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Management of odontoid fracture with associated atlantoaxial dislocation

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Resumo

Introdução: A fratura da apófise odontoide associada a subluxação atlanto-axial é uma lesão pouco frequente, com notável letalidade e incapacidade física. Esta lesão pode surgir em diferentes contextos, como traumas ou instabilidade cervical devido a artropatias, mais comummente a artrite reumatoide. A rápida identificação desta condição é crucial em todos os casos, uma vez que o atraso do diagnóstico pode resultar em compressão medular e défices neurológicos prolongados decorrentes da instabilidade articular. Devido à insuficiência de dados, o tratamento destas fraturas não está bem estabelecido na literatura.

Objetivos: Fornecer uma visão geral da fratura da apófise odontoide com subluxação atlanto-axial, incluindo detalhes sobre a apresentação clínica, o mecanismo de lesão, as características dos doentes, os métodos de diagnóstico, o tratamento cirúrgico, o seguimento e o prognóstico.

Metodologia: Foi analisada uma série de casos clínicos de seis doentes com o diagnóstico de fratura da apófise odontoide associada a uma subluxação atlanto-axial. A etiologia da doença deveu-se a lesão traumática ou a artrite psoriática num único caso. Dois dos seis pacientes apresentavam sintomas neurológicos na admissão e, dos quatro restantes, três apresentavam dor cervical e um era assintomático. Todo os doentes foram submetidos ao mesmo procedimento cirúrgico, utilizando a técnica de Harms, na mesma instituição. Efetuou-se uma revisão da literatura com base em estudos semelhantes e discutiu-se a abordagem e o tratamento destas lesões.

Resultados: Seis doentes foram incluídos (3 homens e 3 mulheres) com uma idade compreendida entre os 55 e os 88 anos. Os dois doentes com défices neurológicos realizaram uma ressonância magnética para avaliar a presença de possíveis lesões medulares. Em ambos os casos, os resultados demonstraram a presença de compressão medular e mielomalácia. Uma vez estabelecido o diagnóstico, procedeu-se à redução de todas as fraturas, tendo os doentes sido posteriormente submetidos a uma fixação posterior. A avaliação pós-cirúrgica revelou que todos os pacientes apresentaram uma evolução clínica favorável, sem complicações relacionadas com o procedimento.

Conclusão: Com o aumento da esperança média de vida da população, e tendo em consideração a distribuição etária destas lesões, é expectável um aumento da sua prevalência. Para minimizar a mortalidade e morbilidade que lhe são intrínsecas, é essencial uma rápida avaliação diagnóstica. A redução imediata utilizando tração e manobras adequadas deve constituir a primeira abordagem no tratamento das fraturas da apófise odontoide com subluxação atlanto-axial, seguida de estabilização cirúrgica. A técnica utilizada neste estudo, com fixação cirúrgica posterior com parafusos, resultou em índices satisfatórios de consolidação óssea e baixa incidência de complicações.

Palavras-chave: Subluxação antlanto-axial; fratura da apófise odontoide; fixação interna da fratura; vértebra C2; vértebra C1; apófise odontoide; dor cervical; Procedimentos Cirúrgicos;

Abstract

Background: Odontoid fracture associated with atlantoaxial subluxation is an infrequent injury with significant lethality and physical impairment. This injury can arise in different contexts, such as trauma or cervical instability originated by arthropathies, most commonly rheumatoid arthritis. Rapid identification of this condition is crucial in all instances since the delay in diagnosis may result in spinal cord compression and long-lasting neurological impairment resulting from joint instability. Treatment of these fractures needs to be better established in the literature due to insufficient data.

Objective: To provide an overview of odontoid fractures with atlantoaxial subluxation, including details on the clinical presentation, mechanism of injury, patient characteristics, diagnostic methods, surgical treatment, follow-up, and prognosis.

Methods: A case series of six patients diagnosed with odontoid fractures associated with atlantoaxial subluxation was reviewed. The etiology of the condition was due to either traumatic injury or psoriatic arthritis in a single case. Two of the six patients manifested neurological impairment at admission, and of the remaining four, three presented with neck pain, and one was asymptomatic. All six patients underwent the same surgical procedure utilizing the Harms technique at the same institution. A literature review was performed based on similar studies and the approach and treatment to these injuries was discussed.

Results: Six patients (3 male and 3 female) with ages between 55 to 88 years were included. In addition, the two patients with neurological deficits also performed an MRI to evaluate the presence of possible medullar damage. The findings demonstrated the presence of spinal cord compression and myelomalacia in both cases. Once the diagnosis was established, all fractures were reduced, and the patients subsequently underwent closed reduction and posterior C1-C2 fixation. Post-surgical assessments revealed that all patients exhibited favorable clinical progress without any major complications related to the procedure.

Conclusion: As the population's life expectancy increases, it is expected an increase in the prevalence of these types of injuries. A rapid diagnostic assessment is essential to minimize the mortality and morbidity that are intrinsic to this injury. A prompt reduction utilizing traction and appropriate maneuvering should constitute the first approach in treating odontoid fractures with atlantoaxial subluxation, followed by surgical stabilization. The technique used in this study involving a posterior surgical fixation with screws resulted in satisfactory rates of bone union and a low incidence of complications.

Keywords: Antlanto-axial subluxation; odontoid fracture; internal fracture fixation; C2 Vertebra; C1 Vertebra; odontoid process; cervical pain; Surgical Procedures;

Abbreviations

CT: Computerized tomography
ASIA: American Spinal Injury Association
MRI: Magnetic resonance imaging

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Introduction

The odontoid process is a protuberance of the Axis (C2), exhibiting a slight constriction where it joins the main body of the vertebra. It lies anterior to the spinal cord and provides the lateral rotation of the cervical spine by allowing the Atlas (C1) to rotate around it.

Odontoid fractures are the form of cervical fracture that occurs most often, representing approximately 18% of cervical fractures in the population and more than 50% in patients older than 80. [1,2] Despite occurring in all demographic groups, the underlying cause of the fracture differs depending on the age. Thus, odontoid fractures in young patients correlate with high-energy trauma in the manner of vehicle accidents or high falls. In contrast, in the elderly, this fracture is primarily associated with low-energy trauma in the form of falls from standing height.[3] The most common trauma mechanism is hyperextension of the cervical spine, driving the head and the C1 vertebrae backwards, which can culminate in an odontoid fracture with variable displacement. [4] This fracture depends not only on the resulting force of the trauma but also on the patient's bone density, which is compromised in elderly patient populations. However, less frequently, the hyperflexion of the cervical spine can also cause an odontoid fracture. [5] Furthermore, cervical spine instability is a common problem in patients with rheumatoid arthritis, which may spontaneously have fractures of the odontoid process without any history of significant trauma. These fractures can be complicated to diagnose because the structural changes resulting from rheumatoid involvement of the cervical spine progress very slowly. Thus, a high degree of suspicion should be exercised in patients with rheumatoid arthritis who have neck pain complaints. [6]

