visual control of the bony and neural elements, and reduction of the kyphosis is mandatory to avoid sagittal malalignment with rigid secondary post-traumatic kyphosis that may require aggressive surgery like pedicle subtraction osteotomy in the future. Kyphosis may be reduced by progressive translation of the spine in the sagittal plane with the use of reduction screws or reduction towers, completed by compression maneuvers at the site of the fracture; laminectomy is indicated in the case of spinal cord compression. Arthrodesis will be the final goal of the surgery.

In the case of a chance fracture as a complication of pedicle screw instrumentation, surgical management will include removal of the screws from the fracture site, reduction of the kyphosis and extension of the fusion proximally or distally, depending on the location of the fracture.

Pedicle screw fixation has become the mainstay of spinal fractures' instrumentation. However, like any other technique, it has its challenges, especially in the upper thoracic spine, where screw malposition is the main potential complication. Such complication may be avoided by the following steps: a thorough preoperative planning with accurate assessment of the thoracic pedicles' size and orientation on preoperative CT scan, the use of the free-hand technique with a double check with the pedicle feeler (once after the pedicle finder insertion, and once after the tap insertion just before screw insertion), the feeler should systematically reveal a bony feeling on the four walls of the pedicle, a doubtful trajectory should be considered as a wrong trajectory and must be corrected; otherwise, screw insertion must be avoided, screw length should always be 5 mm less than the trajectory to avoid any anterior cortex violation, the use of C-arm in the high thoracic area may be difficult because of the shoulders, and navigation, if available, could be an interesting option.

In the case of our patient, given the important secondary kyphosis, percutaneous approach was not used and a classical open posterior approach was used for posterior spinal correction and fusion with T1-to-T5 instrumentation. No laminectomy was done as no cord compression or no bony fragment in the spinal canal could be seen, which improved the bed of the graft for better fusion.

Operative procedure

Under general anesthesia, with a patient in a prone position, on four cushions, a posterior cutaneous midline incision was made. The spine was exposed subperiosteally from T1 to T5, in a fashion similar to other posterior instrumented surgeries, going laterally to the transverse processes. Important bleeding

was coming from the T3 fracture site and was controlled with Gelfoam and Surgicel; wax was avoided. Care was taken to preserve the supraspinous and interspinous ligaments between the upper instrumented vertebra and the level above. Resection of the inferior articular processes at all levels was performed bilaterally to provide maximum flexibility to the spine. The spinous processes were also resected, and the bone recovered prepared for use as a graft at the end of the procedure. We next used the free-hand technique to place the pedicle screws at all levels from T1 to T5 except T3, and screw insertion was difficult in this case due to small thoracic pedicles and the proximal thoracic kyphotic deformity that was moving the cervicothoracic junction forward modifying the usual vertebral orientation. Before reduction of the kyphosis, C-arm check of the screw position revealed a partially extra-anatomical right T5 screw with its tip ending up in the upper T4T5 disc, the screw was removed and the pedicle feeler revealed a clear bony feeling on the four walls of the pedicle on the proximal half of the screw trajectory, and a soft tissue feeling on the distal half (disc feeling), decision was made to put the screw back again for the following reasons: the screw grip was satisfactory with the existing pathway, changing the trajectory may weaken the thin pedicle which may compromise the screw and the kyphosis reduction subsequently, the concerned disc was part of a fused level, the fracture site was bleeding, and delaying further the reduction of the fracture was to be avoided.

For the correction technique, cantilevering of the spine with one straight titanium alloy rod on each side was performed simultaneously; after the rods were blocked distally on T4 and T5, reduction towers were put on the proximal screws pulling the upper thoracic spine to the rods. Slight compression was applied at the level of the fracture for further closure of the remaining gap.

Bleeding at the fractured level decreased significantly after the reduction.

No laminectomy was performed and the prepared grafts were placed to cover the maximum surface. Post-operatively, the course was uncomplicated, the patient was authorized to walk the first day post-surgery, and a single drain was removed on day 3.

Clinical outcome

The patient showed a significant improvement of his neurological symptoms (related to brain injury) after extubation, left the ICU 3 days after the spinal surgery and returned to normal walking on day 7. A postoperative CT scan confirmed the closure of the posterior bony gap of T3 with correction of the secondary kyphosis to 9° and restoration of the normal cervical lordosis (Fig. 5). He showed a satisfactory clinical and radiological result at 1 year (Fig. 6).

Compliance with ethical standards

Conflict of interest There is no conflict of interest for this case report.

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