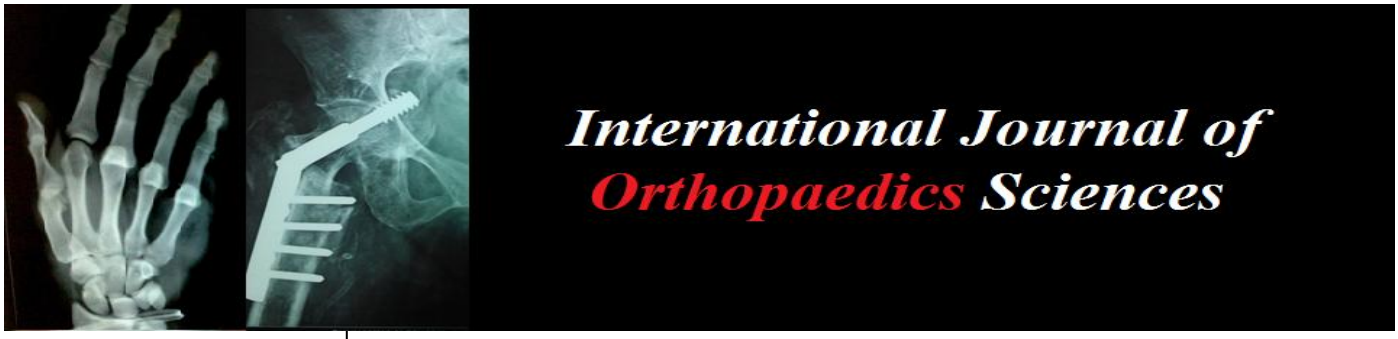

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C2 dens fracture with closed cervical migration of a 6cm humeral fragment

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Abstract
Case: A 39-year-old woman, with bipolar disorder, suffered an eight-meter fall, resulting in dens and proximal and distal humeral fractures associated with migration of a 6cm humerus fragment to the left cervical region.
There were no skin breaches on admission.
Posterior instrumented C1-C2 fusion was performed along with proximal humerus stabilization through anterograde static nailing after removal and repositioning of the cervical migrated fragment.
Conclusion: High-energy trauma significantly increases treatment complexity. Understanding injury mechanism is crucial to adequately diagnose undisclosed lesions that otherwise might go unnoticed. In cases of bone migration, a thorough debridement is advised to prevent heterotopic calcifications.

Keywords: Odontoid process, humeral fracture, trauma, complication, neurologic deficit

Introduction
Trauma lesions are influenced by the magnitude and direction of the applied force as well as the orientation of the axial / appendicular skeleton at the exact moment of injury [1].
The range of damage is usually a reflection of direct and indirect effects [1].
Trauma is known to be a major cause of death and disability worldwide, with 10 to 20% of the patients sustaining multiple injuries [2-6]. While cervical spine fractures are estimated to occur in 2% to 3% of all patients who sustained a blunt trauma [6, 7], odontoid fractures account up to 10-20% of all cervical fractures [7] and proximal humeral fractures represent approximately 7% of all injuries to the appendicular skeleton [5, 8-10].
The majority of odontoid fractures are consequence of a flexion loading, while only a minority of cases result from an extension load [6]. Proximal humeral fractures usually result from a lower-energy indirect injury to the shoulder during a fall on outstretched hand, even though it may also occur due to high-impact direct trauma to the shoulder [8, 9, 11]. Brachial plexus injuries in adults are mainly associated with motor-vehicle accidents however other traumatic events like falls, gunshot or stab wounds might also be blamed [12].
Even though these injuries have been fairly studied and characterized [8-14], the association of cervical fracture, proximal and distal humeral fracture as well as brachial plexus injury is a rare event. Even more, and to the best of the authors' knowledge, there is no mention in the literature to the closed migration of a 6cm humeral fragment to the cervical region without evident external signs of the injury.
This case report intends to raise awareness to the complexity and underline complications that may arise from a high-energy trauma.

Case report
A 39-year-old woman, with past medical history relevant for HIV positive and bipolar affective disorder, suffered a self-inflicted fall from an eight-meters height. After stabilization at the scene, she was transferred to a central emergency trauma unit. Primary and secondary survey were performed and the main injuries identified were a type III (Anderson-D'Alonzo

classification [15]) dens fracture (Fig. 1), along with a 6 cm bone fragment lodged in the left postero-lateral cervical region (Fig. 2); a left comminute proximal humerus fracture (Fig. 3); a left distal humerus fracture; and a brachial plexus injury.

No neck or shoulder skin breaches were identified.

Two days later after the adequate patient`s clinical stabilization a C1-C2 posterior autologous bone grafting arthrodesis was performed, implemented by a hook, bar and cross-linking device (Fig. 4). At the same time the humeral fragment located in the cervical region was recovered and used for the proximal humerus reconstruction stabilized through anterograde nailing (Fig. 5). The distal humeral fracture was treated with a two anatomic parallel plate and screws construct. As for the brachial plexus injury it was evaluated by MRI and electromyography, and considered not suitable for surgery by the microsurgery team.