Atlantoaxial joint dislocation is a rare and severe injury associated with a high mortality rate. Combining an odontoid fracture with this dislocation results in instability and potential neurologic and vascular damage. The estimated frequency of these is less than 2% among upper cervical spine injuries and is more often associated with Type II and Type III odontoid fractures. [7] White and Panjabi defined a system based on imaging to divide C1-C2 dislocations into translational (anteroposterior or lateral), rotatory or distractive.[8] The dislocation most often associated with odontoid fractures and instability is translational. [9] These groups can further be divided into five types of dislocations: type A describes an anterior displacement; type B a posterior displacement; type C is the rotation of the Atlas with the Axis, moving the Atlas anteriorly; type D is a rotation resulting in a posterior dislocation of the Atlas, and type E involves a bilateral displacement around the center of the odontoid process. (Figure 1) [10] Most luxated fractures are displaced anteriorly and associated with flexion movement. In contrast, posterior luxation is more common in the elderly and has been associated with an extension of the neck. [1] Due to the scarcity of this injury, the appropriate management in these cases still needs to be established. [11]

Most patients with this injury complain of upper cervical pain with restriction of neck movement. Due to the risk of primary or secondary vascular and neurologic injury, it is mandatory to perform a complete neurologic evaluation to evaluate the presence of any neurologic deficit.

With this study we aim to present a comprehensive overview of odontoid fractures associated with atlantoaxial subluxation, addressing the clinical presentation, mechanism of injury, patient characteristics, diagnostical and surgical approach, with information relative to six patients treated at our institution.

Methods

All the individuals in this study underwent surgery according to the Harms technique – a posterior C1-C2 fusion with polyaxial screw and rod fixation. This procedure is performed with patients under general anesthesia and prone position, applying cranial traction using Gardner-wells tongs and traction (Figure 2).

All the fractures were reduced prior to surgical stabilization. In some cases, the reduction was performed in the operating room; when the surgery was performed later, the reduction was placed 1-3 days before, and the patient was left with traction. The reduction was performed using cervical maneuvers and a Stryker table® with adequate skull traction. The cervical maneuvers depended on the dislocation associated with the fracture. When the dislocation is anterior, there is a need for a flexion movement. On the contrary, when there is a posterior dislocation, the chosen maneuver is the neck extension. An image intensifier was used intraoperatively to ensure the correct position of the C1-C2 complex. (Figures 3 and 4). The reduction was performed with the patient awake to monitor any neurologic changes.

After adequate reduction, a posterior midline approach was performed, extending from the skull base to the C2-C3 joint, exposing the cervical spine. Laterally, the C1-C2 complex was exposed to the lateral border of the joint. During this step, due to the dissection around the epidural venous plexus, bleeding often occurs, which can be controlled using bipolar electrocautery, Gelfoam with thrombin and cotton pledgets. Lastly, to expose the entry point for the C1 screw, it is necessary to retract the dorsal root ganglion of C2 (Figure 5).

After exposing the C1-C2 complex, two 3.5mm polyaxial screws were inserted in the lateral masses of C1, followed by the insertion of two other 3.5mm polyaxial screws in the pedicles of C2. In this study, the material used was Vertex System, Medtronic® or Symphony, Depuy-Synthes®. The drilling was guided by anatomic landmarks, pre-operative CT scan or X-ray and intraoperative image intensifier (C-arm) (Figures 6A and 6B). After the insertion of the four screws, their position and the maintenance of the reduction were confirmed using image control and a rod was used to connect them. (Figures 7A, 7B, 7C, 7D and 7E) [12] Whenever necessary, intraoperative adjustment of the traction, flexion and extension of the cervical spine was performed to maintain adequate fracture alignment.

Before wound closure, 2 grams of vancomycin powder was applied to the surgical site to prevent infection. A subfascial drain was left during the first 24 hours. The patients were monitored during the postoperative period and an early ambulation start was encouraged.

Results

This study is based on six patients diagnosed with an odontoid fracture associated with dislocation of the atlantoaxial joint. The median age at presentation was 75,6 years, with the patients ranging from 55 to 88 years (Table I). There was an equal representation of both sexes, with three female and three male patients. Neurologic impairment was found in 2 (33%) of the patients. The diagnostic image method employed on the arrival of the patients was the X-ray, complemented by the CT scan in 100% of the cases. There was also a need to resort to MRI in 50% of cases, mainly to assess the degree of spinal cord compression. (Table II) Figures 8, 9, 10, 11, 12 and 13 represent the imaging studies performed on each patient.

Out of the six, only one had no history of trauma but had a background of psoriatic arthritis. On arrival at the hospital, two patients presented with neurologic deficits such as gait loss and muscle weakness in all four limbs.

Patient 3 sustained a fall resulting in a C2 fracture five months before her consultation. Despite progressive fracture dislocation, she was treated at another institution that opted for conservative treatment. She presented to our hospital with intense cervical pain, reduced muscle strength in the upper and lower limbs (2/5) – ASIA B - and a total loss of walking capacity initiated in the prior three weeks. The X-ray and CT scan showed a C2 body fracture with anterior atlantoaxial luxation of the odontoid process and an anteriorization of the posterior arc of the Atlas, as well as a thickening of the peri odontoid tissues, resulting in a reduction of the space of the vertebral canal with cord deformation and compression (Figures 10A and 10B). An MRI confirmed spinal cord compression and myelomalacia at the level of C1-C2 (Figure 10D).

Patient 5 had a previous history of psoriatic arthritis and was referred to our institution due to a 2-month history of neck pain associated with a two-week evolution of difficulty breathing and neurologic motor deficits leading to frequent falls. He did not report any recent traumatic events. On examination, he had predominant brachial tetraparesis with an ASIA B. A CT scan was performed, which revealed a non-recent type II odontoid fracture-dislocation, significantly reducing the spinal canal amplitude (Figure 12A). An MRI confirmed spinal cord compression with myelomalacia (Figure 12B).

In all patients, significant improvement was noticed in terms of symptoms, particularly neck pain and neurologic deficits, after surgical treatment. No major intraoperative complications were noted. The management consisted of a protocol composed of two moments: temporary axial traction followed by definitive surgical treatment. In 3 patients, the traction, reduction, and surgery were performed on the same day. Patients whose surgery could not be performed at admission, were placed in axial traction until taken to the operating theatre.

Minor complications were reported in 3 patients (2, 5 and 6).

Patient 2 reported dysphagia two days after surgery, which was attributed to progressive dementia. He also developed a respiratory infection which was treated with empirical antibiotics. He started ambulation on day five and was discharged two months after the surgery while waiting for a vacancy in a continuous care facility. Patient 5 developed purulent wound discharge starting one week after initial surgery and was submitted to wound debridement with retention of the instrumentation. He was placed on empirical antibiotic therapy followed by directed antibiotherapy. He was discharged on day 23 post-op with no further complications. Patient 6 presented with a depression of the state of consciousness with marked somnolence on the first day after surgery. She performed a cervical spine and cerebral CT scan, which revealed an old stroke but without apparent cause for the depressed state of consciousness. All symptoms resolved after administration of naloxone, indicating opioid intoxication in the postoperative period.

Patients were immobilized with a rigid cervical collar for six weeks. Patients were followed clinically and radiographically at 2 and 6 weeks, 3 and 6 months and yearly after surgery. The mean follow-up was 11,6 months (range 3-36 months). (Figures 8E, 9E, 12C, 12D, 12E, 12F and 12G)

Discussion

Odontoid fractures have a bimodal distribution, accounting for 20% of cervical spine fractures. This distribution can be explained by the low bone density in the elderly population and the high energy traumas in younger ages, usually related to traffic accidents. Furthermore, the C2 is the most frequently injured cervical vertebrae, with the odontoid fracture representing 50% of all C2 fractures. [13].

The main concern with this type of injury lies due to the characteristic anatomical harmonious arrangement of the occipital-cervical junction, as this body segment contains very delicate structures such as the spinal cord and the lower cranial nerves, blood vessels, the vertebral arteries and the carotid arteries. 7

Steel's rule of thirds may explain the surprisingly low rate of spinal cord injury in these cases: one-third of the neural canal at the atlantoaxial level is occupied by the odontoid process, one-third by the cord, and one-third by spinal fluid. By this concept, although the injuring force is sufficient to produce a dislocation with fracture of the odontoid process and a reduction in the canal area, the remaining canal area is sufficiently broad to avoid cord compromise. [14] In cases with an odontoid fracture associated with atlantoaxial subluxation, there is a higher probability of compressive myelopathy due to its instability, which can lead to persistent neurologic deficits. [15]

The imaging modality of choice to evaluate these injuries is the CT scan. The CT scan provides the best resolution for identifying and characterizing odontoid fractures with a sensitivity of 100%. [16] Radiographs have a lower sensitivity and specificity, making diagnosing odontoid fractures with this method more complex, particularly in the elderly due to degenerative processes. [2] MRI in these injuries is reserved for assessing the integrity of stabilizing regional ligaments and spinal cord injuries in cases of neurologic dysfunction. [16] The patients in this study were evaluated according to these recommendations, with 100% of them using CT as the diagnostic image exam. MRI was left only for those who presented with neurologic deficits.

Regarding the reduction of the dislocation, various methods have been proposed, such as cervical traction with increasing weight, transoral anterior release and atlantoaxial reduction plate, anterior odontoidectomy followed by posterior fusion, posterior fixation with manipulation of the facet or drilling and osteotomizing the facets alone or in combination with each other. [17] In our study, in every patient, we tried to reduce the fractures by increasing weight with cervical traction followed by flexion or extension maneuvers, which was successful in all cases.

Several forms of conservative and surgical treatments have been proposed, and the treatment of choice depends on the type of fracture and age of the patient. However, the option for surgical treatment has gained popularity in the last two decades compared to the conservative approach. [18] In odontoid fractures associated with atlantoaxial subluxation, opting for a non-surgical treatment raises the risk of neurologic injury and should not be considered except in exceptional cases. [19]

The Anderson and D'Alonzo classification is often used to classify odontoid fractures. It divides odontoid fractures into three types: Type I, Type II, and Type III, depending on the location and morphology of the fracture. Type I fractures are rare and refer to the avulsion of the tip of the odontoid process, and type III fractures - a fracture through the body of C2 vertebrae. These two fracture types are usually stable. Type II is the most frequent form, accounting for over 50% of all odontoid fractures. [20 13]

Surgical treatment should be considered in Type II unstable fractures (irrespective of age), in stable Type II fractures in the elderly and unstable Type III fractures. The choice of surgical modality relies on the reducibility of the fracture, its morphology, and the patient's age. [3] Furthermore, the surgical approach reduces the nonunion rate of these fractures since it allows a better fixation, therefore being a fundamental part of the treatment of luxated odontoid fractures.[21]

Anterior odontoid fracture fixation is preferred for reducible fractures with a posterior oblique or transverse fracture line – Type IIB. [20] The recommendation regarding the number of screws used in this procedure is based on the age of patients, and the use of 1 screw for young patients and two screws for older patients is recommended. [22] The anterior approach, comparatively to the posterior one, allows the preservation of the cervical spine motion and prompt stability, as well as the possibility to be performed in patients with high-riding vertebral arteries. Although it is associated with less soft tissue damage, organ injury increases, such as the esophagus, pharynx, airway and vascular or nervous structures. Recently, a study has proposed a novel technique to minimize these risks using an endoscopic anterior odontoid fixation with promising results. However, the sample was not significant enough to establish this technique as a treatment of choice since only four cases were reported. [21]

The remaining fracture patterns or irreducible fractures should be treated with a posterior C1-C2 fixation, especially in cases of atlantoaxial dislocation. In most cases, the techniques with screw-rod constructs (SCR) are preferred to sublaminar wiring techniques (Gallie or Brooks). [23] If patients have a high-riding vertebral artery trajectory, the treatment should be C1 lateral mass-C2 pedicle screw fixation (Harms technique) instead of transarticular Screw Fixation (Magerl and Seemann technique). [3, 24] The posterior instrumentation is associated with higher union rates but, from another perspective, is also associated with mobility restriction of the upper cervical spine. Regarding surgical complications, the difference between the different approaches is not significant[25]

Our study relied primarily on the posterior C1-C2 fixation with screw-rod constructs using the Harms Technique. The reason for this is that this technique allows for in situ reduction and provides a more stable construct than an anterior screw approach technique.

Regarding patient five, in which the dislocation was secondary to an inflammatory condition, only another similar case can be found in the literature, which reports an odontoid fracture associated with C1-C2 subluxation related to psoriatic arthritis in a patient with severe psoriatic spondyloarthropathy and cervical psoriatic ankylosing disease who fell at home and sustained a minor trauma.[26] Unlike this case, our patient did not present a history of any previous traumas, major or minor. His medical record only mentioned his diagnosis of psoriatic arthritis, meaning that the most probable cause of his fracture had to be related to his arthropathy. [26]

In conclusion, we report six uncommon cases of odontoid fractures with associated atlantoaxial dislocation. We also report on the methodology for reducing these dislocations, which is related to the type of dislocation and their surgical management.

Conclusion

Odontoid fracture with atlantoaxial subluxation is a rare injury associated with high mortality and morbidity. This lesion occurs more often in the elderly, and its incidence is expected to increase with the population´s ageing. Suspecting these injuries in patients with arthropathies, even without a trauma history, is necessary, as they may be underdiagnosed or diagnosed late. Its prompt diagnosis in every case is essential, as the delay can result in spinal cord compression and permanent neurologic deficits due to the instability inherent to the joint when it sustains this type of lesion. The preferred diagnostic method is the CT scan, with MRI reserved to elucidate cases with neurologic impairment.

The first line of odontoid fracture with atlantoaxial dislocation treatment should be immediate reduction with traction and appropriate reduction maneuvers followed by surgical stabilization. The option for a posterior surgical approach according to the Harms technique presented here resulted in favorable bone union rates and a low incidence of complications. The reduction of the fracture prior to the surgery and the use of traction also play an essential role in the procedure's success.