C2 fracture consolidation was confirmed within two months. However and as expected, at six months follow up thumb abduction and extension deficits still persisted, along with a partial wrist and remaining fingers extension decrease range of motion. A 40º elbow extension deficit was still present at that time point while interestingly a heterotopic calcification was also identified at cervical area, in what appeared to be the trajectory of the previously migrated humerus bone fragment (Fig. 4).

The proximal humeral fracture evolved into a gleno-humeral ankylosis (Fig. 6 and 7) and a bone fusion was uneventfully achieved at the distal humerus fracture.

At 3 years down the line the patient still referred no pain in the cervical region. Even so, and despite progression of the heterotopic calcification and a noticeable cervical scoliotic deformity she refused further surgery.

In spite of a confirmed shoulder ankylosis, the left upper limb gradually recovered its function actually presenting an active elbow range of motion of 80º flexion and 10º extensions, no pronosupination deficits, and sustained global wrist and fingers flexion-extension (Fig. 8 and 9).

Discussion

To fully understand the complexity of a trauma mechanism is of the utmost importance while evaluating a patient. Most of the time, it can lead the surgeon to identify and diagnose injuries that otherwise could go unnoticed [16].

In this particular case, the main force vector was applied to the left elbow and transmitted to the arm and cervical region on the same side. This resulted in a major comminute fracture of the distal and proximal humerus. In fact, the magnitude of the trauma was such that it projected a 6cm humerus fragment through the soft tissue up to the posterior neck, damaging several structures, namely the brachial plexus. The orientation of the cervical spine at the moment of impact resulted in a C2 dens fracture. Of notice, is also the fact that no skin injuries or other external signs were identified pointing to the existence of a humeral fragment in the cervical area.

It is also noteworthy to state that the cervico-brachial heterotopic calcification present at six months follow-up, actually resembling an omo-vertebral bone usually observed in patients with congenital deformities such as the one described by Sprengel [17], is further evidence of the bone trajectory across the soft tissues. This probably results from the remaining periosteum or bone debris that kept osteoinductive/osteogenic properties and weren't completely removed during the previous surgical procedure, and it's interaction with the injured/necrotic muscle [18].

After identification of the different injuries, and its dimension, each one of them was given what we believe was the indicated treatment.

We realize that the selected C1-2 laminar hook construct with cross-linkage and bone grafting was only controlling rotation and flexion movements but not extension. However, it was our choice once we realised that extension movement was blocked by the contact between C1 posterior arch and C2 spinous process as required by the reduction position and consider the risks of different procedures. Additionally, it was a type III dens fracture, usually treated in a nonsurgical way in our spinal unit.

As for the humeral proximal nailing, even if it was stabilizing the humerus, the subsequent shoulder ankylosis wasn't in our first plan. However, at the end of the day and considering the patient neurologic status, it was probably the most effective treatment for the clinical situation being that is the reason why we accept it [19]. The distal plating evolution was as planned, providing the necessary stabilization for the bone healing, actually fully achieved in all three main fractures.

The removal of the fragment wasn't enough to prevent the heterotopic calcification, as noticed 6 months down the line. A thorough debridement of the fragment`s pathway and anti-inflammatory medications might probably be the best option in future similar cases [20], specifically after considering the impact of these medications on fracture union [20]. As for the traumatic heterotopic calcification and whenever detected, it can generally be resected in between six to nine months [20].

At 3 years follow-up, the heterotopic calcification was actually more evident than at 6 months follow up. There was a clear cervical scoliotic attitude probably partially related to the plexus lesion. However the patient refused further surgery, has no neck nor shoulder and elbow pain, and despite the inoperable brachial plexus injury, she still remained with a functional left upper limb compatible with her basic daily activities.

Despite the initial major injuries and deficits the final clinical overall results might be considered satisfactory.

To our knowledge, the authors raise awareness to the fact that this is the first report of a considerable dimension humeral fragment closely migrating to the cervical region, associated with a brachial plexus injury and a C2 dens fracture.

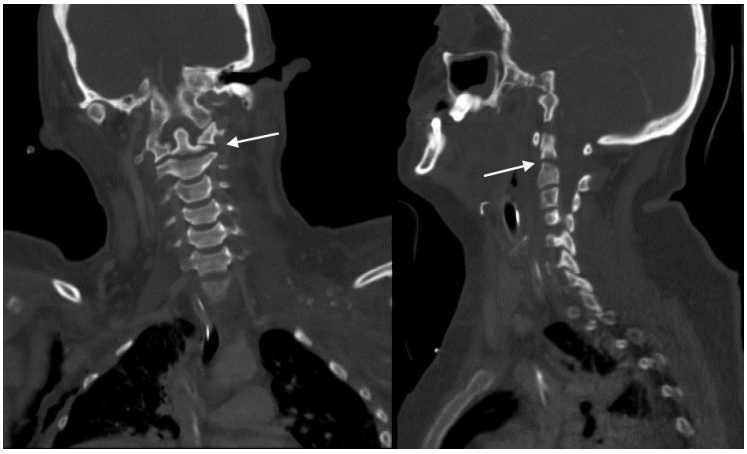

Fig 1: CT Scan showing type III of the Anderson-D'Alonzo classification dens fracture (arrow)