Tables

Table I – Patients' profiles and clinical presentation

Patient Number	Age (years)	Sex	Trauma	Pre-operative Neurologic deficits	Preoperative symptoms
1	82	F	Yes	No	Neck pain
2	84	M	Yes	No	Neck pain
3	88	F	Yes	Yes	Intense neck pain + reduced muscle strength (2/5) + gait loss
4	55	M	Yes	No	No symptoms related to the fracture
5	61	M	No	Yes	2-month history of neck pain + 2-week evolution of difficulty breathing + gait loss
6	84	F	Yes	No	Neck pain

Note: M: Male; F: Female

Table II – Patients' diagnostic methods, treatment, complications, and follow-up

Patient Number	Diagnostic Image	Use of MRI	Time of temporary axial traction	Post-op Complications	Remarks	Follow-up (months)
1	CT	No	In the operating theatre, immediately before surgery	No complications	Improved	9
2	CT	No	1 day	Dysphagia and respiratory infection – not related to the surgery	Improved	6
3	CT	Yes	3 days	No complications	Improved	6
4	CT	Yes	2 days	No complications	Improved	Patient still had not been discharged
5	CT	Yes	In the operating theatre, immediately before surgery	Surgical site infection	Improved	36
6	CT	No	In the operating theatre, immediately before surgery	Depression of the state of consciousness - hypersensitivity to the opioids	Improved	3

Figures

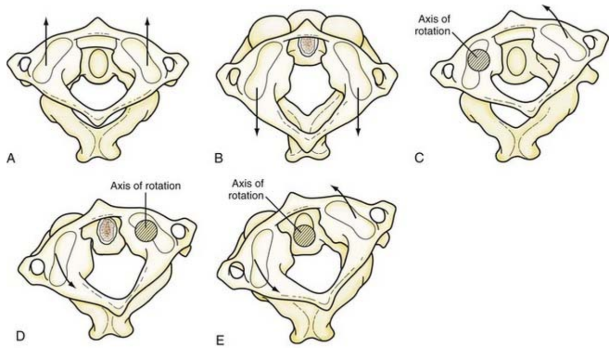


Figure 1- White and Panjabi classification of atlantoaxial rotatory subluxation used with permission from *clinicalgate.com*

Figure 2 – Intraoperative use of cranial traction with Gardner-wells tongs.

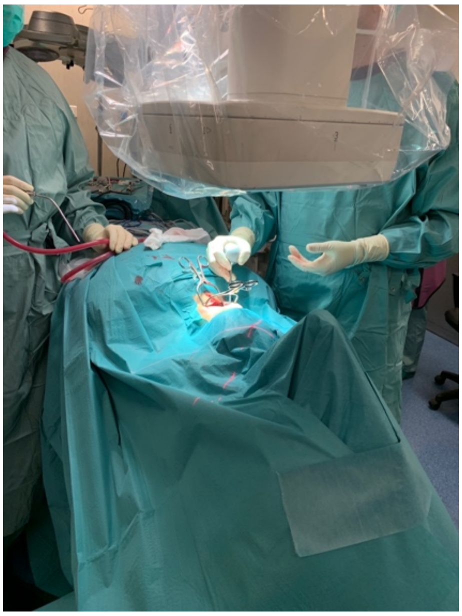


Figure 3 – Intraoperative use of an image intensifier.

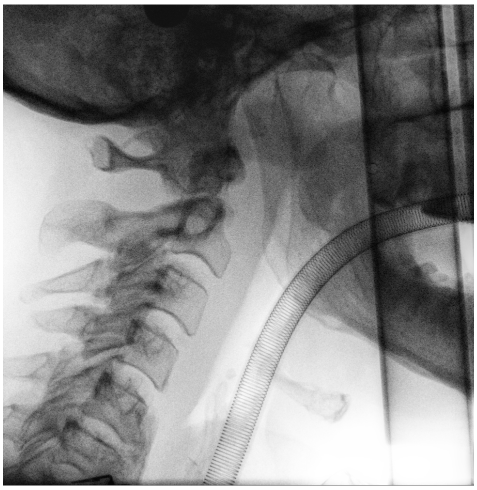


Figure 4 - Intraoperative X-ray to ensure the correct position of the C1-C2 complex.

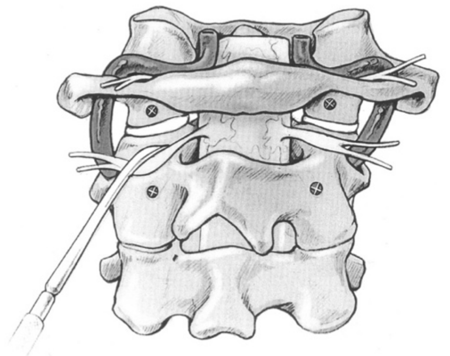
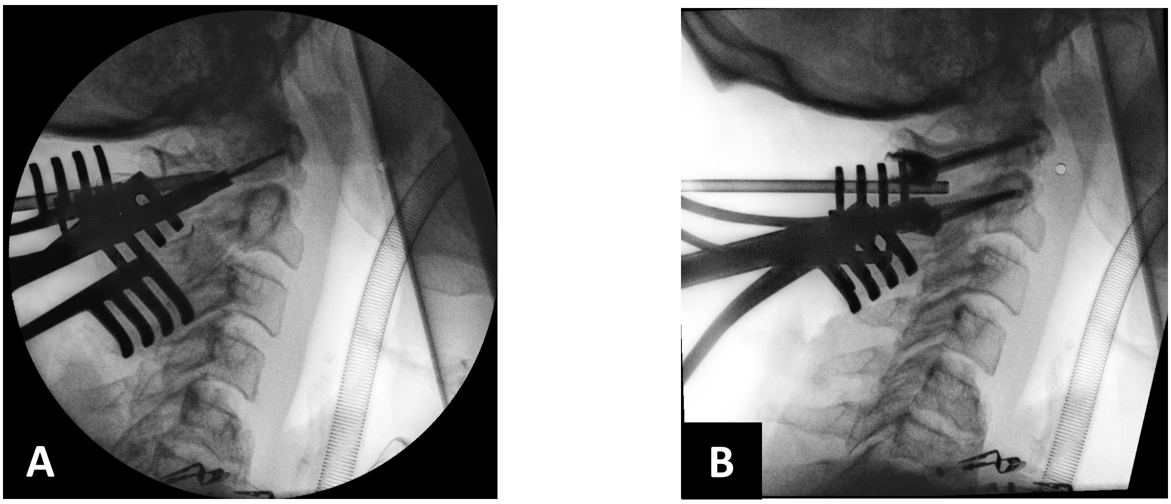


Figure 5 – Illustration of the posterior view of the upper cervical spine showing the location of the entry points in C1 and C2 for screw placement in the polyaxial screw and rod fixation technique used with permission from *Wolters Kluwer Health, Inc*



Figures 6A and 6B - Intraoperative imaging to guide the drilling.

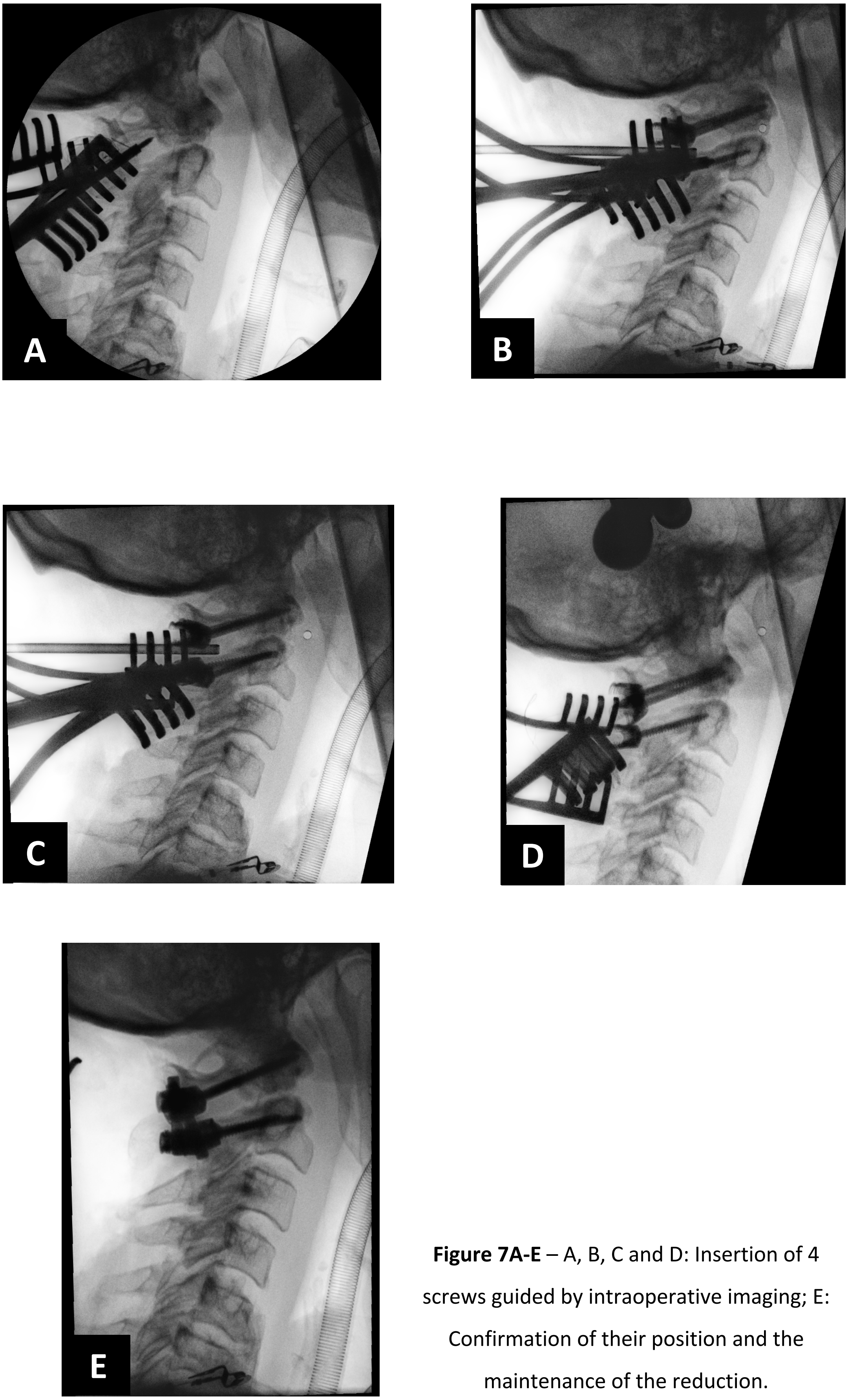


Figure 7A-E – A, B, C and D: Insertion of 4 screws guided by intraoperative imaging; E: Confirmation of their position and the maintenance of the reduction.

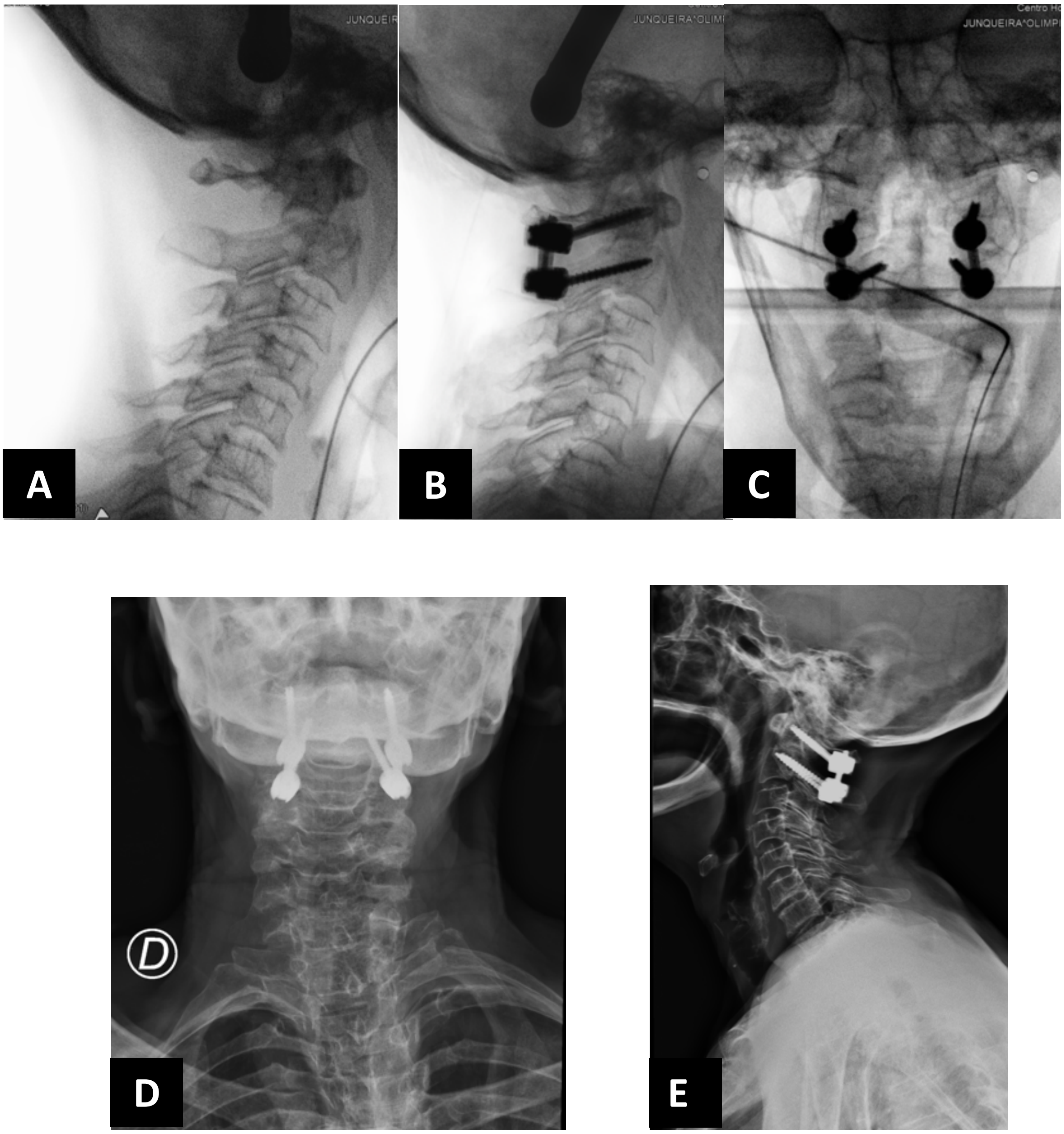


Figure 8A-E – Patient's 1 images. A: preoperative X-ray; B and C: intraoperative X-ray; D and E: 3-month follow up X-ray.