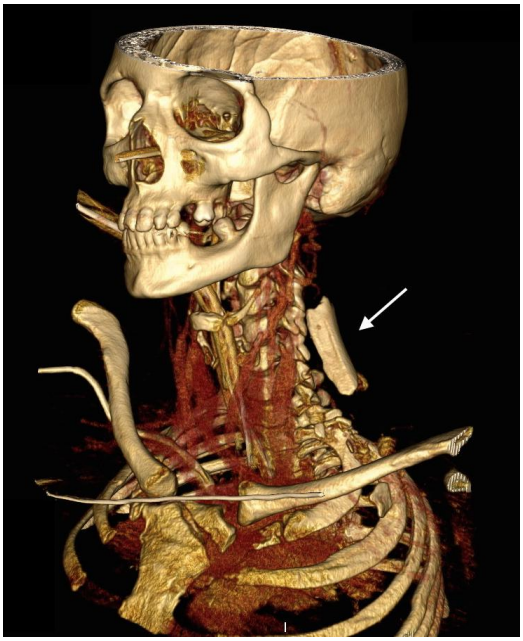

Fig 2: 3D CT Scan reconstruction showing cervical migration of a 6 cm proximal humeral fragment (arrow)

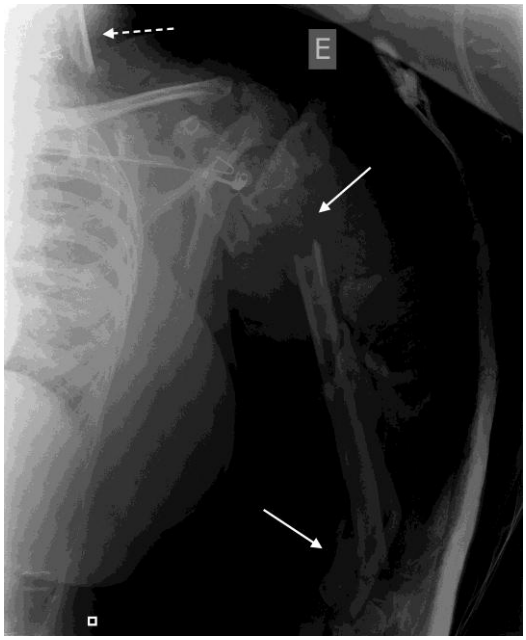

Fig 3: Anteroposterior radiograph of the left shoulder and arm showing comminuted proximal and distal humerus fracture (arrow) and migrated proximal humeral fragment (dashed arrow)

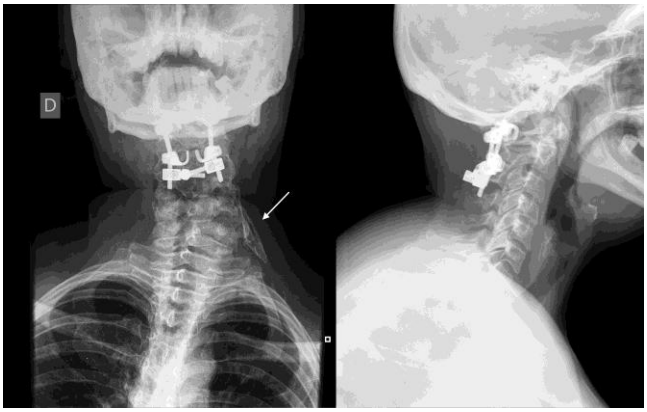

Fig 4: Anteroposterior and lateral cervical radiograph showing C1-C2 instrumentation and cervico-brachial heterotopic calcification (arrow) at 6 months follow-up

Fig 5: Anteroposterior radiograph of the left shoulder and arm showing proximal and distal humerus fixation at 2 weeks follow-up

Fig 6: Anteroposterior radiograph of the left shoulder and arm showing proximal and distal humerus fixation at 6 months follow-up

Fig 7: Anteroposterior radiograph of the left shoulder and arm showing proximal and distal humerus fixation at 3 years follow-up, with gleno-humeral ankylosis

Fig 8: Anterior and Lateral photograph of the neck and left shoulder showing no evidence of skin breach and surgical shoulder scar at 3 years follow-up

Fig 9: Photograph of the left arm showing extension and flexion of elbow and fingers at 3 years follow-up

Conclusion

The singularity of each trauma should always be taken into consideration. The highly atypical injury pattern reported is a reflex of the variety of manifestations we may encounter while dealing with complex trauma patients. In such patients one should always expect the unexpected.

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