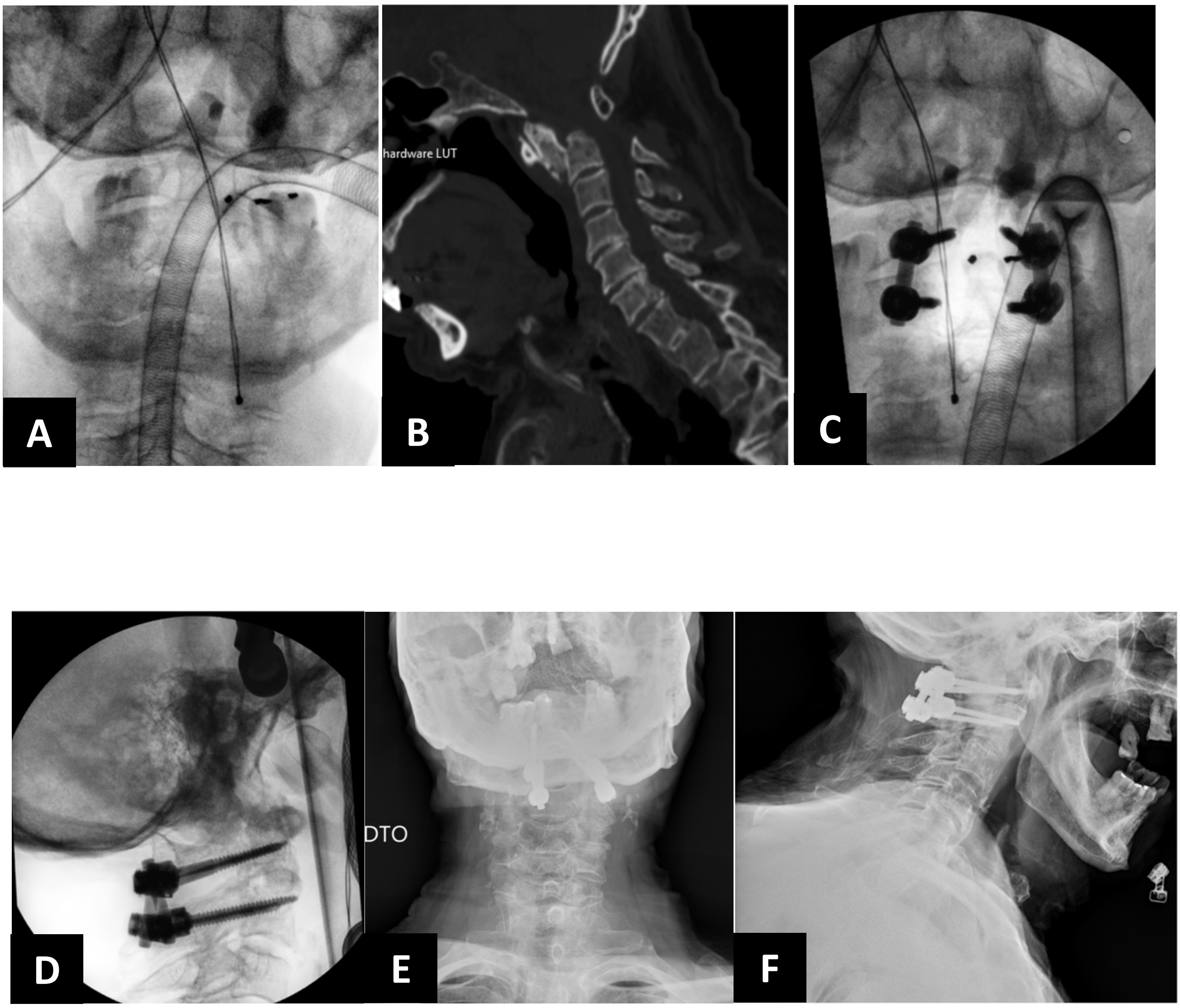


Figure 9A-E – Patient's 2 images. A: preoperative X-ray; B: preoperative CT scan C and D: intraoperative X-ray; E and F: 2-month follow up X-ray.

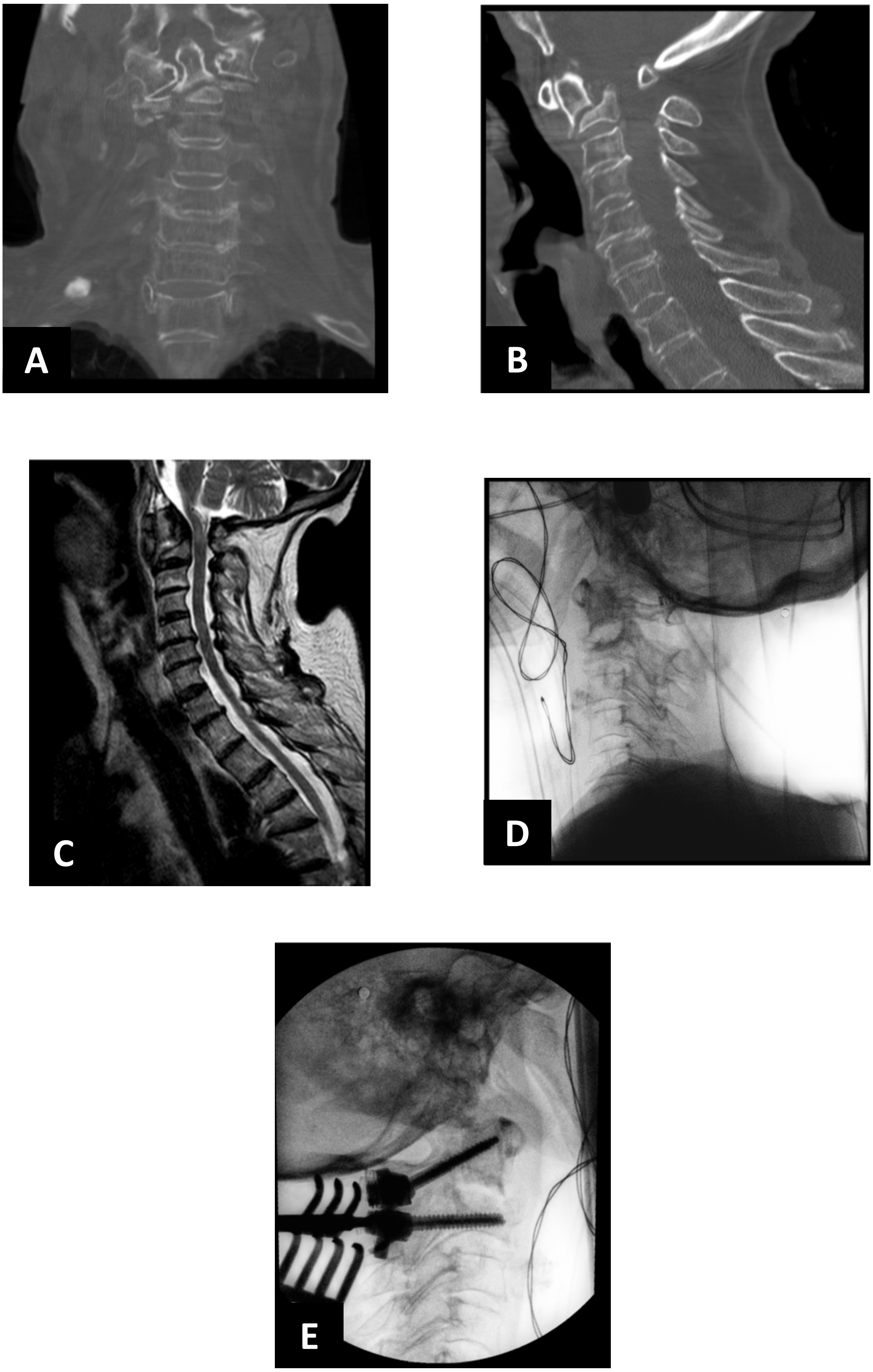


Figure 10A-E – Patient's 3 images. A and B: preoperative CT scan; C: pre-operative X-ray; D: preoperative MRI evidencing spinal cord compression and myelomalacia at the level of C1-C2; D and E: intraoperative X-ray.

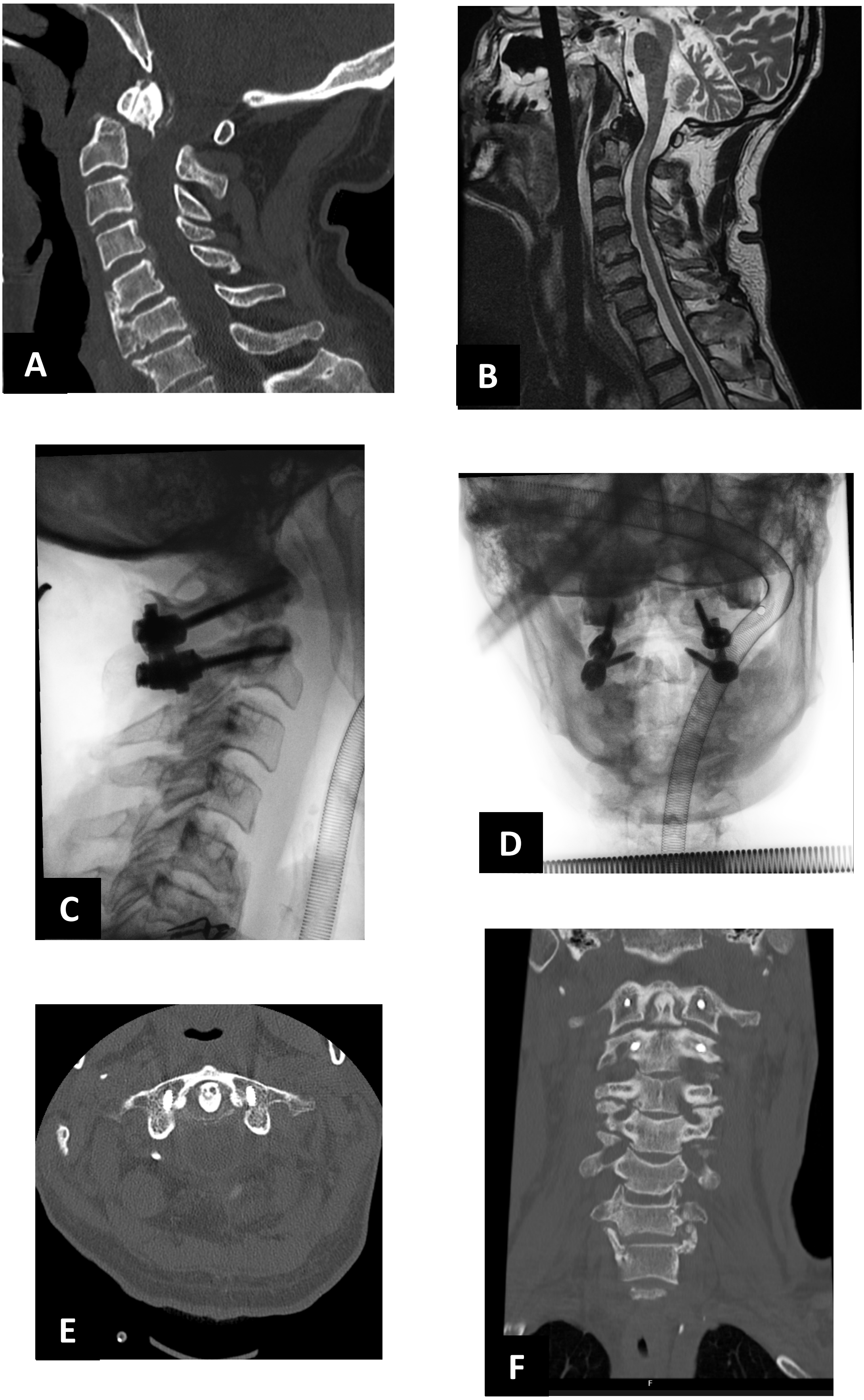


Figure 11A-F – Patient's 4 images. A: preoperative CT scan; B: preoperative MRI; C and D: pre-operative X-ray; E and F: 4-day postoperative CT scan.

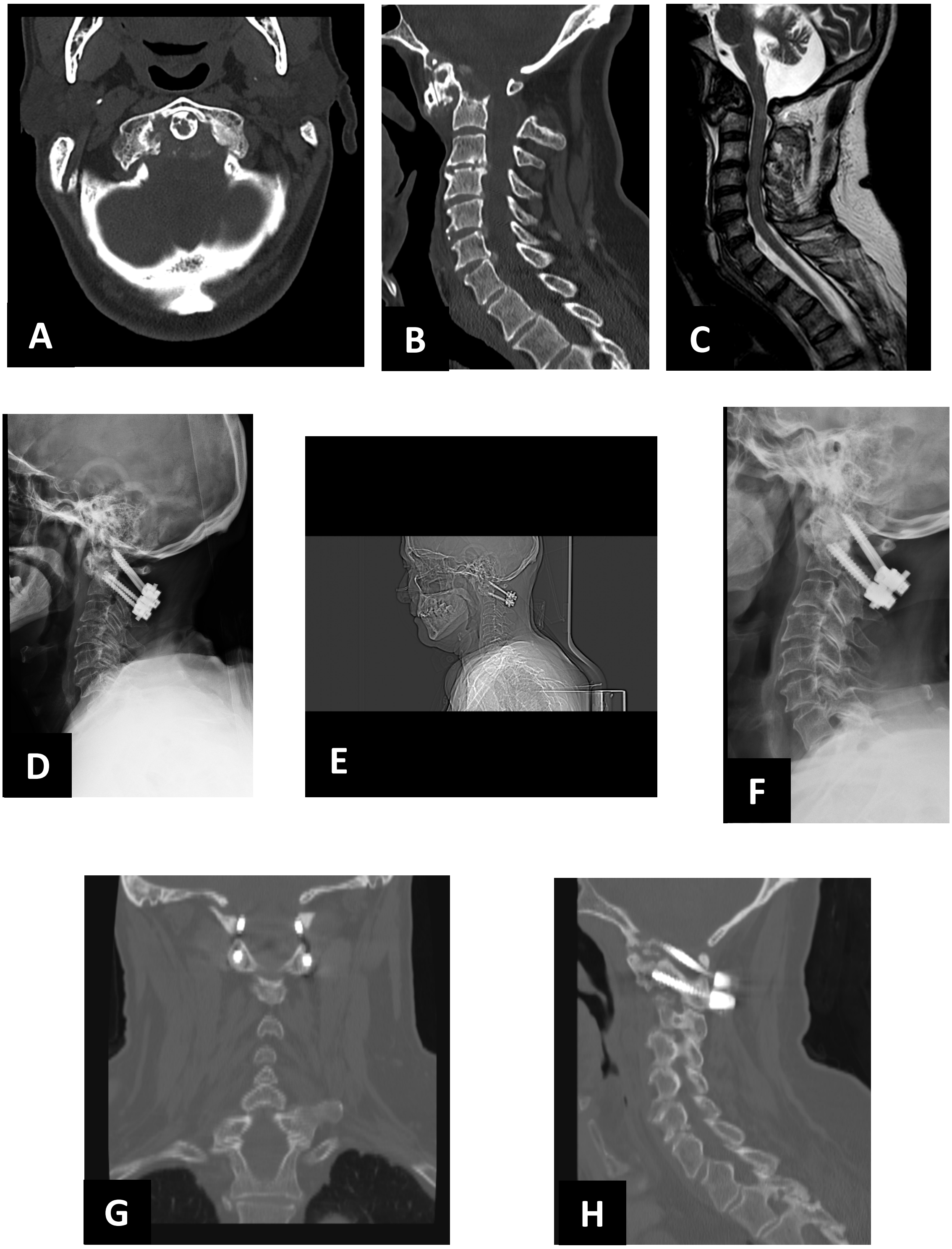


Figure 12A-H – Patient's 5 images. A and B: preoperative CT scan revealing an old Type II odontoid fracture-dislocation; C: preoperative MRI; D and E: 6-month follow-up X-ray; F: 2-years follow up X-ray; G and H: 2-years follow up CT scan.

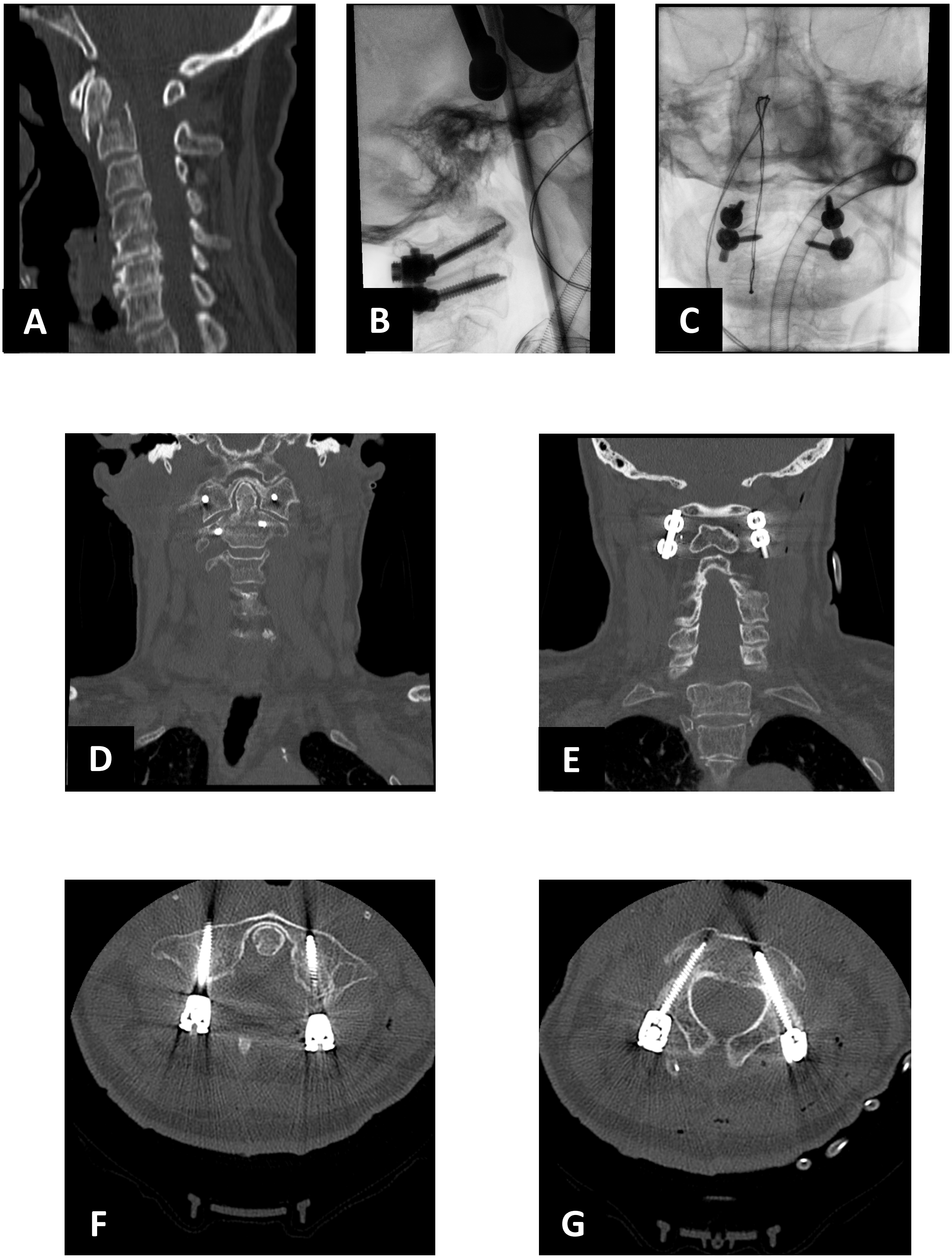


Figure 13A-G – Patient's 6 images. A: preoperative CT; B and C: intraoperative X-ray; D, E, F and G: 1-day postoperative X-ray.

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